# Updated Direct and indirect impacts of Climate Change

An overview of impacts discussed here can be found in the link below. [**https://www.nwcouncil.org/meeting/sif-climate-change-and-2021-power-plan-workshop-may-1-2019**](https://www.nwcouncil.org/meeting/sif-climate-change-and-2021-power-plan-workshop-may-1-2019)

It is generally recognized that direct impacts of climate change are through change in temperature and precipitation patterns. It is also recognized that change in temperature impacts loads more than precipitation. Precipitation is anticipated to impact hydro generation. There are generally accepted that there is an underlying upward trend in temperatures. But there is also uncertainty as to the timing. There are at least three different levels of impact,

### Three Layers of Climate Change Uncertainty

Layer 1: Impact of direct variables, Change in daily temperature and precipitation

Layer 2: impact of indirect variables, deterministic adaptive or mitigative actions; increase in air conditioning saturation, change in demographic and economic mix.

Layer 3: Impacts of indirect variable that have a stochastic behavior, wildfires and Floods/landslides.

### Load Forecast Layers

Layer 1: Global climate Change Models (GCM) can only provide a decadal, not an hourly forecast of temperatures or precipitation. To downscale from decadal and daily GCM forecasts to annual and hourly forecasts steps are taken to create hourly range of load forecast for each year under various temperature conditions.

Layer 2: Deterministic indirect impacts are also subject to uncertainty. Once indirect impacts are incorporated into the load forecast, the resulting forecast is subjected to a wide range of uncertainty like the first layer.

 Layer 3: Stochastic Indirect variables, such as wildfires and landslides/floods, cannot be explicitly incorporated in the load forecast. Although it is recognized that these events will be more prevalent in the future, the key questions of; when, where and how sever they will be is not known at current state of knowledge. Although direct impacts of these variables are expected to impact transmission and distribution infrastructure, there will be temporary or longer-term economic and load destructions. To incorporated impact of these variables we are evaluating if small increases in depth of downward jumps in Regional Portfolio Model can capture impact of wildfires- this is a work-in-progress.

in the rest of this paper, we will focus on the indirect impacts on load forecast.

# Indirect impacts of climate change on load forecast in the Northwest

Recent research on the impacts of climate change suggests interesting outcomes for different regions of the US. Human activity is estimated to have increased global temperature by approximately 1°C since the pre-industrial period.[[1]](#endnote-1) Temperatures are expected to increase to 1.5°C above pre-industrial levels between 2030 and 2052, at a rate of increase of 0.2°C per decade. However, the Northwest has seen slightly less warming than the global average. Rupp et al. (2013) estimate the average annual temperature in the Northwest to have increased by 0.61°C from pre-industrial levels.[[2]](#endnote-2) With this variation in warming comes shifts in precipitation, storm patterns, and droughts, and differences in impact across regions. If the predictions are realized, climate change and its resulting complications hold significant consequences for energy use in the Pacific Northwest.

In this paper, we review the scientific literature on the effects of climate change, with particular attention paid to the impacts on the Northwest region and NWPCC’s energy forecasts. We recommend testing forecast models for sensitivity to impacts beyond the direct temperature impacts of climate change. Furthermore with the estimated additional migration to the Northwest calculated here, we recommend adjusting population forecast models for potential increases in climate migration.

**Summary of Findings**

* The Northwest is expected to be harmed less by climate change relative to other regions of the country and may benefit from certain aspects. Northwest agricultural yield is estimated to increase by 12% for each 1°C of warming.
* Poorer economic conditions in the South and Midwest, driven in part by reductions in crop yield, are likely to cause shifts in migration toward the Northwest.
* We estimate that an additional 1.3 million people will move to the Northwest by 2050, in excess of current population forecasts.

With the amended population estimates presented, we intend to incorporate population growth more broadly into the NWPCC’s industry forecasts. Beyond changes to the region’s residential energy use, growth in residents will affect the Northwest’s commercial and industrial business make-up. In the final section of this paper, we will account for this shift using the concept of elasticity to measure the responsiveness of industries to changes in population.[[3]](#footnote-1)

## Economic Impacts of Climate Change

Annual average temperatures across the United States are projected to increase over this century, with greater changes at higher latitudes.[[4]](#endnote-3) The Northwest is expected to experience increases in flooding, landslides, drought, wildfire, and heat waves. Climate change is also expected to put extra pressure on the Northwest’s healthcare and social programs.[[5]](#footnote-2) Under moderate emissions (RCP4.5),[[6]](#footnote-3) the average annual temperatures could increase by 4°F (2.2°C) in Oregon and Washington, and by 5°F (2.8°C) in Idaho and Montana by the end of the century.[[7]](#endnote-4) Although on an average annual basis, increase in temperature are rather modest, daily and hourly variations in temperatures are not. As we will present number of days with over 95-degree temperature will be increasing significantly over the next few decades.

Estimating the economic impacts of climate change is not a straightforward endeavor. The damage caused by increasing temperatures occurs on a global scale and is not evenly distributed.[[8]](#endnote-5) Furthermore, much of the effects of actions today will not be felt for decades, with many climate projections indicating large impacts by the end of the century. However, there is considerable evidence of current and ongoing damage to the US from recent increases in temperature. In this section, we discuss recent literature on climate change’s economic impacts.

A report by Four Twenty-Seven, a climate and economic research firm, paints a picture of climate hazards at the county level across the US. In considering the impacts of cyclones, rising sea levels, extreme rainfall, heat stress, and water stress, they conclude that climate change is already impacting the country, and long-term impacts on local economies and economic growth are becoming clear. Sea level rise and cyclones are putting coastal economies under pressure, causing billions of dollars in damage every year.[[9]](#endnote-6) Manufacturing hubs in the Midwest are increasingly vulnerable to extreme heat. Increased temperatures in the West are impacting, and projected to further reduce, snowpack and streamflow, with the potential to affect the water access of communities and agriculture.

For many policy decisions, damages in this timeframe are not considered, and if they are, the discounted future damage is often seen as negligible compared to the immediate costs of action. Still some agencies recognize the imminent economic risks of climate change. In a recent economic letter published by the Federal Reserve, Rudebusch (2019) discusses the risks and the monetary authority’s responsibility to act.[[10]](#endnote-7) Climate change may induce individuals to increase precautionary saving in response to higher risk. Shocks to the economy from more frequent extreme weather events may impact price levels and supply chains. The growth of certain industries may also be affected as higher temperatures can reduce productivity. The Finance, Insurance, and Real Estate industries’ output could see a 1.3% point decrease with a 0.5°C / 1.8° F increase, with all industries’ output falling by 0.2% points on average.[[11]](#endnote-8) Annual economic growth could suffer by as much as 0.5% by the end of the century. The impacts will also be more concentrated among lower income areas, reducing income by 0.9% for each decile below the top earners.[[12]](#endnote-9) This suggests the poorest 10% of counties will see reductions in income of 9 percentage points more than the richest 10% of counties.

Despite the widespread negative impacts, regions will not be impacted uniformly and some regions stand to benefit from certain aspects of a changing climate. Notably, the Northwest US is commonly expected to be among the beneficiaries of a warmer climate. This is due in large part to potential increases in precipitation and agricultural yield.[[13]](#endnote-10)

The additional risk associated with increased temperatures and precipitation also contributes to differences in impact across regions. Backus et al. (2012) predict that the uncertainty of climate impacts will reduce US GDP by $1.2 trillion, in 2008 dollars, over the timeframe of 2010 to 2050.10 Due to relative improvements in climate in the Northwest, the region is again expected to benefit: all four states are expected to see a positive increase in GDP, with a region total of $51 billion.

Assessing the potential damages from climate change requires looking beyond regional averages to a more local level. Hsiang et al. (2017) examine the distribution by county of eight potential side effects of climate change, including stresses on segments of the labor force, and changes in crime and mortality rates.9 Figure 1 below displays these results, as well as estimates of total impacts. Certain temperature ranges depress rates of property crime, and general increases in temperature raise occurrence of violent crime. These lead to predictions that property crime will increase in the northern US, while violent crime is expected to increase in nearly all US counties from higher temperatures. Hsiang et al. (2017) place this increase in violent crime rates at around a 0.9% increase in crime per 1°C increase.

Increasing temperatures also lead to health complications, and mortality rates are predicted to increase by as many as 80 additional deaths per 100,000 people in some regions. As with temperature increases, mortality rates are most heavily impacted in southern counties, with mixed impacts in the north. Employment with exposure to outdoor temperatures will come under pressure, whether the exposure is heavy or minimal. Labor with heavy exposure is estimated to fall by upwards of 3% in areas of the South. For the economy, annual losses of GDP may be between 0.6% and 1.7% with each 1°C /1.8°F of warming.

**Figure 1: Spatial Distribution of Climate Change Impacts from Hsiang et al. (2017)**

*“Spatial distributions of projected damages. County-level median values for average 2080 to 2099 high emission (RCP8.5) impacts. Impacts are changes relative to counterfactual “no additional climate change” trajectories. Color indicates magnitude of impact in median projection; outline color indicates level of agreement across projections (thin white outline, inner 66% of projections disagree in sign; no outline, ≥83% of projections agree in sign; black outline, ≥95% agree in sign; thick white outline, state borders; maps without outlines shown in fig. S2). Negative damages indicate economic gains. (A) Percent change in yields, area-weighted average for maize, wheat, soybeans, and cotton. (B) Change in all-cause mortality rates, across all age groups. (C) Change in electricity demand. (D) Change in labor supply of full-time-equivalent workers for low-risk jobs where workers are minimally exposed to outdoor temperature. (E) Same as (D), except for high-risk jobs where workers are heavily exposed to outdoor temperatures. (F) Change in damages from coastal storms. (G) Change in property-crime rates. (H) Change in violent-crime rates. (I) Median total direct economic damage across all sectors [(A) to (H)].”*

An interesting outcome from the work of Hsiang et al. (2017) is their estimated impacts for agricultural yield and energy expenditures. They estimate that increases in energy demand are likely to be minimal within the Northwest states, as increased demand for cooling may be offset by decreased demand for heating. This result may change as preference for air conditioners within the Northwest is expected to increase. Counties in the South and Midwest are likely to experience severe declines in agricultural productivity with increased temperatures. However, the Northwest states are estimated to see increases in yield in the majority of counties, with some seeing between 20% and 45% increases in yield due to end of the century warming. This amounts to around a 12% increase in yield per 1°C /1.8°F of warming. The overall positive outlook for the Northwest indicates that it may be focal point for future growth, and an attractive destination for those seeking better economic opportunity.

## The Impact on Energy Systems

The primary direct impact of climate change on the long-term energy load forecast is through higher summer temperatures and higher winter temperatures. A study by the Climate Impact Lab, shown in Figure 2, suggests the number of days above 95°F (35°C) are expected to more than triple across the Northwest by 2100.4 On the lower end, Washington is expected to see an increase from 3 to 10 days by 2060. With the highest numbers for the region, Idaho may see an increase from 11 to 34 days over the same period. Coinciding with the warming trend, the Northwest may also see a sharp decline in the number of cold days. By 2060, the number of days below 32°F (0°C) in Oregon may drop from 59 to 38 days. For Montana, we would see a larger shift from 168 days to 128 days below freezing.

**Figure 2: Historic and Forecast Annual Hot and Cold Days (population weighted) under RCP8.5**

Source: Climate Impact Lab, 2019

These changes in extreme temperature days are likely to impact energy use through adaptation, such as increased cooling use and air conditioning saturation rates, and decreased heating.[[14]](#endnote-11),[[15]](#endnote-12),[[16]](#endnote-13) Still there are secondary impacts of temperatures on energy loads are not limited to temperatures in the Northwest. Climate change in other states, and even other parts of the globe, can impact loads in the Northwest. In addition, expected increases in flooding, heatwaves, hurricanes, fires, and other climatic events can cause a shift in the economics and population of the United States, and internationally.

Higher temperatures, no matter the region, may impact energy load in the Northwest through 1) changes in the economics of the Northwest relative to other regions, and 2) increased migration to or from other states, due in part to (1). In the remainder of this paper, we provide evidence of this relationship, and propose adjustments to population forecasts used in estimating future energy requirements. This work is supplemented by further research at the end of this report proposing the use of the elasticities of industry measures to changes in population.

## The Indirect Impact on Migration

In addition to the direct impacts of climate change, a greater awareness of the indirect impacts of climate change on migration and state economies is coming into focus. The changing climate likely has a significant influence on local energy loads through its impact on migration, as residential consumption has accounted for between 38 and 43% of non-DSI electricity sales since 1980.

In the past, climate events have been observed to trigger large-scale migration increases. Social scientists have widely studied the changes in migration related to environmental conditions of the Dust Bowl in the 1930s. Extended drought, as well as poor land use patterns, in the Great Plains led to drastically reduced productivity of agriculture and wide-spread outmigration.[[17]](#endnote-14) According to McLeman et al. (2014), nearly 300,000 people from the Great Plains migrated to California alone in the late 1930s.[[18]](#endnote-15) Census counts indicate growth in the population of Oklahoma of 22% and 18% in the decades before the 1920 and 1930 censuses, respectively. However, after the Dust Bowl, the population fell by 2.5% in the 1940 census and a further 4.4% in the 1950 census, and did not return to past population levels until the mid-1960s. Outmigration resulting from the Dust Bowl was not spread evenly across the country. Much of the migration from the Great Plains region was toward rapidly developing California, largely driven by relatives in California who had moved west and the need for agricultural workers.[[19]](#endnote-16)

As a more recent and visible example of climate migration, Louisiana experienced increased outmigration in the aftermath of two hurricanes starting in August of 2005. Hurricanes Katrina and Rita destroyed over 217,000 homes, 875 schools, and 18,750 businesses, and affected 4.5 million of the state’s residents.[[20]](#endnote-17) NOAA estimates the insured losses from the dual storms at $160 billion (in 2017 dollars).[[21]](#endnote-18) Louisiana lost nearly 6 percent of its population after Hurricane Katrina struck, and the population of New Orleans was still down 250,000 people a year later, a reduction of over 50% from 2000 census levels.

Extreme weather events are also becoming more expensive.17 In 2017, Hurricane Harvey resulted in the flooding of 185,000 homes in Houston, Texas. In total the storm caused $125 billion in damages, requiring additional funding of emergency services from the federal government.18 Weeks later, Hurricane Maria caused widespread blackouts for the more than 3.4 million residents of Puerto Rico,[[22]](#endnote-19) and killed an estimated 2,975 people.[[23]](#endnote-20) Since the storm, the local government has struggled to manage the recovery, and around 130,000 have fled the area.

While migration from sudden and extreme weather events is concerning and likely to increase with climate change, on average their impact is temporary and lesser in magnitude than migration strictly due to increases in temperature and precipitation.[[24]](#endnote-21) The scientific literature suggests that much of climate migration will be more gradual and as a result of economic pressures.[[25]](#endnote-22),[[26]](#endnote-23) In the next section, we discuss the general theory on the drivers of this migration.

### Factors Influencing Decisions to Migrate

The factors influencing decisions to migrate are generally broken into one of three categories.[[27]](#endnote-24) First, push factors are the characteristics of the individual’s origin that they wish to leave behind. Second, pull factors are those that draw the individual to the destination. Within each are economic, social, and environmental drivers, and as the categories are the converse of each other, the underlying causes are related. A downturn in their local economy is compared to the demand for workers and higher wages of another. Subpar school districts where they currently live are weighed against educational opportunities of the destination. Storm damage in the Gulf area is compared to the climate amenities of the Northwest.

The third set of factors influencing migration are intervening factors, which either facilitate or hinder the ability to move. These might include restrictions on immigration or availability of funds for moving. Typically the choice also depends on whether there is an existing social network of friends or family in the new or old area. Social ties or the presence of a historic family home may make individuals reluctant to move, regardless of economic or environmental conditions. Furthermore, not all groups can or will migrate. Some population segments, such as the elderly or poor, cannot afford to move to a new and safer area. Often in the case of environmental and natural disasters, the elderly are disproportionally affected: 60% of those who died during Hurricane Katrina were above the age of 65.[[28]](#endnote-25)

**Figure 3: Push, Pull, and Intervening Factors of Migration**

**Environmental Drivers**

Hazard Exposure\*

Agricultural Productivity\*

Climate Amenities\*

**Intervening Factors**

Social Networks

Access to Capital\*

Laws & Policies\*

**Economic Drivers**

Employment\*

Wages

**Social Drivers**

Education

Family

**Context at Origin**

**Environmental Drivers**

Hazard Exposure\*

Agricultural Productivity\*

Climate Amenities\*

**Economic Drivers**

Employment\*

Wages

**Social Drivers**

Education

Family

**Context at Destination**

**Decision about Migration**

**Stay and Adapt**

**Move**

 \*Causal factors that are particularly sensitive to climate change are indicated by a red asterisk. Source: Saperstein (2015)

For migration within the US, access to the capital required to move is also an important intervening factor. Without some money saved or available credit, individuals may not be able to move. Lack of funds may have also reduced migration during the Great Depression.23 With respect to climate change, credit may become even more important as climate change is estimated to affect the poor more heavily.

Much of the evidence of migration factors point to the dominance of economics in the decision to migrate,24 as other drivers, such as family ties to an area, are more difficult to quantify. Assessing the direct impact of climate change on migration similarly complicates migration theory. In the past, the placement of climate change within these factors has largely been restricted to environmental amenities or hazards. Recently a growing body of evidence suggests that climate change may feedback into migration through other causes.

Within the literature, there are three popular mechanisms through which climate change impacts migration. First, climate change impacts the temperatures that individuals experience and compels them to adapt. In some cases this leads to health complications, such as with the elderly or those whose work requires outdoor exposure, which require the individual to move. However, barring health issues, adapting to increased temperatures is more easily accomplished by increasing use of air conditioning.[[29]](#footnote-4)

Next, climate change exacerbates extreme weather events that force the individual from the area, either temporarily or permanently. While extreme weather can induce large scale migration, primarily seen in the aftermath of hurricanes, evidence suggests this migration is shorter in distance, temporary, and smaller in scale than migration from temperature alone. Using data from Indonesia, Bohra-Mishra et al. (2014) find that sudden disasters, such as flooding and earthquakes, have less of an influence on migration than temperature and precipitation.21

The third common connection between climate change and migration is the impact of temperature on economic conditions. As mentioned previously, increased temperatures can negatively impact productivity, and are related to lower growth in certain industries.8 As a more direct impact on output, temperature also influences the growth rate of crops. Lobell and Asner (2003) find that increases in temperature from 1982 to 1998 led to reductions in corn and soybean yields at a rate of 17% per 1°C increase.[[30]](#endnote-26)

Rather than focusing on each impact of climate change on migration, estimating the entire impact of climate change lends a view into what may come with increased temperatures. In a recent study, Fan et al. (2018) consider the impacts of climate change on migration between regions of the US.22 As opposed to prior studies, their models control for the changes in wage and housing prices as a result of in- and outmigration, as these pressures would counteract some of the destinations pull factors. This method results in estimates that are potentially more realistic to changing market conditions. The authors predict that between 2010 and 2065, Midwest and Southern states will lose 8.1% and 4.5% of their populations, respectively. As the regions with a proportionally lesser impact due to climate change, California (12.5%) and the Northeast (9.1%) grow in population. Meanwhile the West is predicted to grow considerably by 14.7%. Moreover, these estimates are strictly the result of changing temperatures and precipitation, and add to predicted overall population growth and movement between regions.

**Table 1: Regional Economic Impacts from Climate-Induced Migration in 2065 (%)**

Source: Table 5 in Fan et al. (2018)

Table 1 above displays the regionally aggregated results from climate change and increased climate migration. The added population translates to increases in gross regional product of 9-10% for the West, as income per capita falls by around 4.5%. This is perhaps a result of the disproportionate impact of climate change on lower income areas, leading to higher concentrations of lower income people in the destination areas. Net exports from the West is expected to increase by 8-12%.

As the overall impacts of climate change are predicted to focus migration toward the Northwest, other pressures, such as climate uncertainty, add to this trend. Rising temperatures are also driving residents of smaller Pacific Island nations toward larger population centers as their origin countries struggle.[[31]](#endnote-27) And Stern (2013) acknowledges the absence of studies on mass migration risk, and recommends adding it to existing climate change impact models.[[32]](#endnote-28)

### Climate Change and Agriculture

Beyond predictions of natural disasters, perhaps the greatest economic impact of climate change is its effect on agriculture. Larger scale production crops, such as corn and soybeans, are highly sensitive to changes in temperature. According to Schlenker & Roberts (2009),[[33]](#endnote-29) each of these crops has a breakpoint at which their growth is optimized: 29°C for corn, and 30°C for soybeans. Up to these temperatures, production of the crop increases. One result of this is the potential for certain areas of the country to see increases in agricultural yields, as seen in the results of Hsiang et al. (2017) displayed in Figure 1.

Any warming above the breakpoint for each crop has dire consequences for crop yield. While a degree increase up to the breakpoint results in an increase in yield, a further increase in temperature reduces yield by 10 times this effect.29 This indicates a steep decline in productivity for increases in certain warming situations. While it is still unclear where the Northwest lies relative to its crop yield breakpoint, smaller temperature changes, like the 0.5°C increase predicted sometime before 2052,1 are expected to increase Northwest crop yield.

Rasmussen et al. (2015) lay out a possibility that could be particularly damaging to agriculture in the US.[[34]](#endnote-30) They estimate that there is a 5% chance that temperatures in the lower 48 states could increase by around 8°C/14°F from 2010 levels by the end of the century. With this level of warming, the average American could experience maximum daily temperatures at or above 30°C (86°F) for four months out of the year. Combined with the breakpoint relationship between crops and temperature, this would lead to a devastating reduction in agricultural yield for much of the US.

Rising temperatures and changing precipitation are likely to impact agriculture in the Midwest more than other regions.9 Feng et al. (2012) estimate an elasticity of populations within the US Corn Belt to crop yields of 0.17, i.e. all else constant, a 1% decrease in crop yields is correlated with a 0.17% decrease in the local population. When broken down by age group, those age 15-29 are more likely to move from reductions in crop output, with an elasticity of 0.28. Those over the age of 45 are not significantly likely to move in response to crop yields, potentially due to social connections to the area, property ownership, or less mobility. However, these elasticities are potentially underestimates for longer-term declines in crop yield. Crop insurance programs may relieve some of the economic pressures to migrate of single-year declines in crop yield. Additionally, when temperature and precipitation impacts are separated, the impacts of variation in precipitation are relatively small compared to those of temperature.

Where agriculture is more concentrated, weather-induced changes in crop yield also impact the employment of non-farm workers, and the impact is greater than its effect on farm employment.232 This result suggests that agricultural output acts as the bedrock of local productivity, to a certain extent. Years of increased agricultural output coincide with increased non-farm activity, and similar for decreases in output. However, the effects of decreased yield do not extend to non-agricultural areas, as temperature-driven changes in crop yield have no significant impact in areas where agriculture is a small percentage of the economy. This suggests that the predicted change in migration is due to changes in economic opportunity resulting from agriculture rather than preferred climate.

By 2050, Feng et al. (2012) estimate reduced crop production from higher temperatures will lead to 3.7% of the adult population in rural counties to move out of the Corn Belt. This share of rural adult populations leaving the Corn Belt is expected to increase to 11% by the end of the century.

In addition to within-US migration, any impact on agricultural production outside the US may also increase migration. Feng et al. (2010) look at changes in output due to heat and drought conditions in Mexico from 1995 to 2005, a period of increased emigration.[[35]](#endnote-31) The authors’ find an elasticity of migration to crop yields of -0.2, similar to that found by Feng et al. (2012), suggesting that 1% of the populations of Mexican states would migrate to the US with a 5% reduction in crop yields. Their modeling also predicts a 26% decrease in crop yields in Mexico by 2080. A shift of this magnitude would result in 3.6 million people migrating to the US.

With further warming, international migration is also expected to increase, a concern for both sending and receiving countries. Cai et al. (2016) report on international migration patterns related to climate change, with particular attention paid to the countries’ concentration of agriculture.[[36]](#endnote-32) Across the globe, warming is expected to more greatly impact countries where agriculture accounts for a higher share of the economy. Each 1°C of increase results in a 5% increase in outmigration from agricultural countries, while outmigration from non-agricultural countries is not affected. This suggests that these countries, largely in the tropics, are already on the negative end of their breakpoints.

### Northwest State Estimates

The premise of migration due to temperature-induced changes in agricultural output is thoroughly supported by the literature. Temperature impacts the growth of plants, which in turn affects the incomes of both farmers and the local economies that support them. While states in the South and Midwest are expected to be disproportionately harmed by warming, the Northwest and Northeast are likely to benefit, with large agricultural benefits predicted for the Northwest. Residents of areas that are negatively impacted will likely move northward for a more amenable climate and better economic conditions.

The Northwest region’s cooler climate is one of the reasons its agricultural productivity is expected to increase with climate change. With increases in crop yields in the Northwest of 12% for each 1°C of warming,9 the Northwest could be an attractive destination for Corn Belt migrants, where a predicted 0.17% of rural agricultural area populations will move per 1% decrease in crop yield.23 This is further supported by the migration patterns of Dust Bowl populations to areas where their skills are in demand.

Given the evidence of a driver of climate migration and that migration is predicted on top of population forecasts, estimates of Northwest state populations should be updated to incorporate the impacts of climate change. While thorough, the estimates from Fan et al. (2018) of total migration, including the influence of agricultural impacts and climate preference, do not differentiate which states within the West will see larger changes in migration. Next, we will use these values to extrapolate the resulting population increases in the Northwest states.

First, we use the Northwest state population forecasts from Global Insight, the source regularly used by NWPCC. The annual Global Insight forecasts allow us to compare additional migration to their predicted annual migration, which does not explicitly account for climate factors. Since the migration changes of Fan et al. (2018) are predicted for the population in 2065, we adjust these down assuming constant rate exponential growth.

After adjusting the South and Midwest region migration rates to the predicted migration from 2017 to 2050, we utilize reported migration patterns from the 2017 American Community Survey (ACS) to observe what shares of migrants are moving to which states. Because the migrants are moving from their regions of origin entirely, we restrict migration to the states that are expected to gain in population. This assumes that preference for destination is constant over the forecast period, which is unlikely, though it is the best information we currently possess. Migration patterns to the Northwest may increase due to higher agricultural output and the dominance of agriculture in the origin regions, but also may decrease due to changing water and wildfire conditions.

The predicted change in migration, when combined with forecast populations, provide estimates of how many migrants from each state will move to or from each of the four Northwest states. The sum of these returns the predicted additional migration to the Northwest in Table 2. By 2050, an additional 1.3 million people will migrate to the Northwest beyond the forecast estimates provided by Global Insight. This constitutes an additional 7.4 percentage points of growth above current 2050 population estimates.

**Table 2: Additional Population Growth Estimates to 2050**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Impact in 2050 | Washington | Oregon | Idaho | Montana | Region |
| Population in 2017 | 7,437,915 | 4,151,415 | 1,723,275 | 1,054,054 | 14,366,659 |
| Forecast Population in 2050 (from Global Insight) | 9,394,824 | 4,994,743 | 2,405,147 | 1,164,422 | 17,959,136 |
| Additional Migration | 864,981 | 338,895 | 157,957 | -35,478 | 1,326,355 |
| Total 2050 Population | 10,259,805 | 5,333,638 | 2,563,104 | 1,128,945 | 19,285,491 |
|  Additional Growth | 9.21% | 6.79% | 6.57% | -3.05% | 7.39% |
| Total Growth from 2017 to 2050 | 37.9% | 28.5% | 48.7% | 7.1% | 34.2% |

As the state receives the brunt of migrants to the Northwest under current ACS migration patterns, Washington is predicted to see the majority of the future climate migrants, with an additional 860,000 people. Due to Montana’s categorization as a Midwest state within the Fan et al. (2018) study, Montana is predicted to experience reduced migration due to climate change. However, the population of Montana is still predicted to increase by 7.1% between 2017 and 2050.

**Table 3: Annual Additional Growth Compared to Historical and Forecast**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|   | Washington | Oregon | Idaho | Montana | Region |
| Annual Historical Net Migration (1981-2017) | 1.03% | 0.88% | 0.93% | 0.37% | 0.91% |
| Annual Forecast Net Migration (2018-2050) | 0.59% | 0.70% | 0.66% | 0.22% | 0.61% |
| Annualized Additional Growth | 0.33% | 0.24% | 0.27% | -0.10% | 0.27% |
| Total Annual Net Migration from 2017 to 2050 | 0.92% | 0.94% | 0.93% | 0.12% | 0.88% |

Table 3 compares the predicted additional migration to historic and forecast migration for the region. The predicted climate migration adds between 0.24 and 0.33 percentage points to migration to Washington, Oregon, and Idaho annually. Migration to Montana is reduced by 0.10 percentage points per year, though still leading to positive net migration of 0.12% per year.

For the rest of the region, climate change’s addition to the forecast still results in annual migration near levels seen between 1981 and 2017. This is because the population forecasts provided by Global Insight predict reductions in annual net migration of between one-third and one-half relative to historic levels. For example, between 1981 and 2017, net migration to the Northwest occurred at the annualized rate of 0.91% per year, and forecasts to 2050 predict a reduction of this rate to 0.61% per year. Though the additional migration proposed by the climate migration literature requires a complex chain of impacts, the resulting effect on overall migration is reasonable: adding climate change’s impact on migration to the current NWPCC population forecast results in annualized migration of 0.88% per year, a reduction from historic migration levels.

**Table 4: Total Climate Migration across time (cumulative)**

|  |  |  |  |
| --- | --- | --- | --- |
|  | 2030 | 2040 | 2050 |
| Washington | 329,437 | 592,746 | 864,981 |
| Oregon | 130,339 | 233,377 | 338,895 |
| Idaho | 60,577 | 108,620 | 157,957 |
| Montana | -14,121 | -24,855 | -35,478 |
| Region | 506,232 | 909,888 | 1,326,355 |

Table 4 displays the increase in population change due to climate migration at points in time. Despite the assumed exponential relationship of the change in migration, the annual growth rates are so low (-0.10% to 0.33%) as to almost seem linear, with annual migration to the region only increasing by around 1,000 people per year. By 2030, approximately 500,000 people are expected to migrate to the Northwest. Total migration increases to 910,000 by 2040, and 1.3 million by 2050.

## Precipitation, Drought, and Fire

The benefits to the Northwest are partially derived from predicted changes in temperature relative to the Northwest’s current climate. The region’s agriculture could see improved crop yields from relationships such as the breakpoint impacts of temperature presented by Schlenker and Roberts (2009).29 However, the work of Backus et al. (2012) suggests caution in the certainty of the predicted impacts for the Northwest.10 Much of their results are driven by expected increases in precipitation within the global climate models used in the study. Certain predictions for precipitation under climate change may not be so amenable to growth in agriculture.

Rupp et al. (2013) estimates that between 1901 and 1999 there was not a statistically significant increase in regional precipitation, and the change is negative if the range is restricted to after 1940.2 They report a trend of increased precipitation of only 0.5% per century. Rupp et al. (2017) highlights the uncertainty in changes to precipitation with regard to climate modeling.[[37]](#endnote-33) Under moderate emissions, the models tested indicate an inner 90 percentile range of precipitation projections for 2040-2069 that includes zero for all seasons, though the number of simulations that predict decreases in annual precipitation are a minority. Over this period, the models return a mean increase in precipitation of 3%, with mean increases in precipitation during winter and spring months of 5% and 6%, respectively. The model mean for summer months show a 5% decrease in precipitation.

Though variation in precipitation has a less of an impact than temperature,23 future availability of water in the Midwest is also uncertain, and shortages will likely increase yield-induced climate migration. Precipitation is expected to increase in northern areas of the Midwest and decrease southward. Due to recent reductions in rainfall, much of the agriculture in Nebraska and further south depend on water drawn from the Ogallala Aquifer. Water from the aquifer is being pumped faster than it is being refreshed,17 meaning wells need to be dug deeper, which also requires more energy to pump out, and threatens a resource that was previously considered renewable.

Along with the expected trend of higher winter and lower summer precipitation, changes in snowmelt pose problems for the region. As temperatures increase, less snow is expected to fall, leading to declining snowpack and shrinking glaciers. As of 2015, snowpack has decreased at the vast majority of EPA glacier monitoring sites across the Columbia River Basin, with many seeing a decrease of greater than 60% relative to 1955 levels.[[38]](#endnote-34) Collection of snow in the region’s mountains is vital for streamflow, and could have consequences for forest habitat and irrigation. Furthermore, higher temperatures mean greater evaporation, leaving less water to flow down streams and rivers. For the models predicting benefits to the Northwest in Hsiang et al. (2017), factors such as the timing of the precipitation and the effects on snowmelt were not direct factors in the model and will likely have a significant impact in the region, particularly for agriculture and hydropower.9

The emergence of “atmospheric rivers” will also play a part in the Northwest’s precipitation. Atmospheric rivers are concentrated channels of condensation in the atmosphere that have led to extreme flooding in some situations, and relief from drought in others. In the Northwest, extreme precipitation events increased by 22% between 1901 and 2016, of which 9 percentage points occurred since 1958.[[39]](#endnote-35) While projections suggest further increases of 10-30% under moderate emissions, high emissions going forward may lead to increases in extreme precipitation of 40% across the region. Extreme precipitation is projected to increase more in the Midwest and Northeast regions, both of which have seen increases of at least 42% since 1958. As a result, communities are failing to keep up with damages to housing.[[40]](#endnote-36)

Rising temperatures and changing precipitation patterns are intensifying droughts, putting water access at risk in many regions of the country. In 2017, severe drought caused $2.5 billion in damage to field crops in the northern Great Plains.3 Abatzoglou & Rupp (2017) find that climate modeling in the Northwest has difficulty estimating the variability and magnitude of precipitation related to droughts, particularly droughts that last multiple years.[[41]](#endnote-37) The unpredictability of precipitation and drought are expected to disrupt agricultural productivity across the United States.3 Furthermore, increased variance in temperature will likely lead to more frequent, less predictable extreme temperature events, such as the recent heatwave in Europe.[[42]](#endnote-38)

Changes in temperature and precipitation are also affecting wildfire in the West, and are impacting farmers, recreation, air quality, and health in the region.3 Even areas previously considered too wet to burn are seeing increases in wildfires. As of late June in 2019, the number of wildfires in the western regions of Washington and Oregon have more than doubled compared to the previous decade.[[43]](#endnote-39) In some cases, electric companies are choosing to turn off power due to extreme fire risk.[[44]](#endnote-40) These additional risks are likely to detract from the future appeal of the West and Northwest.

In response to climate change, some organizations are recommending larger adaptation measures, such as federal land buyouts.36 These programs would greatly help those with financial or economic mobility restrictions leave risk-prone areas, and may also increase the occurrence of climate migration.

## Conclusions, Complications, and Future Research

As we have seen, several studies show that climate change will affect the population and economy of the Northwest, not only from changes in the region’s temperature and precipitation, but also from the impacts of climate change on the rest of the country. Overwhelmingly, the potential impacts from climate change suggest caution in planning for the future. The Northwest will be harmed considerably less than other regions, and may benefit from certain aspects of a warming climate. This will likely make the Northwest an attractive destination for those fleeing climate impacts in less well-off regions, such as the South and Midwest. However, further review of the impacts of climate change on regional outlook, such as precipitation and fire-risk, is required to fill the holes in the research presented here. Research on adapting regional agricultural practices is also needed, as mitigating climate change will likely require a changes in agricultural land use.1

Many of the studies reviewed in this paper are grounded in the uncertainty of climate projections. Their estimates are largely predictions for the counterfactual worlds of their many climate models. While the authors take pains to incorporate the all potential climate change factors, no one model is perfect. The results they report are an observation of past behavior, and future adaptation to warming may evolve or not conform to observed patterns. In Hsiang et al’s (2017) prediction of impacts by the end of the century, the uncertainty of outcomes contributed to between 40% and 100% of the variance in impact.9 Essentially, the assumptions of each model drive the predicted impacts. While this suggests some predictions may be overstated, still others may be understated or not at all considered in the literature. As it stands, the impacts discussed in this paper are the best estimates currently available from analyzing a range of warming situations.

In the final section of the report, we propose a new method of incorporating impact from change in regional population on the economy of the region.

# A REVISED APPROACH TO CALCULATE SECONDAY IMPACT OF CLIMATE CHANGE

In our past approach, we had used a survey instrument to measure impact of increase in population on the economy of northwest. We had started with estimation of additional population that could come to the Northwest over the next three decades. Using existing literature, we had estimated that by 2050 population in the Northwest is expected to increase by roughly 10% due to in-migration to the region.

The question at hand is; what are impacts of this increase in population. How much more commercial floorspace would be needed? How would the industries in the region react to this increase in population? Would industrial output in the region increase or decrease and by how much. ‘

we have been working on developing an alternative method for measuring secondary impacts. In the second approach, documented here, we are using concept of elasticity, relating percent change in population and percent change in the sector level output.

An example: What is elasticity of agricultural output and population? If population change by 1 percent, how much agricultural output changes. Ratio of percent change in one variable to percent change in the other variable measures the elasticity of response between the two variables.

Beginning with the model:

$$Log\left(agricultural output\right)=Log\left(population\right) + constant + error term$$

The term on the right-hand side is the percent change in *population*, and the term on the left-hand side is the percent change in *Agricultural output* , so coefficient of population measures the elasticity of response in agricultural output when population change. Suppose we obtain the estimates

$$Log (Agricultural output) =2.1+0.45\*log(population)$$

Coefficient 0.45 means that for every 1% change in population, agricultural output increases by 0.45%.

To calculate elasticity of response to change in population and a given variable, we need data on both series. Typically, historic values for both variables are used to estimate the elasticities.

In our case we are using both historic and future values for population and either industrial outputs or commercial floorspace requirements. The reason we are using future values is to recognize that industrial output in the region may be changing and we want to capture these structural changes. This is in lieu of using an integrated macro-economic model. We are using the state level forecast of outputs from manufacturing sectors from Global Insight and relating it to forecasted population.

The mechanics of estimating the elasticities is straight forward. Take historic and forecast of industrial output (adjusted for inflation) and relate it to historic and forecast of population. We do this at state and industry level. In our case history starts in 1985 and goes to 2050. We tested for non-stationary nature of the two variables, but given our application is not a traditional forecast, we felt that for practical reasons creating a stationary set of variables in not needed. We did correct for any autocorrelation in the structure of the models. We estimated correlation values between the dependent variable and population using 188 separate state level equations.

*What data are we using?*

1. For explanatory variable, we use population at state level, both actual and forecasted (without additional immigration discussed earlier)
2. For residential sector we are using total stock of housing from 1985-2050
3. For Commercial sector we are using square footage stock, by building type.
4. For Industrial, agriculture and Data Centers we are using historic and forecasted output in constant dollars.

*How we would use the estimated elasticities?*

For a given sector, to capture impact of change in population on that sector, we take the increase in population and multiply it with that sector’s elasticity. So, if for a given industry, in our example, Agriculture, we estimated an elasticity of 0.45, then if for a given year in the future population increases by 2%, then agricultural output is estimated to increase by 2\*0.45=0.9%.

*What are the estimated elasticities?*

In the following tables we show the resulting elasticities for all sectors for the four states. Now you would see some odd values. in some cases, an elasticity in one state is higher or lower than the other states. There are many reasons for this to happen. Here are three reasons.

Three caveats are in order.

1. Elasticity is not causality. Elasticity is an estimation of structural correlation between two variables, in our case population and the variable in question.
2. Variations in mix of industries, and commercial entities vary across the states, so for example, Food industry in Idaho is made up of different food sub-industries than Food industry in Washington. So, although we are measuring elasticity for food industry, variations at the sub-sectors level will result in variations in elasticities.
3. Data quality varies. For some sectors they are good/ the best we have. But are we 100% sure about the accuracy of the data. No. For example, commercial sector floorspace estimates are based on finding from survey’s that are best at regional level, so state estimates square footage for different building types have more uncertainty. So, with all the caveats, what are the calculated elasticities? Following table shows calculated regional elasticity for industrial sectors.

***State Level elasticities***

Table below shows the elasticities for residential sector by residence type, commercial/by building type and industrial by industrial sectors. Every one percent change in population will result in change in the economic driver. For example, 1 percent change in population is expected to cause 0.78 percent change in large office building square footage in state of Oregon.

**Table 5: Percent change related to one percent change in Population**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  Sector | Oregon | Washington | Idaho | Montana |
| Residences | 0.84 | 0.91 | 0.85 | 1.0 |
| Single Family | 1.05 | 0.85 | 1.16 | 1.02 |
| Multi Family | 0.63 | 0.68 | 0.58 | 0.61 |
| Other Family | 0.90 | 1.16 | 0.85 | 1.11 |
| Commercial sectors combined | 0.56 | 0.91 | 0.62 | 0.68 |
| Large Office | 0.78 | 0.45 | 0.75 | 0.55 |
| Medium Office | 0.70 | 0.36 | 0.51 | 0.35 |
| Small Office | 1.01 | 0.50 | 0.83 | 0.53 |
| Big Box-Retail | 0.99 | 0.48 | 0.35 | 1.23 |
| Small Box-Retail | 1.86 | 0.61 | 0.40 | 3.56 |
| High End-Retail | 0.54 | 0.33 | 0.24 | 0.51 |
| Anchor-Retail | 1.90 | 0.54 | 0.36 | 1.42 |
| K-12 | 1.55 | 2.28 | 0.54 | 0.39 |
| University | 2.50 | 0.78 | 0.71 | 0.42 |
| Warehouse | 0.44 | 0.75 | 0.65 | 0.83 |
| Supermarket | 1.65 | 0.69 | 0.92 | 0.70 |
| Mini Mart | 1.23 | 1.64 | 0.89 | 0.39 |
| Restaurant | 1.15 | 0.49 | 0.42 | 1.96 |
| Lodging | 0.64 | 0.93 | 0.64 | 2.93 |
| Hospital | 0.57 | 0.39 | 0.27 | 0.42 |
| Other Health | 0.67 | 0.48 | 0.66 | 0.38 |
| Assembly | 0.62 | 0.60 | 0.35 | 0.32 |
| Other | 0.69 | 0.60 | 0.60 | 0.37 |
| Food & Tobacco | 0.29 | 0.39 | 0.50 | 0.20 |
| Textiles | 1.25 | 0.37 | 0.29 | 0.16 |
| Apparel | 0.44 | (0.35) | (0.37) | (0.16) |
| Lumber | (0.24) | (1.66) | (0.46) | (1.01) |
| Furniture | 0.23 | 0.32 | 0.36 | 0.28 |
| Paper \* | (14.37) | (12.63) | 0.62 | (0.10) |
| Printing | 2.99 | (1.15) | 0.83 | 0.30 |
| Chemicals | 0.21 | 0.34 | 0.62 | 0.13 |
| Petroleum Products | 0.37 | 0.39 | 0.29 | 0.16 |
| Rubber | 0.26 | 0.30 | 0.52 | 0.14 |
| Leather | (1.32) | (2.23) | (1.43) | (0.27) |
| Stone, Clay, etc. | 0.32 | 0.36 | 0.60 | 0.23 |
| Other Primary Metals | 0.33 | 0.43 | 0.16 | (0.31) |
| Fabricated Metals | 0.32 | 0.38 | 0.38 | 0.19 |
| Machines & Computer | 0.16 | 0.31 | 0.44 | 0.18 |
| Electric Equipment | 0.23 | 0.61 | 0.28 | 0.21 |
| Transport Equipment | 0.30 | 0.28 | 0.29 | 0.18 |
| Other Manufacturing | 0.23 | 0.26 | 0.32 | 0.15 |
| Data Center | 0.48 | 0.14 | 0.31 | 0.20 |
| Agriculture | 0.40 | 0.45 | 0.64 | 0.23 |

\*Some of the industries, such as Paper, show a wide range of elasticities across the states that cannot be explained with this simple approach. We will be eliminating Oregon and Washington paper industry from our analysis of secondary impacts of climate change.

We also need to consider change in modes of transportation. Passenger vehicles including light duty trucks are driven by population, so it has an elasticity of 1. For the other modes of transport, output of the relevant industries is correlated with population. The result of the analysis is shown below.

**Table 6: Percent change related to one percent change in Population for Transportation**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  Sector | Oregon | Washington | Idaho | Montana |
| AIR FREIGHT | 0.31 | 0.35 | 0.37 | 0.41 |
| AIR PASSENGER | 0.45 | 0.38 | 0.39 | 0.40 |
| FREIGHT | 0.55 | 0.37 | 0.47 | 0.44 |

**Load Impacts - Draft**

We have applied the elasticities and forecast of additional population to estimate economic drivers for each sector in each state. In the following section you will find graphic presentation of the temperature impact of climate change scenarios on average loads as well as load impact of secondary effects of climate change. Overall load impacts are modest and well within range of uncertainty. By 2050, regional average load is expected to increase by about 2000 aMW.



Supporting file location

Q:\MJ\Demand Forecasting Model\Economic Forecasts\Economic drivers for the model-8th plan forecast \_DEC 2019.xlsx

## Appendix

**Estimated Regional Industry Impacts from Fan et al. (2018)**





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### Estimating relationship between population growth and economic activities

Commercial, Residential, transportation and industrial sectors. All equations have significant explanatory power.

LOG(OREGON\_ASSEMBLY) = 3.10609226702683\*LOG(OREGON\_POPULATION) - 21.2851540140253 + [AR(1) = 0.986911895731928,UNCOND,ESTSMPL = "1985 2050"]

LOG(OREGON\_BIGBOXRETAIL) = 0.813910325254038\*LOG(OREGON\_POPULATION) - 3.16643877088982 + [AR(1) = 1.73049497981064,AR(2) = -0.745763309259586,UNCOND,ESTSMPL = "1987 2050"]

LOG(OREGON\_HIGHENDRETAIL) = 1.96126863171043\*LOG(OREGON\_POPULATION) - 13.0507110441879 + [AR(1) = 1.82842695648968,AR(2) = -0.851958122874529,UNCOND,ESTSMPL = "1985 2050"]

LOG(OREGON\_HOSPITAL) = 2.39910669729135\*LOG(OREGON\_POPULATION) - 16.773919889284 + [AR(1) = 0.967913253443062,UNCOND,ESTSMPL = "1985 2050"]

LOG(OREGON\_K12) = 2.58589543122928\*LOG(OREGON\_POPULATION) - 17.4417317827664 + [AR(1) = 0.992702729016927,UNCOND,ESTSMPL = "1985 2050"]

LOG(OREGON\_LARGEOFFICE) = 1.83082396283013\*LOG(OREGON\_POPULATION) - 10.7687927958174 + [AR(1) = 1.74540502772878,AR(2) = -0.768546928226655,UNCOND,ESTSMPL = "1985 2050"]

LOG(OREGON\_LODGING) = 0.341431019198936\*LOG(OREGON\_POPULATION) + 0.938361973130198 + [AR(1) = 0.990640043182336,UNCOND,ESTSMPL = "1985 2050"]

LOG(OREGON\_MEDIUMOFFICE) = 2.87951538671797\*LOG(OREGON\_POPULATION) - 20.2195454083127 + [AR(1) = 0.954323610537708,UNCOND,ESTSMPL = "1985 2050"]

LOG(OREGON\_MINIMART) = 2.55156257823438\*LOG(OREGON\_POPULATION) - 19.6313496185997 + [AR(1) = 0.954503769727419,UNCOND,ESTSMPL = "1985 2050"]

LOG(OREGON\_MULTIFAMILY) = 1.64398204740051\*LOG(OREGON\_POPULATION) - 7.80246677915276 + [AR(1) = 0.939675406157496,UNCOND,ESTSMPL = "1985 2050"]

LOG(OREGON\_OTHER) = 2.69564269307513\*LOG(OREGON\_POPULATION) - 17.4492307959983 + [AR(1) = 0.974697288240636,UNCOND,ESTSMPL = "1985 2050"]

LOG(OREGON\_OTHERFAMILY) = 0.901745026603568\*LOG(OREGON\_POPULATION) - 2.24308615414742 + [AR(1) = 1.97322228621333,AR(2) = -0.981259853862226,UNCOND,ESTSMPL = "1985 2050"]

LOG(OREGON\_OTHERHEALTH) = 2.62478301526001\*LOG(OREGON\_POPULATION) - 18.0157850366482 + [AR(1) = 1.57870129394837,AR(2) = -0.640573740059733,UNCOND,ESTSMPL = "1985 2050"]

LOG(OREGON\_RESTAURANT) = 0.510656151452718\*LOG(OREGON\_POPULATION) - 1.44901342812629 + [AR(1) = 0.996764844724473,UNCOND,ESTSMPL = "1985 2050"]

LOG(OREGON\_SINGLEFAMILY) = 0.979402082143707\*LOG(OREGON\_POPULATION) - 0.932310545014415 + [AR(1) = 0.995951017207067,UNCOND,ESTSMPL = "1985 2050"]

LOG(OREGON\_SMALLBOXRETAIL) = 0.280570610813381\*LOG(OREGON\_POPULATION) + 1.6735505916841 + [AR(1) = 1.55707495637215,AR(2) = -0.603614587284138,UNCOND,ESTSMPL = "1987 2050"]

LOG(OREGON\_SMALLOFFICE) = 1.87976626617305\*LOG(OREGON\_POPULATION) - 11.9746084490017 + [AR(1) = 0.990919948910244,UNCOND,ESTSMPL = "1985 2050"]

LOG(OREGON\_SUPERMARKET) = 1.43353329945877\*LOG(OREGON\_POPULATION) - 9.31978413517324 + [AR(1) = 0.98079169300675,UNCOND,ESTSMPL = "1988 2050"]

LOG(OREGON\_UNIVERSITY) = 2.40229366133209\*LOG(OREGON\_POPULATION) - 16.6744157907069 + [AR(1) = 0.99285886015546,UNCOND,ESTSMPL = "1985 2050"]

LOG(OREGON\_WAREHOUSE) = 1.21021261208639\*LOG(OREGON\_POPULATION) - 5.1781537984899 + [AR(1) = 0.958190095374561,UNCOND,ESTSMPL = "1985 2050"]

LOG(WASHINGTON\_ANCHORRETAIL) = 0.701826944428055\*LOG(WA\_POPULATION) - 2.08771938147055 + [AR(1) = 0.987172424831095,UNCOND,ESTSMPL = "1987 2050"]

LOG(WASHINGTON\_ASSEMBLY) = 1.61595567120063\*LOG(WA\_POPULATION) - 9.05487072037656 + [AR(1) = 0.982156248648819,UNCOND,ESTSMPL = "1985 2050"]

LOG(WASHINGTON\_BIGBOXRETAIL) = 1.01496950183802\*LOG(WA\_POPULATION) - 4.54696142900432 + [AR(1) = 0.995701523241986,UNCOND,ESTSMPL = "1987 2050"]

LOG(WASHINGTON\_HIGHENDRETAIL) = 1.85543166914869\*LOG(WA\_POPULATION) - 12.4719157612658 + [AR(1) = 1.72672218310733,AR(2) = -0.740131556578485,UNCOND,ESTSMPL = "1987 2050"]

LOG(WASHINGTON\_HOSPITAL) = 1.75695405318605\*LOG(WA\_POPULATION) - 11.4161161656808 + [AR(1) = 0.99505177338922,UNCOND,ESTSMPL = "1985 2050"]

LOG(WASHINGTON\_K12) = 0.645872065280008\*LOG(WA\_POPULATION) - 0.776096001418265 + [AR(1) = 0.978412489927564,UNCOND,ESTSMPL = "1985 2050"]

LOG(WASHINGTON\_LARGEOFFICE) = 1.27951367218233\*LOG(WA\_POPULATION) - 5.85266017649689 + [AR(1) = 0.992616230255019,UNCOND,ESTSMPL = "1987 2050"]

LOG(WASHINGTON\_LODGING) = 1.55212291265766\*LOG(WA\_POPULATION) - 9.17750751592317 + [AR(1) = 0.989033100992438,UNCOND,ESTSMPL = "1985 2050"]

LOG(WASHINGTON\_MEDIUMOFFICE) = 1.42651195601448\*LOG(WA\_POPULATION) - 7.85915814789633 + [AR(1) = 0.995453031618089,UNCOND,ESTSMPL = "1987 2050"]

LOG(WASHINGTON\_MINIMART) = 0.810632756001033\*LOG(WA\_POPULATION) - 4.54261737585072 + [AR(1) = 0.986715775925739,UNCOND,ESTSMPL = "1987 2050"]

LOG(WASHINGTON\_MULTIFAMILY) = 1.5986913144172\*LOG(WA\_POPULATION) - 7.63122399399535 + [AR(1) = 1.86221209544182,AR(2) = -0.915921864850178,UNCOND,ESTSMPL = "1985 2050"]

LOG(WASHINGTON\_OTHER) = 1.45387166981205\*LOG(WA\_POPULATION) - 8.07780792385248 + [AR(1) = 0.882346011374235,UNCOND,ESTSMPL = "2016 2050"]

LOG(WASHINGTON\_OTHERFAMILY) = 1.11302467301267\*LOG(WA\_POPULATION) - 4.46299645586472 + [AR(1) = 0.991185449221298,UNCOND,ESTSMPL = "1985 2050"]

LOG(WASHINGTON\_OTHERHEALTH) = 1.49755330045652\*LOG(WA\_POPULATION) - 8.97982298285069 + [AR(1) = 0.988950601756458,UNCOND,ESTSMPL = "2005 2050"]

LOG(WASHINGTON\_RESTAURANT) = 0.869736767866486\*LOG(WA\_POPULATION) - 4.30239065599249 + [AR(1) = 0.995413960644687,UNCOND,ESTSMPL = "1985 2050"]

LOG(WASHINGTON\_SINGLEFAMILY) = 0.950643033443825\*LOG(WA\_POPULATION) - 0.747706212412484 + [AR(1) = 0.991815587476077,UNCOND,ESTSMPL = "1985 2050"]

LOG(WASHINGTON\_SMALLBOXRETAIL) = 0.536866241121697\*LOG(WA\_POPULATION) + 0.0150619738423325 + [AR(1) = 0.971716183459204,UNCOND,ESTSMPL = "1987 2050"]

LOG(WASHINGTON\_SMALLOFFICE) = 0.990685781202295\*LOG(WA\_POPULATION) - 4.13361131594176 + [AR(1) = 0.98212611531766,UNCOND,ESTSMPL = "1985 2050"]

LOG(WASHINGTON\_SUPERMARKET) = 0.604399170469908\*LOG(WA\_POPULATION) - 1.92735729234518 + [AR(1) = 0.96126472780172,UNCOND,ESTSMPL = "1987 2050"]

LOG(WASHINGTON\_UNIVERSITY) = 0.399718798071059\*LOG(WA\_POPULATION) + 0.613672682344447 + [AR(1) = 0.971801513150042,UNCOND,ESTSMPL = "1985 2050"]

LOG(WASHINGTON\_WAREHOUSE) = 2.25015175382733\*LOG(WA\_POPULATION) - 14.7012150263091 + [AR(1) = 0.99241564852055,UNCOND,ESTSMPL = "1985 2050"]

LOG(IDAHO\_ANCHORRETAIL) = 1.84636514477095\*LOG(ID\_POPULATION) - 11.6283214674585 + [AR(1) = 0.990117131441237,UNCOND,ESTSMPL = "1987 2050"]

LOG(IDAHO\_ASSEMBLY) = 1.65737981854534\*LOG(ID\_POPULATION) - 9.09796399925488 + [AR(1) = 0.970425111878693,UNCOND,ESTSMPL = "1985 2050"]

LOG(IDAHO\_BIGBOXRETAIL) = 2.0944925385737\*LOG(ID\_POPULATION) - 13.202596882428 + [AR(1) = 0.987790786777143,UNCOND,ESTSMPL = "1987 2050"]

LOG(IDAHO\_HIGHENDRETAIL) = 3.00464142112818\*LOG(ID\_POPULATION) - 20.2476036322648 + [AR(1) = 0.976969379170139,UNCOND,ESTSMPL = "1985 2050"]

LOG(IDAHO\_HOSPITAL) = 2.57926049496825\*LOG(ID\_POPULATION) - 16.3524531297195 + [AR(1) = 0.986124022377913,UNCOND,ESTSMPL = "1985 2050"]

LOG(IDAHO\_K12) = 0.43930573481193\*LOG(ID\_POPULATION) - 0.515093162568405 + [AR(1) = 0.977697054020784,UNCOND,ESTSMPL = "1985 2050"]

LOG(IDAHO\_LARGEOFFICE) = 2.20525682534712\*LOG(ID\_POPULATION) - 13.4869700422599 + [AR(1) = 0.991282530608072,UNCOND,ESTSMPL = "1985 2050"]

LOG(IDAHO\_LODGING) = 1.07041110255062\*LOG(ID\_POPULATION) - 5.55764001458459 + [AR(1) = 0.778910122454839,UNCOND,ESTSMPL = "2005 2050"]

LOG(IDAHO\_MINIMART) = 0.609723195196352\*LOG(ID\_POPULATION) - 4.42266885296019 + [AR(1) = 0.946074038934292,UNCOND,ESTSMPL = "2012 2050"]

LOG(IDAHO\_MULTIFAMILY) = 1.46280621905492\*LOG(ID\_POPULATION) - 6.50061415370022 + [AR(1) = 0.963256774878142,UNCOND,ESTSMPL = "1985 2050"]

LOG(IDAHO\_OTHER) = 1.66011927552209\*LOG(ID\_POPULATION) - 8.39907013424884 + [AR(1) = 0.99305316244038,UNCOND,ESTSMPL = "1985 2050"]

LOG(IDAHO\_OTHERFAMILY) = 0.861221906644455\*LOG(ID\_POPULATION) - 2.06664323956496 + [AR(1) = 0.990126639687501,UNCOND,ESTSMPL = "1985 2050"]

LOG(IDAHO\_OTHERHEALTH) = 2.06860409696237\*LOG(ID\_POPULATION) - 13.3476495392827 + [AR(1) = 0.873388038311687,UNCOND,ESTSMPL = "2012 2050"]

LOG(IDAHO\_RESTAURANT) = 2.0212982052796\*LOG(ID\_POPULATION) - 14.1282923692079 + [AR(1) = 0.987754745495514,UNCOND,ESTSMPL = "1985 2050"]

LOG(IDAHO\_SINGLEFAMILY) = 1.16968735465333\*LOG(ID\_POPULATION) - 2.31826222479189 + [AR(1) = 0.992153199039252,UNCOND,ESTSMPL = "1985 2050"]

LOG(IDAHO\_SMALLBOXRETAIL) = 1.63435024459638\*LOG(ID\_POPULATION) - 9.47978133211754 + [AR(1) = 0.991804261691812,UNCOND,ESTSMPL = "1985 2050"]

LOG(IDAHO\_SMALLOFFICE) = 2.00896458841291\*LOG(ID\_POPULATION) - 12.7573341240974 + [AR(1) = 0.990580302090074,UNCOND,ESTSMPL = "1986 2050"]

LOG(IDAHO\_SUPERMARKET) = 1.44861319532139\*LOG(ID\_POPULATION) - 9.89105586643492 + [AR(1) = 0.984454585132841,UNCOND,ESTSMPL = "2012 2050"]

LOG(IDAHO\_UNIVERSITY) = 1.28099801961163\*LOG(ID\_POPULATION) - 6.78331978073507 + [AR(1) = 0.988641546963508,UNCOND,ESTSMPL = "1985 2050"]

LOG(IDAHO\_WAREHOUSE) = 1.33684090218248\*LOG(ID\_POPULATION) - 6.69150465686193 + [AR(1) = 0.990216312220479,UNCOND,ESTSMPL = "1985 2050"]

LOG(IDAHO\_MEDIUMOFFICE) = 2.79531294864816\*LOG(ID\_POPULATION) - 18.2448261733118 + [AR(1) = 0.986931510814216,UNCOND,ESTSMPL = "1987 2050"]

LOG(MONTANA\_BIGBOXRETAIL) = 2.88007940185511\*LOG(MT\_POPULATION) - 17.4376777834129 + [AR(1) = 0.98522623210474,UNCOND,ESTSMPL = "1988 2050"]

LOG(MONTANA\_HIGHENDRETAIL) = 4.16200822812797\*LOG(MT\_POPULATION) - 26.6090754210696 + [AR(1) = 0.991911324301571,UNCOND,ESTSMPL = "1990 2050"]

LOG(MONTANA\_ANCHORRETAIL) = 2.8064887980066\*LOG(MT\_POPULATION) - 17.0804010487361 + [AR(1) = 0.990172016073791,UNCOND,ESTSMPL = "1987 2050"]

LOG(MONTANA\_ASSEMBLY) = 2.89375198175529\*LOG(MT\_POPULATION) - 16.7359816866246 + [AR(1) = 0.996949716493743,UNCOND,ESTSMPL = "1988 2050"]

LOG(MONTANA\_HOSPITAL) = 3.70766222456733\*LOG(MT\_POPULATION) - 23.071711172954 + [AR(1) = 0.994527040057362,UNCOND,ESTSMPL = "1990 2050"]

LOG(MONTANA\_K12) = 1.86625791265871\*LOG(MT\_POPULATION) - 10.5064128194329 + [AR(1) = 0.94992201064034,UNCOND,ESTSMPL = "2012 2050"]

LOG(MONTANA\_LARGEOFFICE) = 1.3357654769279\*LOG(MT\_POPULATION) - 6.15807237992037 + [AR(1) = 0.949301055704036,UNCOND,ESTSMPL = "1985 2050"]

LOG(MONTANA\_LODGING) = 1.56479401831847\*LOG(MT\_POPULATION) - 8.02113288358837 + [AR(1) = 0.989498330003693,UNCOND,ESTSMPL = "2012 2050"]

LOG(MONTANA\_MEDIUMOFFICE) = 1.97107469178852\*LOG(MT\_POPULATION) - 10.9726285288937 + [AR(1) = 0.998166892414689,UNCOND,ESTSMPL = "1990 2050"]

LOG(MONTANA\_MINIMART) = 1.12880197770274\*LOG(MT\_POPULATION) - 7.12810883828971 + [AR(1) = 0.969895258957254,UNCOND,ESTSMPL = "1987 2050"]

LOG(MONTANA\_MULTIFAMILY) = 1.71039201332901\*LOG(MT\_POPULATION) - 7.67319370873825 + [AR(1) = 0.997916472325971,UNCOND,ESTSMPL = "1990 2050"]

LOG(MONTANA\_OTHER) = 1.67577013592972\*LOG(MT\_POPULATION) - 8.11590554623823 + [AR(1) = 0.998022061177267,UNCOND,ESTSMPL = "1990 2050"]

LOG(MONTANA\_OTHERFAMILY) = 1.180081586213\*LOG(MT\_POPULATION) - 4.00890688762877 + [AR(1) = 0.994482528006191,UNCOND,ESTSMPL = "1985 2050"]

LOG(MONTANA\_OTHERHEALTH) = 1.50497542889214\*LOG(MT\_POPULATION) - 8.32637332591933 + [AR(1) = 0.996788344540332,UNCOND,ESTSMPL = "1992 2050"]

LOG(MONTANA\_RESTAURANT) = 2.37767310955455\*LOG(MT\_POPULATION) - 14.3201278216779 + [AR(1) = 0.989874369650861,UNCOND,ESTSMPL = "1990 2050"]

LOG(MONTANA\_SINGLEFAMILY) = 0.863868559857074\*LOG(MT\_POPULATION) - 0.159173103174186 + [AR(1) = 0.998899079745005,UNCOND,ESTSMPL = "1985 2050"]

LOG(MONTANA\_SMALLBOXRETAIL) = 2.50809409498567\*LOG(MT\_POPULATION) - 14.389595125932 + [AR(1) = 0.989697837890372,UNCOND,ESTSMPL = "1987 2050"]

LOG(MONTANA\_SMALLOFFICE) = 1.20939094324476\*LOG(MT\_POPULATION) - 5.90037499848916 + [AR(1) = 0.997444007613592,UNCOND,ESTSMPL = "1987 2050"]

LOG(MONTANA\_SUPERMARKET) = 1.092043620894\*LOG(MT\_POPULATION) - 5.86433434364322 + [AR(1) = 0.996669218206746,UNCOND,ESTSMPL = "1987 2050"]

LOG(MONTANA\_UNIVERSITY) = 1.41121254143478\*LOG(MT\_POPULATION) - 7.60798039535587 + [AR(1) = 0.965600428213078,UNCOND,ESTSMPL = "1990 2050"]

LOG(MONTANA\_WAREHOUSE) = 1.53825595768901\*LOG(MT\_POPULATION) - 7.3948964895477 + [AR(1) = 0.997290417385946,UNCOND,ESTSMPL = "1985 2050"]

LOG(ID\_AIR\_FREIGHT) = 3.18909777677732\*LOG(ID\_POPULATION) - 18.4213938282793 + [AR(1) = 0.994639471274104,UNCOND,ESTSMPL = "1985 2050"]

LOG(ID\_AIR\_PASSENGER) = 2.22901504497256\*LOG(ID\_POPULATION) - 12.3871639013942 + [AR(1) = 0.993626995200064,UNCOND,ESTSMPL = "1985 2050"]

LOG(ID\_FREIGHT) = 1.80514319905036\*LOG(ID\_POPULATION) - 9.06732893195449 + [AR(1) = 0.868724832375645,UNCOND,ESTSMPL = "1985 2050"]

LOG(MT\_AIR\_FREIGHT) = 2.88593974463026\*LOG(MT\_POPULATION) - 15.6247739521606 + [AR(1) = 0.998574557291662,UNCOND,ESTSMPL = "1985 2050"]

LOG(MT\_AIR\_PASSENGER) = 2.59789949476821\*LOG(MT\_POPULATION) - 14.3192705602638 + [AR(1) = 0.998484158517094,UNCOND,ESTSMPL = "1985 2050"]

LOG(MT\_FREIGHT) = 2.72822546838723\*LOG(MT\_POPULATION) - 14.9115201710488 + [AR(1) = 0.936159886640108,UNCOND,ESTSMPL = "1985 2050"]

LOG(OR\_AIR\_FREIGHT) = 2.69288497814403\*LOG(OREGON\_POPULATION) - 16.5121023561611 + [AR(1) = 0.995844456398807,UNCOND,ESTSMPL = "1985 2050"]

LOG(OR\_AIR\_PASSENGER) = 2.55865359130454\*LOG(OREGON\_POPULATION) - 16.0007318096646 + [AR(1) = 0.996157969131635,UNCOND,ESTSMPL = "1985 2050"]

LOG(OR\_FREIGHT) = 2.12640203194014\*LOG(OREGON\_POPULATION) - 12.3221476092298 + [AR(1) = 0.961487200585257,UNCOND,ESTSMPL = "1985 2050"]

LOG(WA\_AIR\_FREIGHT) = 2.45910747164655\*LOG(WA\_POPULATION) - 15.3970414061883 + [AR(1) = 0.9954177168839,UNCOND,ESTSMPL = "1985 2050"]

LOG(WA\_AIR\_PASSENGER) = 2.51221132054931\*LOG(WA\_POPULATION) - 16.3401370244459 + [AR(1) = 0.995047886784742,UNCOND,ESTSMPL = "1985 2050"]

LOG(WA\_FREIGHT) = 2.27332392155476\*LOG(WA\_POPULATION) - 14.0416442028192 + [AR(1) = 0.960190612303422,UNCOND,ESTSMPL = "1985 2050"]

LOG(OR\_AGRICULTURE) = 2.47772618242088\*LOG(OREGON\_POPULATION) - 19.1478791839495 - 0.0372437358798042\*(@YEAR = 2010) + [AR(1) = 0.694213307797784,UNCOND,ESTSMPL = "1985 2050"]

LOG(OR\_ALUMINUM) = 5.63575335346158\*LOG(OREGON\_POPULATION) - 49.2368436679799 + [AR(1) = 0.324185185728507,UNCOND,ESTSMPL = "2001 2050"]

LOG(OR\_APPAREL) = 2.28699256418803\*LOG(OREGON\_POPULATION) - 20.9735442866727 - 0.0292269765541689\*@TREND

LOG(OR\_CHEMICALS) = 4.70938980194818\*LOG(OREGON\_POPULATION) - 39.3074359712592 + [AR(1) = 0.772345081855108,UNCOND,ESTSMPL = "1985 2050"]

LOG(OR\_DATACENTER) = 2.09953338475379\*LOG(OREGON\_POPULATION) - 10.0561165334692

LOG(OR\_ELECTRICEQUIPMENT) = 4.39364672126575\*LOG(OREGON\_POPULATION) - 37.5089693313433 + [AR(1) = 0.354425099438529,UNCOND,ESTSMPL = "2002 2050"]

LOG(OR\_FABRICATED\_METALS) = 3.0968609903116\*LOG(OREGON\_POPULATION) - 25.3289811606471 + [AR(1) = 0.631290976840941,UNCOND,ESTSMPL = "1985 2050"]

LOG(OR\_LEATHER) = -0.755268241024723\*LOG(OREGON\_POPULATION) + 2.21847766982114

LOG(OR\_LUMBER) = -4.14417493443246\*LOG(OREGON\_POPULATION) + 33.9035393490998 + 0.0408926092692972\*@TREND

LOG(OR\_MACHINES) = 6.36429054678109\*LOG(OREGON\_POPULATION) - 49.7415313158009 + 0.196334845228627\*(@YEAR > 2007) + [AR(1) = 0.900555296721016,UNCOND,ESTSMPL = "1985 2050"]

LOG(OR\_OTHER\_MANUFACTURING) = 4.2748450004287\*LOG(OREGON\_POPULATION) - 35.8862705613174 + [AR(1) = 0.819121750315757,UNCOND,ESTSMPL = "1985 2050"]

LOG(OR\_PAPER) = -0.0695845462209115\*LOG(OREGON\_POPULATION) + 0.425976838748003

LOG(OR\_PETROLEUM) = 2.70172612638909\*LOG(OREGON\_POPULATION) - 24.6789590766508 + [AR(1) = 0.933026589703607,UNCOND,ESTSMPL = "1985 2050"]

LOG(OR\_PRIMARY\_METALS) = 2.98829012225158\*LOG(OREGON\_POPULATION) - 24.7112252681165 + [AR(1) = 0.714301179003766,UNCOND,ESTSMPL = "1985 2050"]

LOG(OR\_PRINTING) = 0.334483107727372\*LOG(OREGON\_POPULATION) - 3.58486084940602

LOG(OR\_RUBBER) = 3.86916498507004\*LOG(OREGON\_POPULATION) - 32.9795657740856 + [AR(1) = 0.959316903978201,UNCOND,ESTSMPL = "1985 2050"]

LOG(OR\_STONE) = 3.10607496676657\*LOG(OREGON\_POPULATION) - 26.4460480333736 + [AR(1) = 0.46981942767908,UNCOND,ESTSMPL = "1985 2050"]

LOG(OR\_TEXTILES) = 0.798690105365446\*LOG(OREGON\_POPULATION) - 9.35041919372341 + [AR(1) = 0.718951959628161,UNCOND,ESTSMPL = "1985 2050"]

LOG(OR\_TRANSPORT\_EQUIPMENT) = 3.51863608758314\*LOG(OREGON\_POPULATION) - 28.8051472138734 - 0.135274655356958\*(@YEAR = 2008) + [AR(1) = 0.893077535030811,UNCOND,ESTSMPL = "1985 2050"]

LOG(OR\_FOOD) = 3.46141816419647\*LOG(OREGON\_POPULATION) - 27.6599099380625 + [AR(1) = 0.648027298402665,UNCOND,ESTSMPL = "1985 2050"]

LOG(OR\_FURNITURE) = 4.35977705525848\*LOG(OREGON\_POPULATION) - 37.0156596899263 + [AR(1) = 0.850161989315891,UNCOND,ESTSMPL = "1985 2050"]

LOG(WA\_AGRICULTURE) = 2.21826404405938\*LOG(WA\_POPULATION) - 17.7292705392498 + [AR(1) = 0.776256746695783,UNCOND,ESTSMPL = "1985 2050"]

LOG(WA\_APPAREL) = -2.82208431138071\*LOG(WA\_POPULATION) + 22.6151783599704 + [AR(1) = 0.897974512855799,UNCOND,ESTSMPL = "1995 2050"]

LOG(WA\_CHEMICALS) = 2.92435758385364\*LOG(WA\_POPULATION) - 25.302141124865 + [AR(1) = 0.615650122772515,UNCOND,ESTSMPL = "1985 2050"]

LOG(WA\_DATACENTER) = 6.96767984463129\*LOG(WA\_POPULATION) - 53.0390165135667 + [AR(1) = 0.852092110350966,UNCOND,ESTSMPL = "2007 2050"]

LOG(WA\_ELECTRICEQUIPMENT) = 1.65116390518447\*LOG(WA\_POPULATION) - 14.9420019529966 + [AR(1) = 0.813403820427709,UNCOND,ESTSMPL = "1985 2050"]

LOG(WA\_FABRICATED\_METALS) = 2.64875297803392\*LOG(WA\_POPULATION) - 23.0211642493681 + [AR(1) = 0.820090799640728,UNCOND,ESTSMPL = "1985 2050"]

LOG(WA\_FOOD) = 2.57600814920424\*LOG(WA\_POPULATION) - 21.3945773436134 + [AR(1) = 0.617287514482311,UNCOND,ESTSMPL = "1985 2050"]

LOG(WA\_FURNITURE) = 3.11186859200002\*LOG(WA\_POPULATION) - 28.4144726962369 + [AR(1) = 0.865773692543546,UNCOND,ESTSMPL = "1985 2050"]

LOG(WA\_LEATHER) = -0.447995931069274\*LOG(WA\_POPULATION) - 1.11905841100642 + [AR(1) = 0.981979243535588,UNCOND,ESTSMPL = "1985 2050"]

LOG(WA\_LUMBER) = -0.601190366382325\*LOG(WA\_POPULATION) + 5.66507988729556

LOG(WA\_MACHINES) = 3.25334882620321\*LOG(WA\_POPULATION) - 27.2102680378076 + [AR(1) = 0.825290226467544,UNCOND,ESTSMPL = "1985 2050"]

LOG(WA\_OTHER\_MANUFACTURING) = 3.8130638060667\*LOG(WA\_POPULATION) - 33.700539363768 + [AR(1) = 0.830210762608854,UNCOND,ESTSMPL = "1985 2050"]

LOG(WA\_PAPER) = -0.0791665028192028\*LOG(WA\_POPULATION) + 0.905371942746487 + [AR(1) = 0.745223316331644,UNCOND,ESTSMPL = "1985 2050"]

LOG(WA\_PETROLEUM) = 2.56461568968076\*LOG(WA\_POPULATION) - 22.4525873553236 + [AR(1) = 0.857222868455266,UNCOND,ESTSMPL = "1985 2050"]

LOG(WA\_PRIMARY\_METALS) = 2.32704989164382\*LOG(WA\_POPULATION) - 21.4203221985961 + [AR(1) = 0.632633239567206,UNCOND,ESTSMPL = "1985 2050"]

LOG(WA\_PRINTING) = -0.871496694157239\*LOG(WA\_POPULATION) + 6.97421705728889 + [AR(1) = 0.778680537962902,UNCOND,ESTSMPL = "1997 2050"]

LOG(WA\_RUBBER) = 3.32365978698307\*LOG(WA\_POPULATION) - 29.8446128167026 + [AR(1) = 0.941359080005245,UNCOND,ESTSMPL = "1985 2050"]

LOG(WA\_STONE) = 2.81565903680965\*LOG(WA\_POPULATION) - 24.9104765161855 + [AR(1) = 0.802815633942037,UNCOND,ESTSMPL = "1985 2050"]

LOG(WA\_TEXTILES) = 2.69226391011409\*LOG(WA\_POPULATION) - 26.0296990836259 + [AR(1) = 0.911978846520425,UNCOND,ESTSMPL = "1985 2050"]

LOG(WA\_TRANSPORT\_EQUIPMENT) = 3.37549345680635\*LOG(WA\_POPULATION) - 26.4702206718309 + [AR(1) = 0.881574746218193,UNCOND,ESTSMPL = "1985 2050"]

LOG(ID\_AGRICULTURE) = 1.55799848637655\*LOG(ID\_POPULATION) - 10.4807888469983 + [AR(1) = 0.752254028807682,UNCOND,ESTSMPL = "1985 2050"]

LOG(ID\_APPAREL) = -2.68256687592745\*LOG(ID\_POPULATION) + 16.0774252536176 + [AR(1) = 0.72817797383739,UNCOND,ESTSMPL = "2015 2050"]

LOG(ID\_CHEMICALS) = 1.62238880775732\*LOG(ID\_POPULATION) - 12.7545119230199 + [AR(1) = 0.568016269628298,UNCOND,ESTSMPL = "1985 2050"]

LOG(ID\_DATACENTER) = 3.19147515494367\*LOG(ID\_POPULATION) - 18.5263614292782 + [AR(1) = 0.896466355255474,UNCOND,ESTSMPL = "2012 2050"]

LOG(ID\_ELECTRICEQUIPMENT) = 3.57121635020273\*LOG(ID\_POPULATION) - 29.188687007947 + [AR(1) = 0.895541858211256,UNCOND,ESTSMPL = "1985 2050"]

LOG(ID\_FABRICATED\_METALS) = 2.6074959309922\*LOG(ID\_POPULATION) - 20.5052006515845 + [AR(1) = 0.962978947440647,UNCOND,ESTSMPL = "1985 2050"]

LOG(ID\_FOOD) = 2.01863461278732\*LOG(ID\_POPULATION) - 14.4558961012463 + [AR(1) = 0.791236248283883,UNCOND,ESTSMPL = "1985 2050"]

LOG(ID\_FURNITURE) = 2.74583829304512\*LOG(ID\_POPULATION) - 23.3064661360706 + [AR(1) = 0.973371971640427,UNCOND,ESTSMPL = "1985 2050"]

LOG(ID\_LEATHER) = -0.699719060238172\*LOG(ID\_POPULATION) - 0.156309275659785 + [AR(1) = 0.953464976604218,UNCOND,ESTSMPL = "1997 2050"]

LOG(ID\_MACHINES) = 2.2701397401104\*LOG(ID\_POPULATION) - 15.9590215225349 + [AR(1) = 0.87795950677148,UNCOND,ESTSMPL = "1985 2050"]

LOG(ID\_OTHER\_MANUFACTURING) = 3.147239254986\*LOG(ID\_POPULATION) - 25.5968802021835 + [AR(1) = 0.855421090902161,UNCOND,ESTSMPL = "1985 2050"]

LOG(ID\_PAPER) = 1.62047017704559\*LOG(ID\_POPULATION) - 13.5589750368333 + [AR(1) = 0.881372793579893,UNCOND,ESTSMPL = "1985 2050"]

LOG(ID\_PETROLEUM) = 3.47034652394016\*LOG(ID\_POPULATION) - 30.2211559079441 + [AR(1) = 0.734557739539986,UNCOND,ESTSMPL = "1992 2050"]

LOG(ID\_PRIMARY\_METALS) = 6.37931577556646\*LOG(ID\_POPULATION) - 49.5383089407125 + [AR(1) = 1.46065643453557,AR(2) = -0.491640389943357,UNCOND,ESTSMPL = "1985 2050"]

LOG(ID\_PRINTING) = 1.20117105445966\*LOG(ID\_POPULATION) - 10.3544198105307 - 0.765182517456548\*(@YEAR > 1996) - 0.193825048739167\*(@YEAR = 2012) + [AR(1) = 0.77769750423722,UNCOND,ESTSMPL = "1985 2050"]

LOG(ID\_RUBBER) = 1.93715066920947\*LOG(ID\_POPULATION) - 16.2405162314804 + [AR(1) = 0.900296861801781,UNCOND,ESTSMPL = "1985 2050"]

LOG(ID\_STONE) = 1.67558818301244\*LOG(ID\_POPULATION) - 14.8185453341045 + [AR(1) = 0.887384132557502,UNCOND,ESTSMPL = "1985 2050"]

LOG(ID\_TEXTILES) = 3.45025509405122\*LOG(ID\_POPULATION) - 29.9731144430281 + [AR(1) = 0.837011075738152,UNCOND,ESTSMPL = "1985 2050"]

LOG(ID\_TRANSPORT\_EQUIPMENT) = 3.42549255254613\*LOG(ID\_POPULATION) - 26.9651124654225 + [AR(1) = 0.808739723503749,UNCOND,ESTSMPL = "1985 2050"]

LOG(ID\_AGRICULTURE) = 1.55799848637655\*LOG(ID\_POPULATION) - 10.4807888469983 + [AR(1) = 0.752254028807682,UNCOND,ESTSMPL = "1985 2050"] [↑](#endnote-ref-40)