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# ICEAA Cost Challenge 2023:

***What is the cost of a human?***

**June 29, 2023**

# AGENDA

- Team & Task Introduction
- WBS & GR&A
- Direct Costs Approach
- Indirect Costs Approach
- Results & Crosschecks
- Takeaways & Lessons Learned

# TEAM INTRODUCTION

### Andrew Shober

***Lead Analyst***

Andrew has a B.S. in Supply Chain & Information Systems from Penn State. He has worked at Technomics for four years, providing cost estimates for numerous USCG and US Navy ship programs. He currently supports the Columbia Class Submarine Program Office and works within Technomics' Cost Analysis & Acquisition Support (CAAS) Service Area.

### Sydney Kacek

***Lead Analyst***

Syd has a B.S. in Business Management from Clemson University and an MBA in Marketing Analytics from Penn State. She joined Technomics in September 2022 after working for NAVAIR and NAVSEA. She currently provides cost/acquisition support to the PEO IWS X Program Office and resides in Technomics' Cost Analysis & Acquisition Support (CAAS) Service Area.

### Brandon Schwark

***Lead Analyst***

Brandon has a B.S. in Economics from Penn State and a Masters in Applied Economics from the University of Maryland. He primarily supports the National Nuclear Security Administration (NNSA) providing cost analysis, modeling, and analytical support. He currently works within the Program, Portfolio and Performance Management (P3M) Service Area

### Ben Bergen

***Senior Associate***

Ben has a B.S. in Industrial and Systems Engineering from Virginia Tech. Since joining Technomics in March 2021, he has provided Cost and financial planning support to multiple Navy programs in IWS 2.0. He currently works within the Program, Portfolio, and Performance Management (P3M) Service Area.

### Harry Smith

***Senior Associate***

Harry has a B.S. in Environmental Engineering from the University of Virginia. He joined Technomics in March 2022 after 1.5 years in the Environmental Engineering field and now supports the Defense Cost and Resource Center (DCARC) while residing in Technomics' Professional Development Pathway (PDP).

# PURPOSE AND SCOPE

- **General Guideline:** Gather data pertinent to estimate the Whole Life Cost (WLC) of a human within the US
- **Defining WLC:**
  - WLC is commonly defined as the total cost of ownership over the life of an asset
  - Often used in economic appraisal and asset management
  - Similar to a Life Cycle Cost (LCC), but also considers externalities, such as economic and societal impacts
- **Understanding the problem space:**
  - How do we define the person we're estimating?
  - How do we account for costs of dependents?
  - Should we account for intangible, secondary, or tertiary costs?
  - What data sources are available?
  - How might data constrain the estimate?

# ESTIMATING PROCESS OVERVIEW

The Technomics Team followed ICEAA’s structured cost estimating process, as defined in Module 1 of the CEBoK.

## WBS DEVELOPMENT

- Developed a structure for relating cost elements to each other at the top level and relating applicable costs at the summary level of detail
- Tailored to capture cost elements relevant to the WLC of a human in the US
- Costs organized by category (i.e., direct and indirect)

## BASELINE DEVELOPMENT

- Generation of GR&A to define the estimate baseline
- Research into existing WLC-like estimates and analogous models

## DATA COLLECTION & ANALYSIS

- Obtained relevant data for the estimate at hand
- Normalized data
- Validated data and sources to ensure credibility
- Data visualizations (i.e., plots, charts, graphs)
- Analysis of descriptive statistics (i.e., Regression Analysis, Exploratory Analysis)

## METHODOLOGY

- Chosen based on available, relevant data and hypothesized logical relationships
- Hybrid parametric / bottoms-up cost estimation framework from CES survey data

## MODEL DEVELOPMENT & VALIDATION

- Developed a model with appropriate cost estimating techniques
- Compared point estimate to models/figures generated by other Government agencies (i.e., FEMA, OMB, etc.)
- Technomics-developed XGBoost model used as a crosscheck

## RESULTS & REPORT GENERATION

- Sensitivity/Risk Analysis
- Adjustments based on findings
- Result is a dynamic model with ability for user-specific inputs

# WORK BREAKDOWN STRUCTURE (WBS)

1. **Direct Costs: Costs directly paid for by the person**
   - Quantifies costs of expenditures
   - Lower-level categories consistent with data source
2. **Indirect Costs: Costs not directly paid for by the person**
   - **Environmental Costs:** Captures environmental externalities that one human being may impose on other human beings
   - **Government Expenditures:** Amount of government expenditures allotted to the person
   - Exclusions:
     - Other environmental costs with limited data available, such as overpopulation, deforestation, other pollutants
     - Secondary occupational costs such as energy costs at work, tools, work uniforms

| WLC of a Human within the US | |
|---|---|
| **1.0** | **Direct** |
| 1.1 | Food |
| 1.2 | Alcoholic Beverages |
| 1.3 | Housing |
| 1.4 | Apparel and Services |
| 1.5 | Transportation |
| 1.6 | Healthcare |
| 1.7 | Entertainment |
| 1.8 | Personal Care Products and Services |
| 1.9 | Reading |
| 1.10 | Education |
| 1.11 | Tobacco Products and Smoking Supplies |
| 1.12 | Miscellaneous |
| 1.13 | Cash Contributions |
| 1.14 | Personal Insurance and Pensions |
| **2.0** | **Indirect** |
| 2.1 | Environmental – Greenhouse Emissions |
| 2.2 | Government Expenditures |

# GROUND RULES & ASSUMPTIONS

- **Defining the human:**
  - Point estimate reflects the cost for the average US human
  - Impact of demographic characteristics analyzed, and can be dynamically altered in the model
  - Person lives in the US for entirety of life
- **Defining the phasing:**
  - Start of estimate = Start of base legal independence (18 years old)
  - End of estimate = US median life expectancy (77 years old)
- **Cost Estimating GR&A:**
  - Estimate presented in CY23$
  - Estimate reflects recent spending trends

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# DIRECT COSTS

# DATA SOURCE

- **Data Source: Consumer Expenditure Survey (CES)**
  - Program conducted by the US Bureau of Labor Statistics (BLS) that provides data on expenditures, income, and demographics of consumers in the US
  - Focused data collection on Interview Surveys, which captures expenditures at a high-level, quarterly

| Limitations | Advantages |
|---|---|
| • Sampling error: Sample may be unrepresentative of the entire population (missing high-income individuals)<br>• Non-Sampling error: Human errors (data entry errors and underestimation of expenses) | • Data available in raw format via Public Use Microdata (PUMD)<br>• Substantial amount of data – allowing for multiple variable regressions<br>• Highly documented |

# CES DATA PREPARATION

1. **Collect & Merge**
   - Tool Utilization: R programming language
   - Set bounds: collected data from 2017-2022
   - Identified appropriate data: Summary expenditures, income, characteristics by family and family members
   - Downloaded raw CSV files: 2 files per quarter, 24 files total
   - Merged into one data table: Over 115k observations, and over 900 variables
2. **Consolidate**
   - Researched variable definitions and codes with CES Data Dictionary
   - Filtered out irrelevant variables
   - Impact: reduced data table to about 100 variables
3. **Normalize**
   - Inflation: All dollars converted to CY23$ using the Personal Consumption Expenditures Price (PCE) Index
     - PCE tracks the change in prices of goods and services purchased by consumers
   - Content: Adjusted end items for homogeneity
     - Filtered out missing or absent elements (I.e. zero and negative values for quarterly expenditures)

# RAW DATA

Portion of raw data (actual data consisted of over 900 columns)

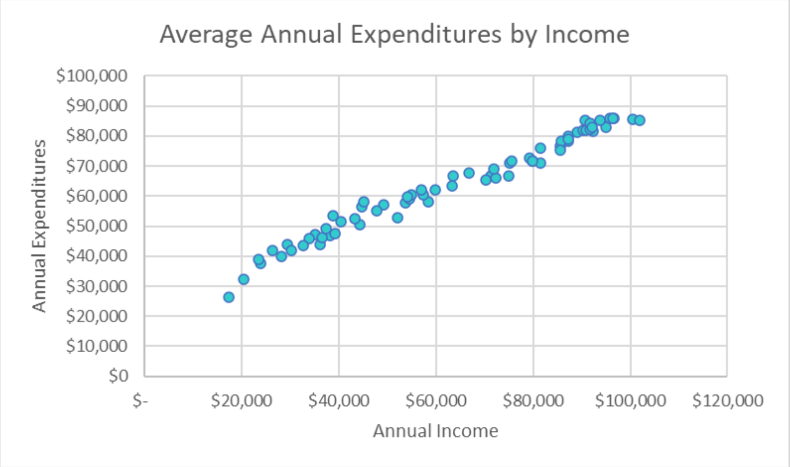
| NEWID | DIRACC | DIRACC_ | AGE_REF | AGE_REF_ | AGE2 | AGE2_ | AS_COMP | AS_C_MP1 | AS_COMP | AS_C_MP2 | FINCBTAX | FINCBT_X | FINDRETX | FIND_ETX | FINLWT21 | FJSSDEDX | FJSS_EDX | FPRIPENX | FPRI_ENX | FRRDEDX | FRRDEDX_ | FRRETIRX | FRRE_IRX | FSALARYX |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3639434 | 1 | D | 36 | D | 36 | D | 1 | D | 1 | D | 200 | D | 0 | D | 21782.77 | 0 | D | 0 | D | 0 | D | 0 | D | 0 |
| 3639444 | 1 | D | 57 | D | 57 | D | 2 | D | 1 | D | 24000 | D | 0 | D | 16063.55 | 1836 | D | 0 | D | 0 | D | 0 | D | 24000 |
| 3639454 | 1 | D | 57 | D | | A | 1 | D | 0 | D | 3684 | D | 0 | D | 11251.54 | 0 | D | 0 | D | 0 | D | 0 | D | 0 |
| 3639504 | 1 | D | 22 | D | 27 | D | 1 | D | 1 | D | 41105 | D | 0 | D | 27474.56 | 3145 | D | 0 | D | 0 | D | 0 | D | 41105 |
| 3639544 | 1 | D | 71 | D | | A | 0 | D | 1 | D | 18300 | D | 0 | D | 14165.96 | 0 | D | 0 | D | 0 | D | 18300 | D | 0 |
| 3639564 | 1 | D | 67 | D | 68 | D | 1 | D | 1 | D | 89376 | D | 0 | D | 20897.87 | 0 | D | 0 | D | 0 | D | 40416 | D | 0 |
| 3639594 | 1 | D | 55 | D | 52 | D | 2 | D | 1 | D | 38000 | D | 0 | D | 22689.35 | 2908 | D | 0 | D | 0 | D | 0 | D | 38000 |
| 3639614 | | A | 72 | D | | A | 0 | D | 1 | D | 36902 | D | 0 | D | 14309.3 | 0 | D | 0 | D | 0 | D | 22704 | D | 0 |
| 3639624 | 1 | D | 65 | D | | A | 0 | D | 1 | D | 25000 | D | 0 | D | 23195.57 | 1913 | D | 500 | D | 0 | D | 0 | D | 25000 |
| 3639634 | 1 | D | 65 | D | 63 | D | 1 | D | 1 | D | 41528 | D | 0 | D | 18173.85 | 0 | D | 0 | D | 0 | D | 33528 | D | 0 |
| 3639734 | 1 | D | 53 | D | 54 | D | 1 | D | 1 | D | 110000 | D | 0 | D | 22539.63 | 8415 | D | 0 | D | 0 | D | 0 | D | 110000 |
| 3639754 | 1 | D | 31 | D | | A | 0 | D | 1 | D | 50000 | D | 0 | D | 23937.3 | 3825 | D | 0 | D | 0 | D | 0 | D | 50000 |
| 3639774 | 1 | D | 88 | T | 68 | D | 1 | D | 1 | D | 0 | D | 0 | D | 21235.73 | 0 | D | 0 | D | 0 | D | 0 | D | 0 |
| 3639794 | 1 | D | 52 | D | 46 | D | 1 | D | 1 | D | 302776 | T | 126545 | T | 33803.69 | 17082 | T | 0 | D | 0 | D | 0 | D | 302776 |
| 3639814 | 1 | D | 30 | D | 29 | D | 1 | D | 1 | D | 46000 | D | 0 | D | 17481.19 | 3519 | D | 462 | D | 0 | D | 0 | D | 46000 |
| 3639854 | 1 | D | 25 | D | | A | 0 | D | 1 | D | 15000 | D | 0 | D | 34061.39 | 1148 | D | 0 | D | 0 | D | 0 | D | 15000 |
| 3639874 | 1 | D | 60 | D | | A | 1 | D | 0 | D | 145590 | D | 0 | D | 23519.82 | 10063 | D | 0 | D | 0 | D | 0 | D | 145000 |
| 3639914 | | A | 47 | D | 50 | D | 1 | D | 2 | D | 110000 | D | 600 | D | 12718.11 | 8415 | D | 0 | D | 0 | D | 0 | D | 110000 |
| 3639944 | 1 | D | 50 | D | 63 | D | 1 | D | 1 | D | 64340 | D | 3500 | D | 17868.04 | 3825 | D | 0 | D | 0 | D | 14340 | D | 50000 |
| 3639974 | 1 | D | 71 | D | | A | 1 | D | 0 | D | 89988 | D | 0 | D | 15619.73 | 4590 | D | 0 | D | 0 | D | 29988 | D | 60000 |
| 3640004 | 1 | D | 88 | T | | A | 0 | D | 1 | D | 11688 | D | 0 | D | 17413.36 | 0 | D | 0 | D | 0 | D | 11688 | D | 0 |
| 3640044 | 1 | D | 74 | D | | A | 0 | D | 1 | D | 1608 | D | 0 | D | 24867.89 | 0 | D | 0 | D | 0 | D | 1608 | D | 0 |

# NORMALIZED DATA

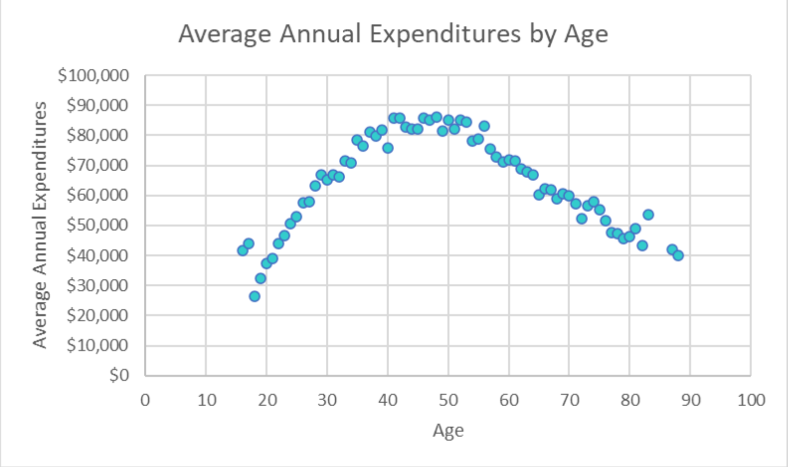
| | | Demographics | | | | | Expenditures (CY23$) | | | | | | Income (CY23$) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Observation | ID | Age | Marital Status | Number of Children | Race | State | Total | Food | Alcohol | Housing | Apparal | Transportation | Salary | Salary of Spouse |
| 2 | 3386774 | 65 | 3 | 0 | 2 | 39 | 4,891.4 | 390.0 | - | 2,352.0 | 92.0 | 696.0 | 16,000.0 | - |
| 3 | 3386804 | 26 | 5 | 0 | 2 | 36 | 10,513.3 | 1,859.0 | 90.0 | 5,490.0 | 75.0 | 290.0 | 25,000.0 | 40,000.0 |
| 8 | 3386924 | 29 | 1 | 0 | 1 | 37 | 29,113.8 | 4,305.0 | 900.0 | 5,899.0 | 894.0 | 2,613.0 | 131,000.0 | 81,000.0 |
| 10 | 3386964 | 41 | 1 | 2 | 1 | 17 | 36,529.5 | 3,707.0 | 53.0 | 8,531.0 | 249.0 | 2,553.0 | - | 264,386.0 |
| 13 | 3387004 | 24 | 5 | 2 | 1 | NA | 45,797.5 | 1,300.0 | 30.0 | 3,002.0 | 373.0 | 36,173.0 | 30,000.0 | 1,600.0 |
| 14 | 3387034 | 24 | 1 | 0 | 1 | NA | 6,821.3 | 2,080.0 | 30.0 | 1,436.0 | - | 845.0 | 40,000.0 | 9,000.0 |
| 15 | 3387054 | 42 | 1 | 2 | 1 | 42 | 27,951.2 | 3,725.0 | 135.0 | 11,943.0 | - | 3,108.0 | 90,000.0 | 140,000.0 |
| 16 | 3387084 | 31 | 1 | 2 | 1 | 48 | 9,454.9 | 1,481.0 | - | 3,374.0 | 130.0 | 1,448.0 | 12,000.0 | 20,000.0 |
| 17 | 3387094 | 53 | 1 | 0 | 1 | 21 | 6,043.5 | 1,105.0 | - | 1,550.0 | - | 825.0 | 9,000.0 | - |
| 18 | 3387104 | 55 | 1 | 0 | 1 | 37 | 71,634.6 | 5,199.0 | 536.0 | 9,876.0 | 506.0 | 23,683.0 | 264,386.0 | 70,000.0 |
| 19 | 3387114 | 40 | 1 | 0 | 1 | 41 | 19,374.6 | 2,195.0 | 565.0 | 3,717.0 | 83.0 | 1,564.0 | - | 59,000.0 |
| 21 | 3387154 | 53 | 5 | 0 | 1 | 15 | 16,085.8 | 2,190.0 | - | 7,460.0 | 141.0 | 1,996.0 | 78,000.0 | - |
| 22 | 3387164 | 68 | 3 | 0 | 1 | 25 | 13,888.8 | 2,145.0 | - | 1,846.0 | 481.0 | 1,530.0 | 118,000.0 | - |
| 30 | 3387354 | 53 | 3 | 0 | 1 | 42 | 7,038.8 | 2,119.0 | - | 1,978.0 | 20.0 | 640.0 | 70,000.0 | - |
| 32 | 3387404 | 57 | 1 | 0 | 1 | NA | 22,032.2 | 1,495.0 | 120.0 | 8,708.0 | 300.0 | 1,608.0 | 100,000.0 | - |
| 34 | 3387424 | 52 | 1 | 1 | 1 | 42 | 24,116.6 | 2,620.0 | 20.0 | 7,161.0 | 1,682.0 | 4,442.0 | 264,386.0 | 5,000.0 |
| 36 | 3387474 | 28 | 1 | 0 | 2 | 48 | 5,925.0 | 1,430.0 | 300.0 | 2,940.0 | - | 644.0 | 15,000.0 | - |
| 37 | 3387514 | 29 | 1 | 1 | 1 | 21 | 5,487.0 | 1,820.0 | - | 2,035.0 | 357.0 | - | - | 24,000.0 |
| 38 | 3387544 | 19 | 5 | 0 | 1 | 4 | 5,277.0 | 1,186.0 | 4.0 | 2,307.0 | - | 1,260.0 | 23,000.0 | - |
| 39 | 3387574 | 39 | 1 | 2 | 1 | 36 | 22,519.3 | 3,240.0 | 425.0 | 8,632.0 | 250.0 | 2,532.0 | 147,000.0 | 50,000.0 |
| 40 | 3387584 | 51 | 1 | 0 | 2 | 40 | 34,452.6 | 3,666.0 | 495.0 | 12,126.0 | 600.0 | 2,872.0 | 65,000.0 | 50,000.0 |

# EXPLORATORY / TREND ANALYSIS

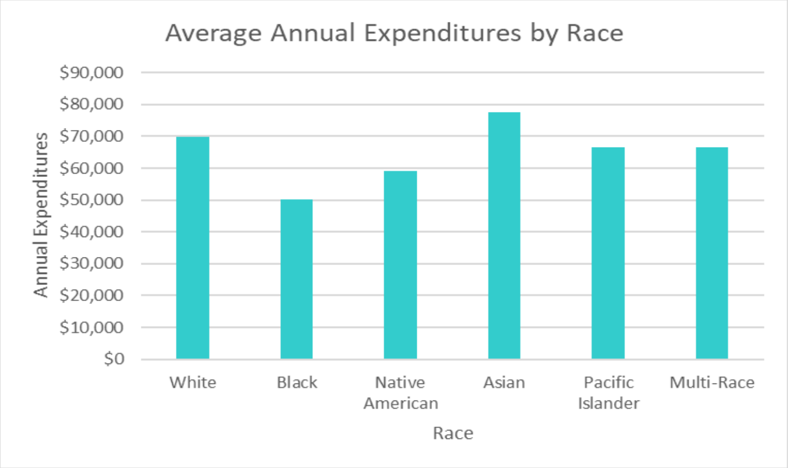
The Technomics team analyzed various data trends before developing a method to calculating expenditures and income



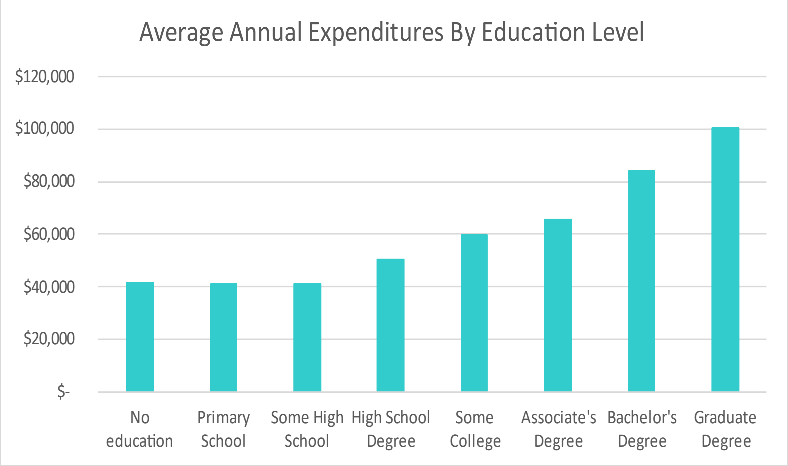

Linear




Polynomial



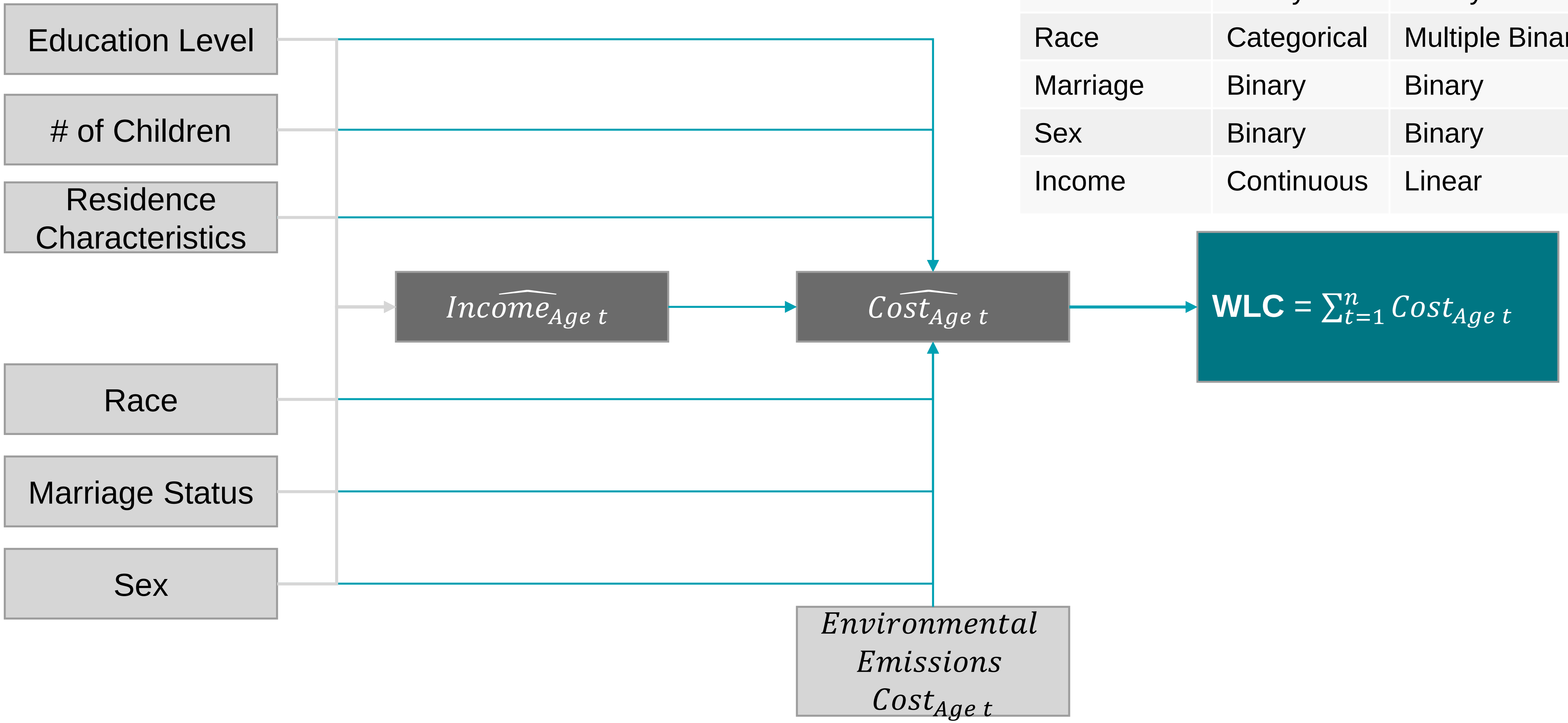

Categorical




Exponential

# MODELING FRAMEWORK

| Variable | Type | Modeling Method |
|---|---|---|
| Education | Discrete | Polynomial |
| Age | Discrete | Polynomial |
| NumKids | Discrete | Linear Approximation |
| Urban | Binary | Binary |
| Race | Categorical | Multiple Binary |
| Marriage | Binary | Binary |
| Sex | Binary | Binary |
| Income | Continuous | Linear |



# APPROACH

- **Approach:** Develop multivariate regressions to predict yearly individual income and expenditures at different ages
- **Model Specification Rationale:**
  - Trend analysis results informed most appropriate model structure
  - Used XGBoost machine learning algorithm to identify highest impact independent variables to include in regression

| Income | Expenses |
|---|---|
| $R^2 = .215$ | $R^2 = .266$ |
| SER = 84,172 | SER = 40,133 |

| Income | Intercept | Educ | Age | NumKids | Female | Urban | White | Black | Native American | Asian | Pacific Islander | Multi−Race | Married | Educ^2 | Age^2 | - |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Coefficient (Standard Error) | -66,902.8 (6,093.24) | -12,116.3 (688.02) | 3,857.6 (84.90) | 3,668.22 (281.48) | -10,198.5 (504.88) | 17,047.2 (1,020.99) | 2,849.57 (3,370.16) | -14,566.9 (3,443.33) | Omit | 1,732.27 (3,529.57) | 3,379.93 (4,998.76) | -367.56 (3,921.06) | 40,519.35 (538.31) | 1,053.80 (27.23) | -39.79 (0.786) | - |

| Expenses | Intercept | Educ | Age | NumKids | Female | Urban | White | Black | Native American | Asian | Pacific Islander | Multi−Race | Married | Educ^2 | Age^2 | PTax Income |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Coefficient (Standard Error) | -12,458.8 (2,906.8) | -1,534.41 (328.49) | 701.08 (40.84) | 2,970.41 (134.31) | -636.8 (241.15) | 4,439.56 (487.40) | 3,509.67 (1,606.90) | -528.63 (1,641.92) | Omit | 1,639.05 (1,682.92) | 749.79 (2,383.43) | 2,055.95 (1,869.58) | 10,443.98 (262.913) | 175.51 (13.07) | -6.47 (0.379) | 0.19 (0.001) |

**P-value < .01** | **P-value < .05** | **P-value > .1**

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# INDIRECT COSTS

## *Environmental*

# PLANNING & RESEARCH

## Planning & Research:

- **Objective:** Capture numerous environmental cost externalities that one human being may impose on other human beings
- **Measurement Method:** Utilize EPA's Social Cost of Greenhouse Gases (SCGHG) as a proxy for environmental externality costs
- **SCGHG Definition:** A monetized, discounted value of the stream of future, worldwide economic damages from a one-ton change in $CO_2$ emissions released **in a particular year**

## Data Sources:

- **Environmental Protection Agency (EPA):**
  - Data estimating social cost of carbon
  - 150,000+ unique monte-carlo simulations
  - Includes low, moderate, high, and extreme estimates
- **Energy Information Agency:**
  - Data on $CO_2$ emissions broken out over time by geographic region
  - Includes per-capita historic emissions rates and emissions projections through 2050
- **Personal Consumption Expenditure (PCE) Index:**
  - Utilized to normalize data to CY23$

# ANALYSIS & RESULTS

- Customizable estimates of environmental cost, based on:
  - Individual's geographic location
  - Expected impacts of emissions on environment
- Default model logic (highlighted):
  - US average $CO_2$ emissions per-person
  - Moderate SCGHG assumption

| Yearly Environmental Cost Estimate by Region & Emissions Impact | | | | | |
|---|---|---|---|---|---|
| Region | $CO_2$ Per Person: 2023 | Emissions Impact | | | |
| | | Low | Moderate | High | Extreme |
| | | **$18.16** | **$61.87** | **$91.56** | **$184.79** |
| **US Average** | **14.1** | $256.12 | $872.17 | $1,290.72 | $2,604.90 |
| **New England** | **9.3** | $168.46 | $573.64 | $848.92 | $1,713.28 |
| **Mid-Atlantic** | **11.4** | $207.65 | $707.11 | $1,046.45 | $2,111.93 |
| **East North Central** | **15.6** | $283.94 | $966.88 | $1,430.88 | $2,887.78 |
| **West North Central** | **19.3** | $350.35 | $1,193.04 | $1,765.58 | $3,563.26 |
| **South Atlantic** | **11.5** | $208.88 | $711.31 | $1,052.66 | $2,124.46 |
| **East South Central** | **19.3** | $351.16 | $1,195.79 | $1,769.64 | $3,571.46 |
| **West South Central** | **22.2** | $403.61 | $1,374.39 | $2,033.96 | $4,104.91 |
| **Mountain** | **15.2** | $276.57 | $941.78 | $1,393.74 | $2,812.82 |
| **Pacific** | **8.7** | $157.90 | $537.69 | $795.72 | $1,605.91 |

- Expected whole-life cost: $52,330.20

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# INDIRECT COSTS

## *Government Expenditures*

# GOVERNMENT EXPENDITURES

**Rationale:**

- Apart from the costs that each person pays for themselves over lifetime, each of us benefits from money that the government pays for various public services (roads, parks, Medicare, defense, etc.)
- Source of funding for federal expenditures is taxes, borrowed money, alternative revenue streams
- Assumptions:
  - All federal dollars spent in some way indirectly benefit each American
  - All Americans benefit equally from government spending on largest expenditures

**Outcome:**

- Federal spending from 2022 discounted to 2023 dollars equal $6.499 trillion
- Average cost per person across the US is $19,416

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# RESULTS & CROSSCHECKS

# POINT ESTIMATE

| | | Education | Children | Race | Sex | Marital Status | Urban | Region | Emissions Impact |
|---|---|---|---|---|---|---|---|---|---|
| **Input Selection** | | | | | | Not Married | | US Average | Moderate |
| **Income** | **Input Value** | 13.5 | 0.52 | 851.3 | -5320.4 | 0.0 | 15949.7 | - | |
| | **Marginal Effect (Yearly)** | $28,915.1 | $1,890.9 | $851.3 | -$5,320.4 | $0.0 | $15,949.7 | - | |
| **Expenditures** | **Input Value** | 13.5 | 0.52 | 2919.5 | -332.2 | 0.0 | 4153.7 | 872.2 | |
| | **Marginal Effect (Yearly)** | $11,356.7 | $1,531.2 | $2,919.5 | -$332.2 | $0.0 | $4,153.7 | $872.2 | |

- Point Estimate is driven by statistical averages
  - I.e., no input = default to statistical average in the data set
- Fixed Inputs
  - Children: PE utilizes average number of children input (0.52), as children are your legal responsibility
  - Marital Status: PE utilizes a '0' input (or unmarried) to isolate the cost of one independent
- Model is beneficial for predicting values for people that align to averages; Less useful for special circumstances where people deviate from the 'norm'

Total Point Estimate Breakout:

| Element | | CY23$K |
|---|---|---|
| **Total WLC** | | **$3,329** |
| **1.0** | **Direct** | **$2,112** |
| 1.1 | Food | $246 |
| 1.2 | Alcoholic Beverages | $16 |
| 1.3 | Housing | $672 |
| 1.4 | Apparel and Services | $53 |
| 1.5 | Transportation | $328 |
| 1.6 | Healthcare | $154 |
| 1.7 | Entertainment | $104 |
| 1.8 | Personal Care Products and Services | $22 |
| 1.9 | Reading | $3 |
| 1.10 | Education | $39 |
| 1.11 | Tobacco Products and Smoking Supplies | $10 |
| 1.12 | Miscellaneous | $28 |
| 1.13 | Cash Contributions | $68 |
| 1.14 | Personal Insurance and Pensions | $230 |
| **2.0** | **Indirect** | **$1,217** |
| 2.1 | Environmental – Greenhouse Emissions | $52 |
| 2.2 | Government Expenditures | $1,165 |

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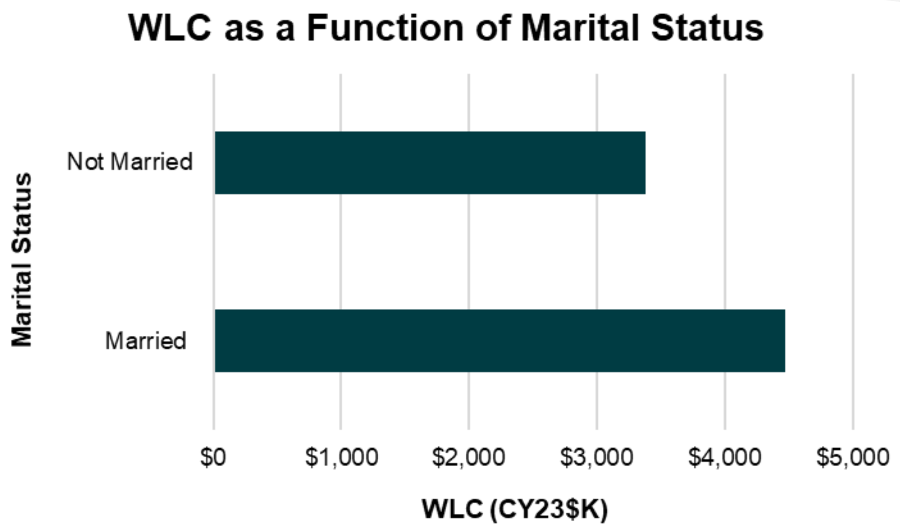
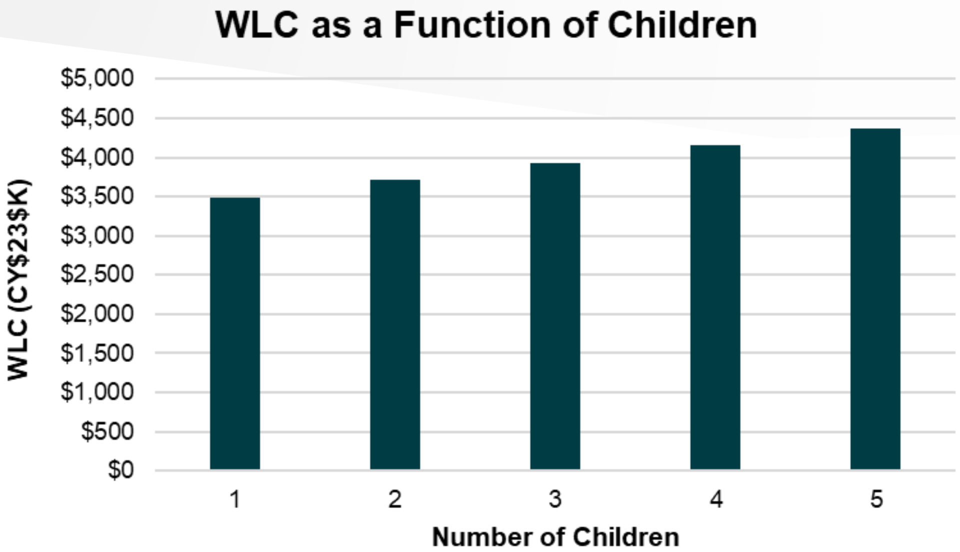
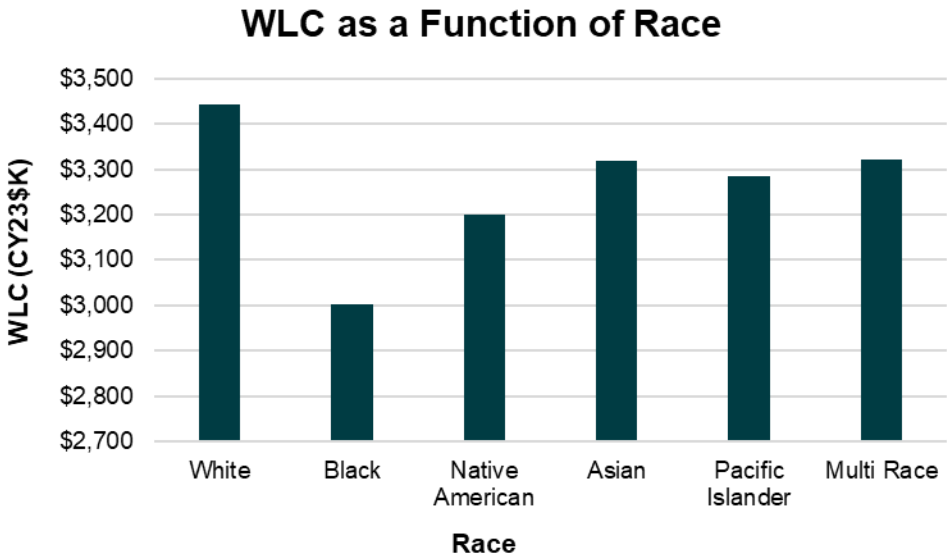
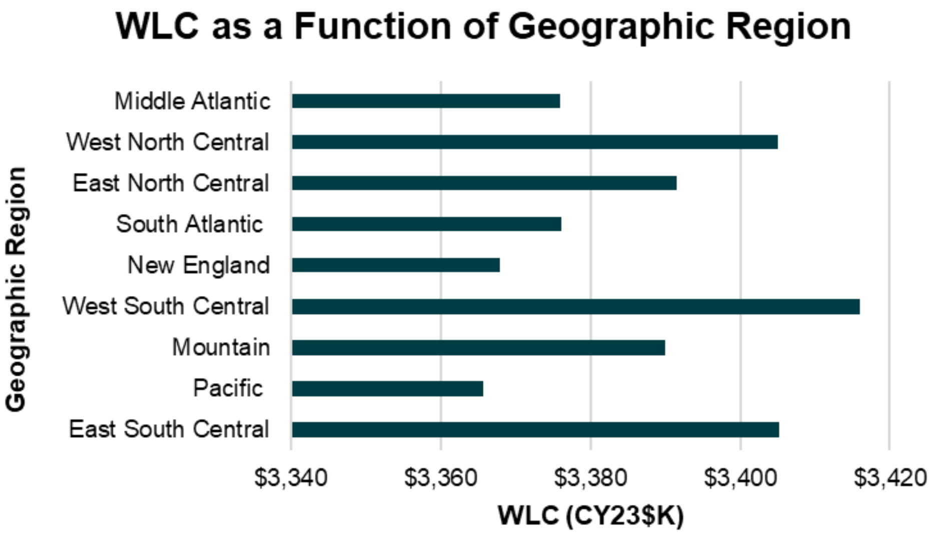
# SENSITIVITY ANALYSIS – MALE

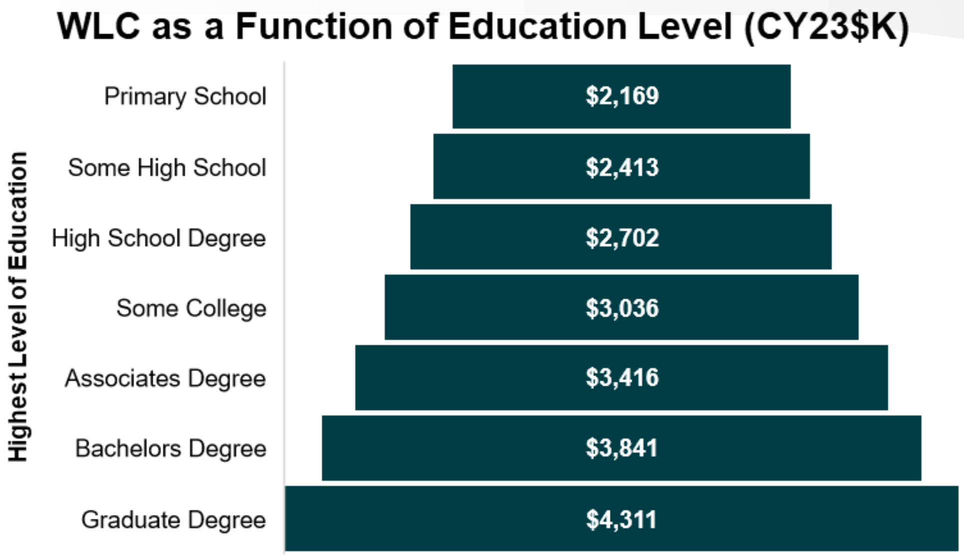


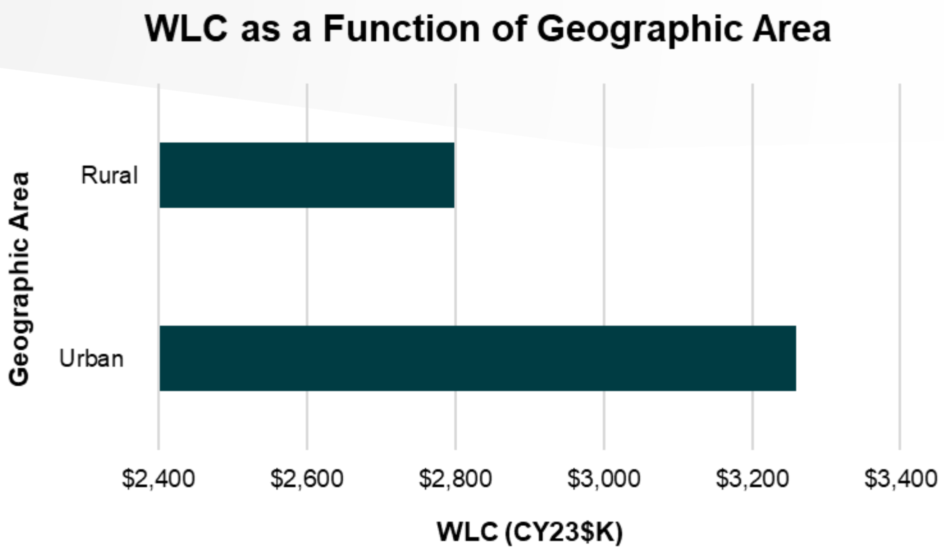



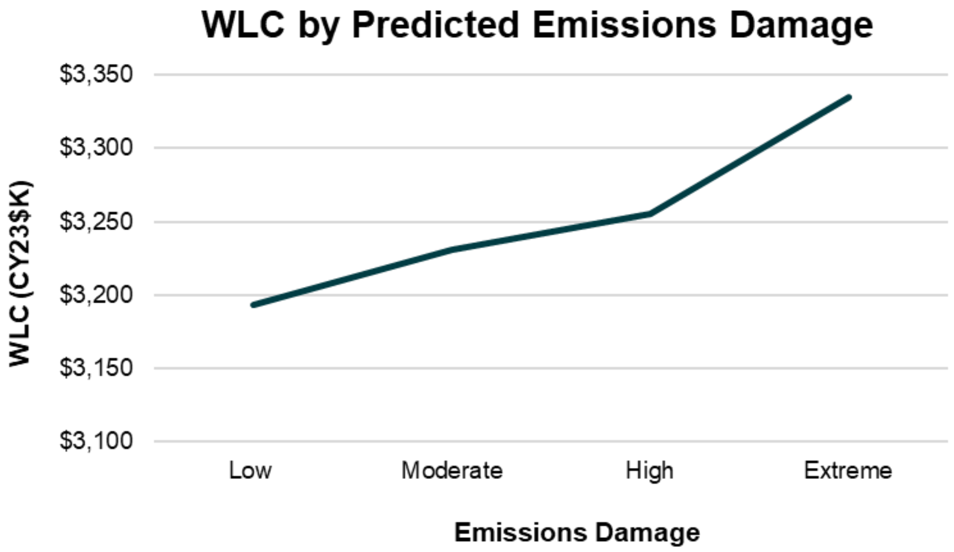



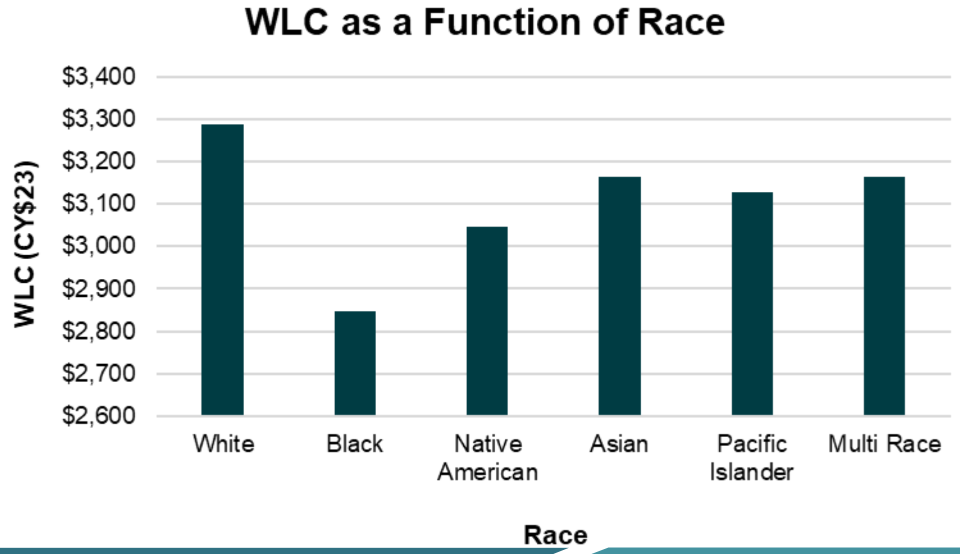



# SENSITIVITY ANALYSIS - FEMALE

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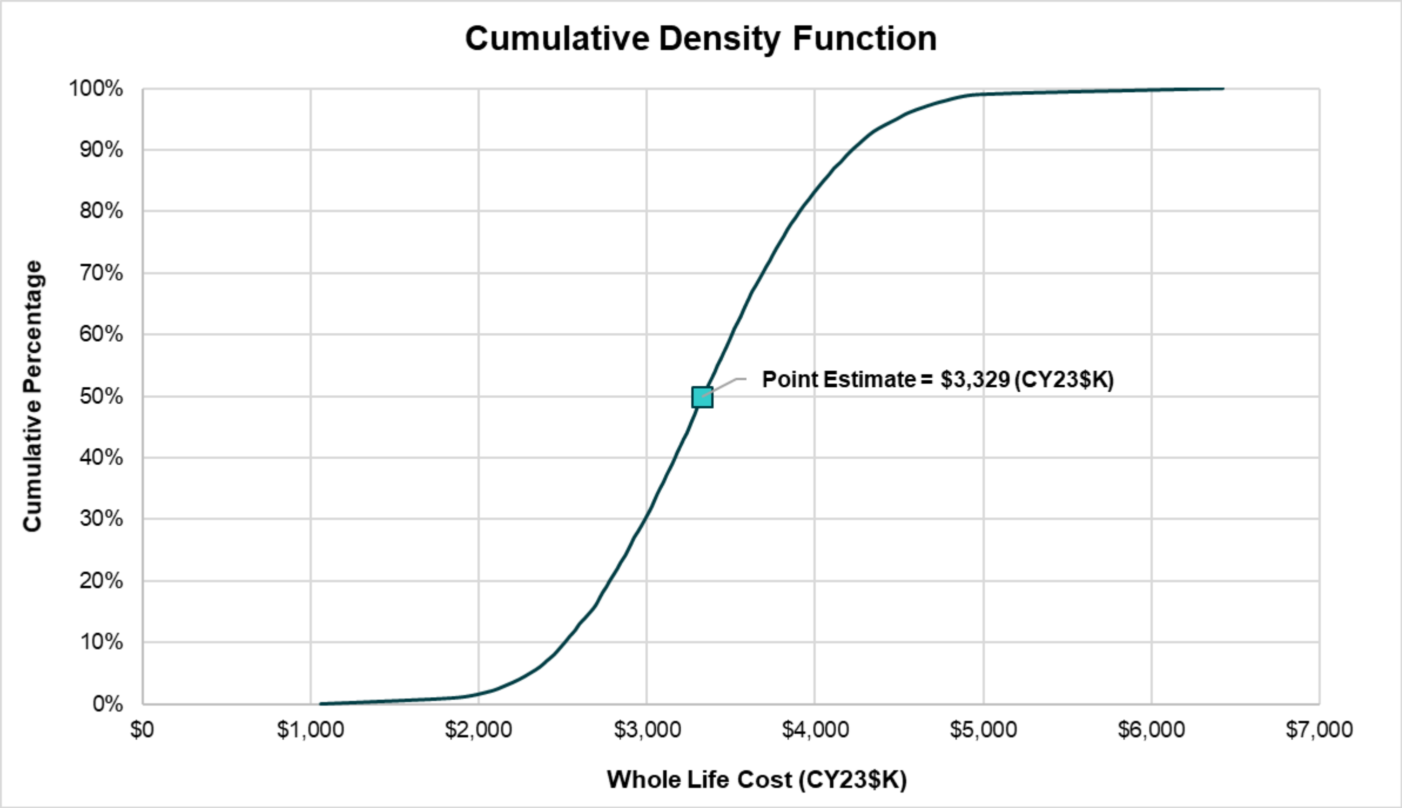
# UNCERTAINTY ANALYSIS

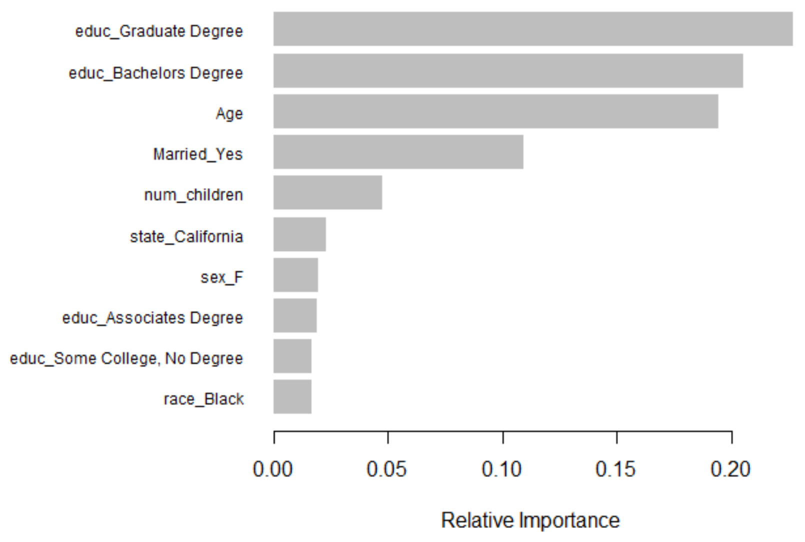
- The Technomics Team conducted a Monte Carlo Simulation to quantify the estimate uncertainty
- Each distribution was derived based on the regressions and data sources the team collected
- The figure below reflects the S-Curve, or cumulative density function, of the estimate WLC of a human




**CY23$K**

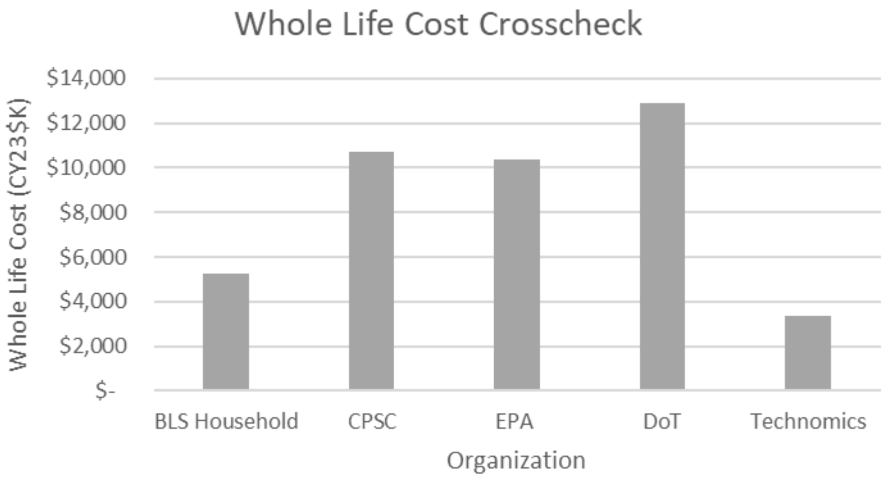
| Percentile | WLC |
|---|---|
| 90% | $4,221 |
| 80% | $3,909 |
| 70% | $3,690 |
| 60% | $3,506 |
| 50% | $3,337 |
| 40% | $3,168 |
| 30% | $2,990 |
| 20% | $2,779 |
| 10% | $2,513 |

# CROSSCHECKS




**Multivariate Regression Crosscheck**

- From the relative importance scheme derived by XGBoost, most important categorical factors are:
  - Education – Graduate degree
  - Marital status – Married
  - State – California
  - Sex – Female
  - Race – Black
  - Residence – Urban
- This allows separation of causal factors independent of influence on one another




**Whole Life Cost Crosscheck**

- Whole Life Cost estimates vary across organizations depending on methodology and assumptions

# TAKEAWAYS & LESSONS LEARNED

**Key Takeaways:**

- **Complexity:**
  - Inability to properly control for all interdependencies between variables
  - Relationships exist between every single independent variable, and can create positive feedback loops
- **Exogeneity Issues:**
  - Cannot account for *everything* that drives cost or income, causing inaccuracy in model and high standard error of the regression

**Areas for Future Improvement:**

- **Interaction Variables:**
  - This could help tease out some of the interdependency issues
- **Leveraging Advanced Machine Learning Algorithms:**
  - # of drivers of expenditures is astronomical; with sufficient data, ML can help narrow down key drivers much faster
- **Greater Customizability:**
  - Simplifying assumptions in model structure were made due to time & resource constraints
  - Sans constraints, further efforts can allow for even more specific predictions, or more appropriate modeling assumptions. Example – utility theory modeling

# THANK YOU

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# SOURCES

- Consumer Expenditure Survey (CES) Data – Bureau of Labor Statistics (BLS)
- Life Expectancy Data – Centers for Disease Control & Prevention (CDC) via the National Vital Statistics System (NVSS)
- Social Cost of Carbon Data – Environmental Protection Agency (EPA) via the Social Cost of Greenhouse Gases (SCGHG)

# Correlation Between Regressors

| | fincbtax(CY23) | educ_ref | age_ref | num_children | Urban | White | Black | Native American | Asian | Pacific Islander | Multi-Race | Married | Educ_ref_sq | Age_ref_sq | Sex |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| fincbtax(CY23) | 1 | | | | | | | | | | | | | | |
| educ_ref | 0.314186939 | 1 | | | | | | | | | | | | | |
| age_ref | -0.109718695 | -0.07784 | 1 | | | | | | | | | | | | |
| num_children | 0.117774215 | -0.0248 | -0.36657 | 1 | | | | | | | | | | | |
| Urban | 0.067202898 | 0.085756 | -0.05453 | 0.005341465 | 1 | | | | | | | | | | |
| White | 0.050893599 | -0.00154 | 0.080108 | -0.02860344 | -0.08574 | 1 | | | | | | | | | |
| Black | -0.102518852 | -0.06389 | -0.02139 | 0.002540198 | 0.059616 | -0.72409 | 1 | | | | | | | | |
| Native American | -0.006089228 | -0.02044 | -0.01692 | 0.017014433 | -0.01897 | -0.1545 | -0.02576 | 1 | | | | | | | |
| Asian | 0.055784218 | 0.098475 | -0.07363 | 0.024484427 | 0.057151 | -0.49996 | -0.08334 | -0.017783523 | 1 | | | | | | |
| Pacific Islander | 0.002502797 | -0.01436 | -0.02713 | 0.027263464 | 0.012328 | -0.14001 | -0.02334 | -0.004980063 | -0.01611 | 1 | | | | | |
| Multi-Race | -0.003611961 | 0.004421 | -0.0398 | 0.014261963 | 0.021098 | -0.2577 | -0.04296 | -0.009166551 | -0.02966 | -0.008306413 | 1 | | | | |
| Married | 0.300078474 | 0.106289 | -0.00644 | 0.235238039 | -0.02247 | 0.090264 | -0.14113 | -0.005736715 | 0.050893 | 0.003396162 | -0.02299 | 1 | | | |
| Educ_ref_sq | 0.3334175 | 0.97982 | -0.07604 | -0.019283307 | 0.091577 | -0.00241 | -0.0704 | -0.021812204 | 0.109807 | -0.013868787 | 0.003213 | 0.117716 | 1 | | |
| Age_ref_sq | -0.143340798 | -0.08944 | 0.985403 | -0.374158875 | -0.05405 | 0.081674 | -0.0259 | -0.018571572 | -0.07133 | -0.026637285 | -0.03689 | -0.04155 | -0.088841341 | 1 | |
| Sex | -0.102544866 | -0.03801 | 0.035745 | 0.050477603 | -0.00814 | -0.02663 | 0.057668 | 0.006573364 | -0.03526 | -0.005647411 | 0.003274 | -0.1325 | -0.042729794 | 0.03968238 | 1 |

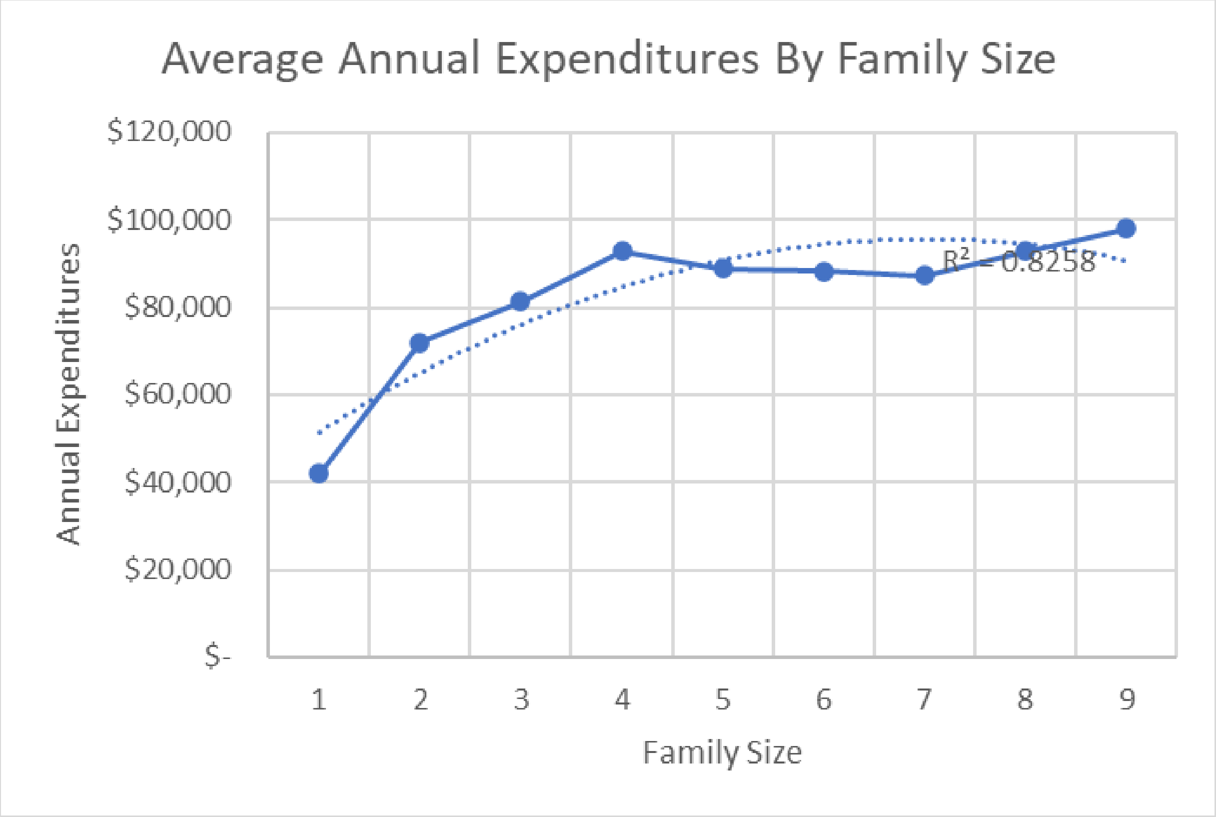
Correlation is generally low between independent variables, suggesting that multicollinearity may not be particularly problematic

# Multicollinearity Tests

- **Goal:** Test for multicollinearity within multivariate regression
- **Approach:** Calculate Variance Inflation Factor (VIF) for each regressor in both the income and the expenditure regressions
- **Method:** Iteratively regress each independent variable on all other independent variables, calculate VIF
- **Results:** VIF coefficients are all close to 1, suggesting very low multicollinearity in multivariate regressions

| Dependent Variable: | R^2 | VIF |
|---|---|---|
| Education | 0.119612 | 1.135863 |
| Age | 0.165778 | 1.198722 |
| NumKids | 0.20666 | 1.260494 |
| Income | 0.21556 | 1.274794 |
| Urban | 0.021909 | 1.022399 |
| White | 0.025301 | 1.025958 |
| Black | 0.03725 | 1.038691 |
| Native American | 0.001519 | 1.001521 |
| Asian | 0.02299 | 1.023531 |
| Pacific Islander | 0.001524 | 1.001527 |
| Multi-Race | 0.002622 | 1.002629 |
| Married | 0.189572 | 1.233915 |
| Sex | 0.035516 | 1.036823 |

# Expenditures and Family Size




Marginal costs associated with an additional family member increase at a decreasing rate - i.e. logarithmically

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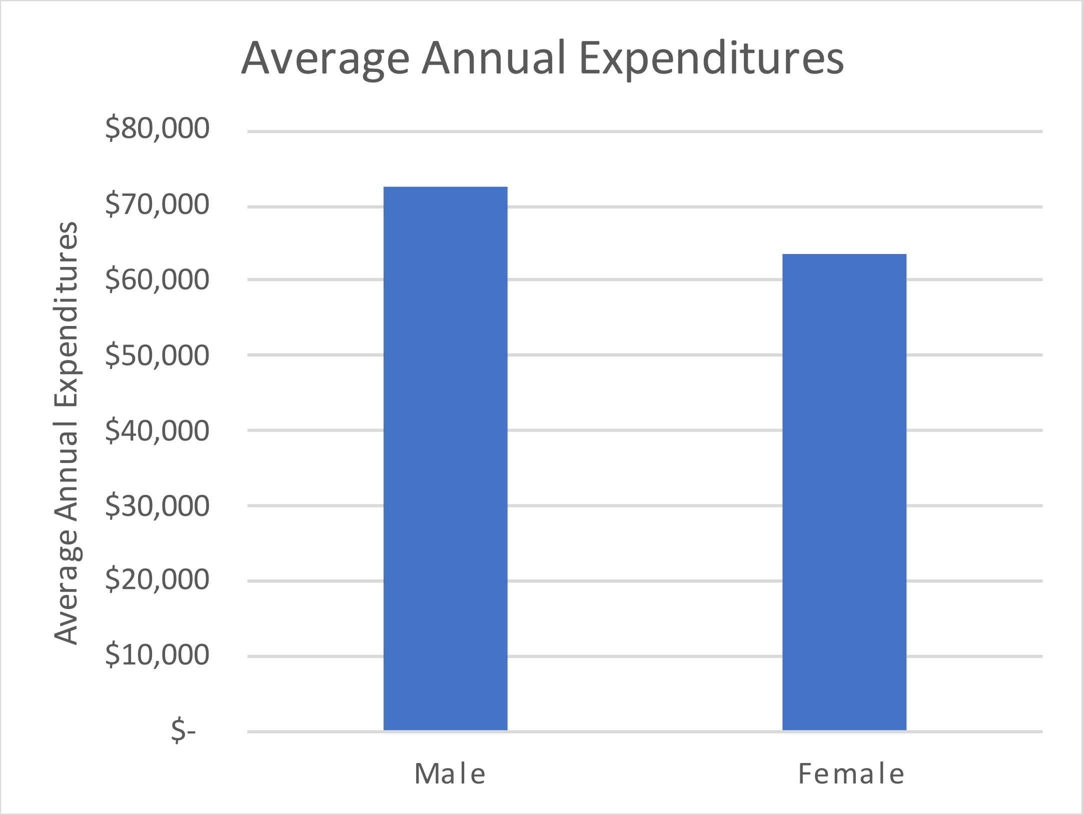
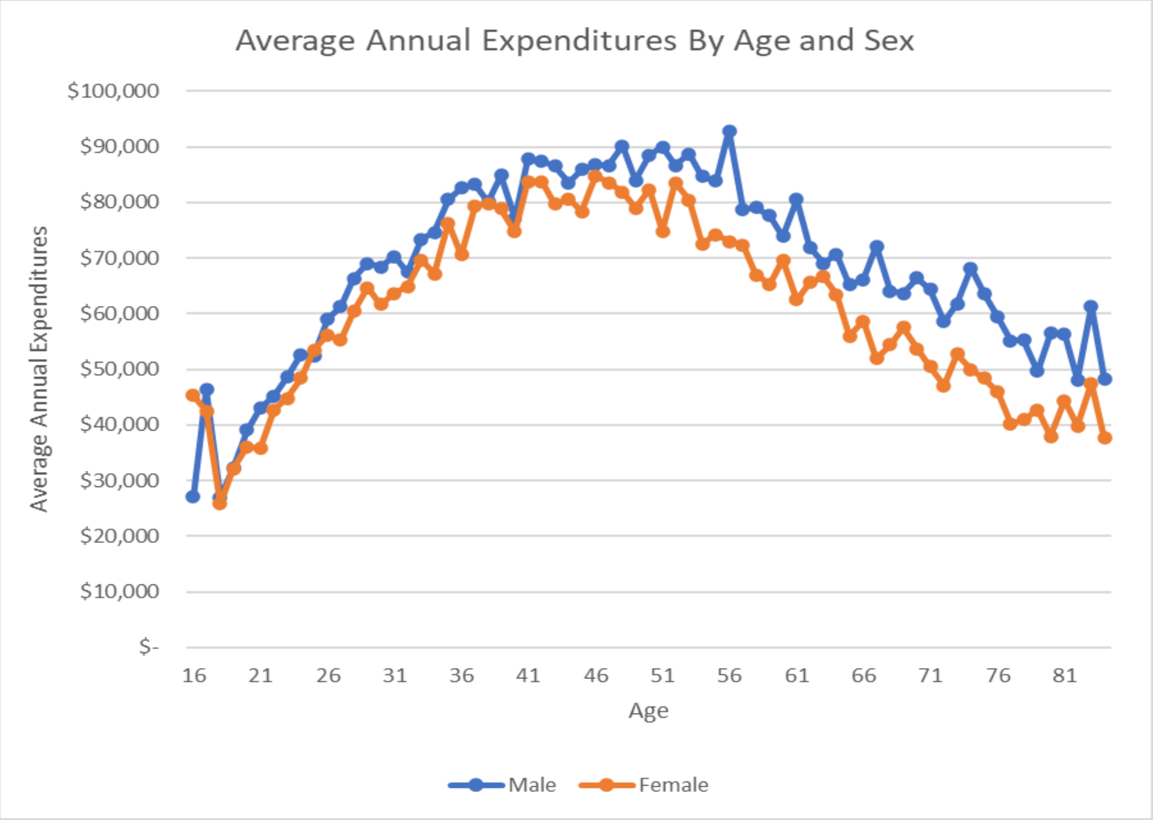
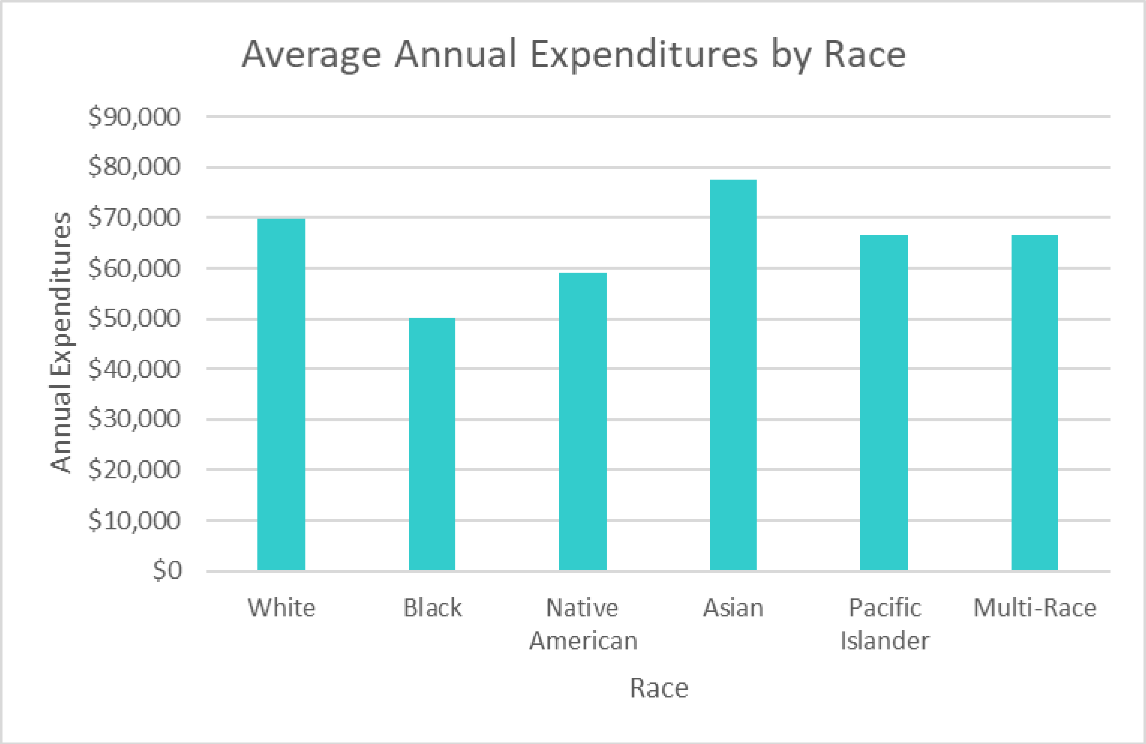
# Expenditures and Sex



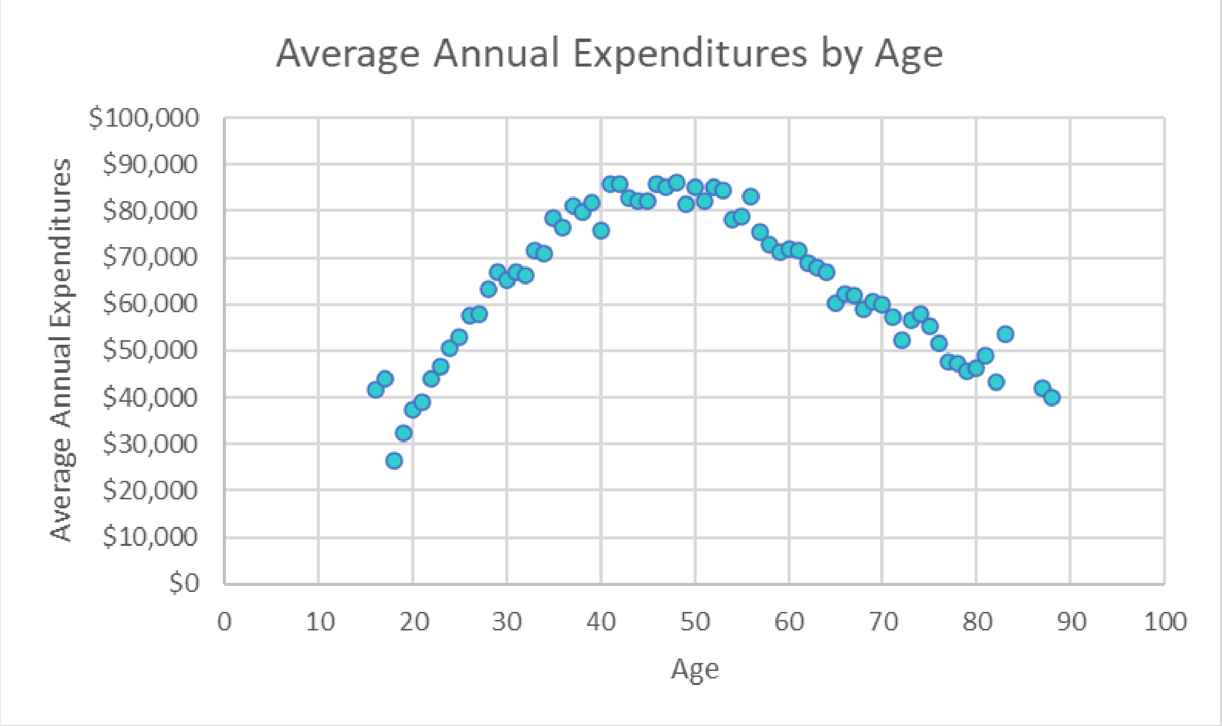



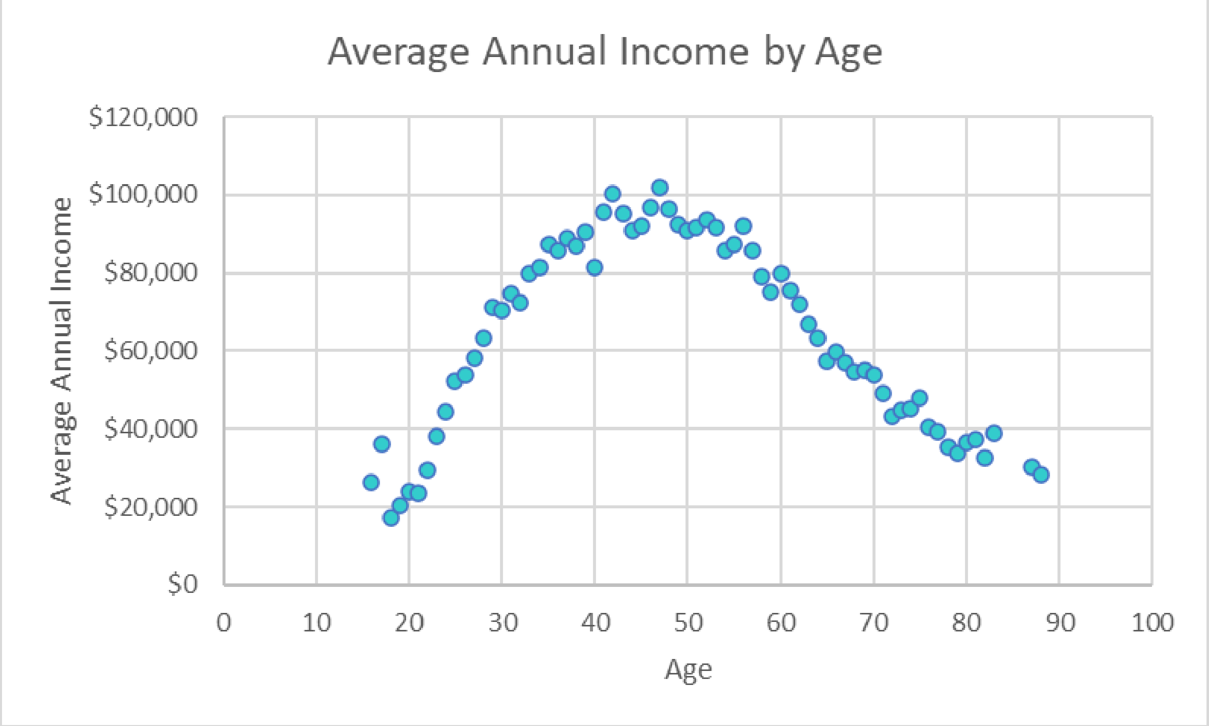

Men spend more than women – but that disparity is also variable at different ages

# Expenditures and Race



# Expenditures, Income and Age




Income and expenditures over time exhibits a quadratic relationship

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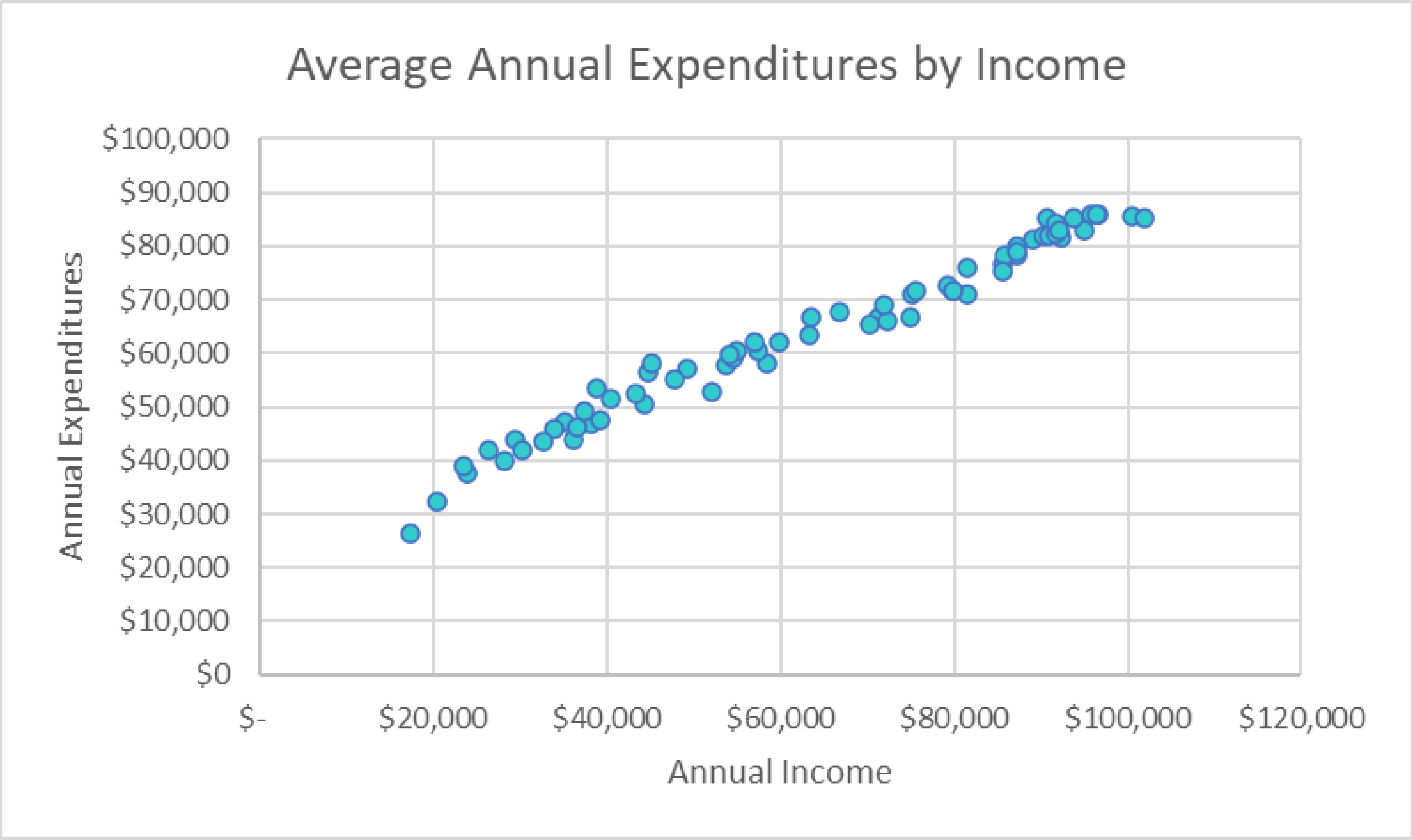
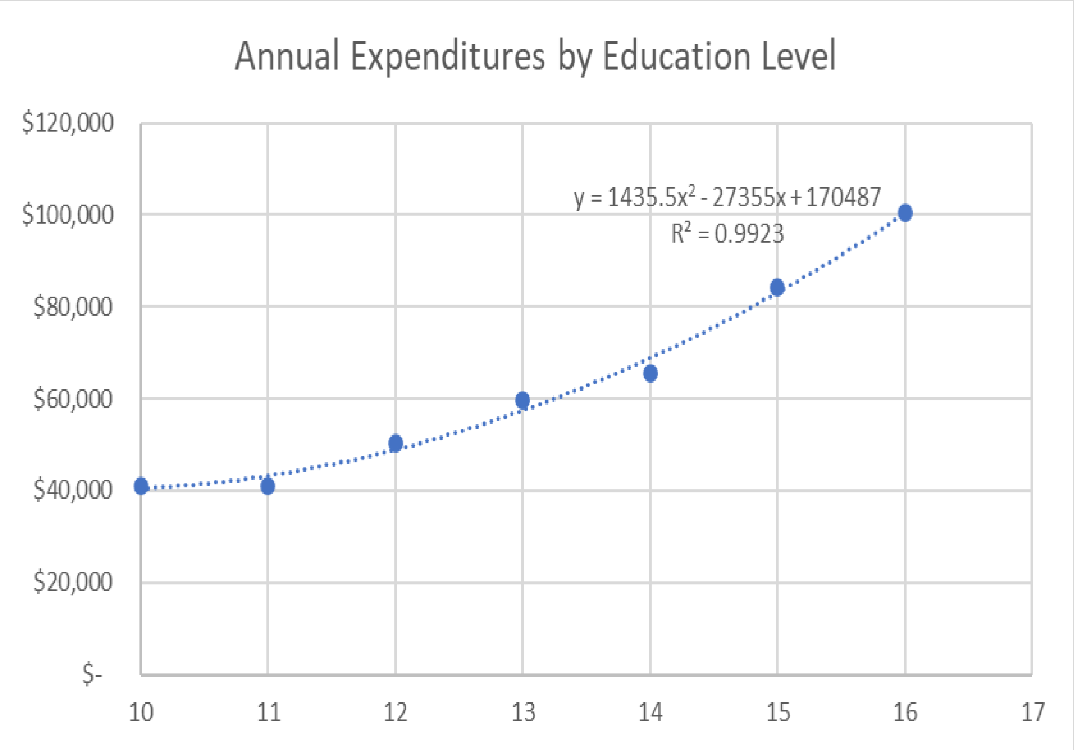
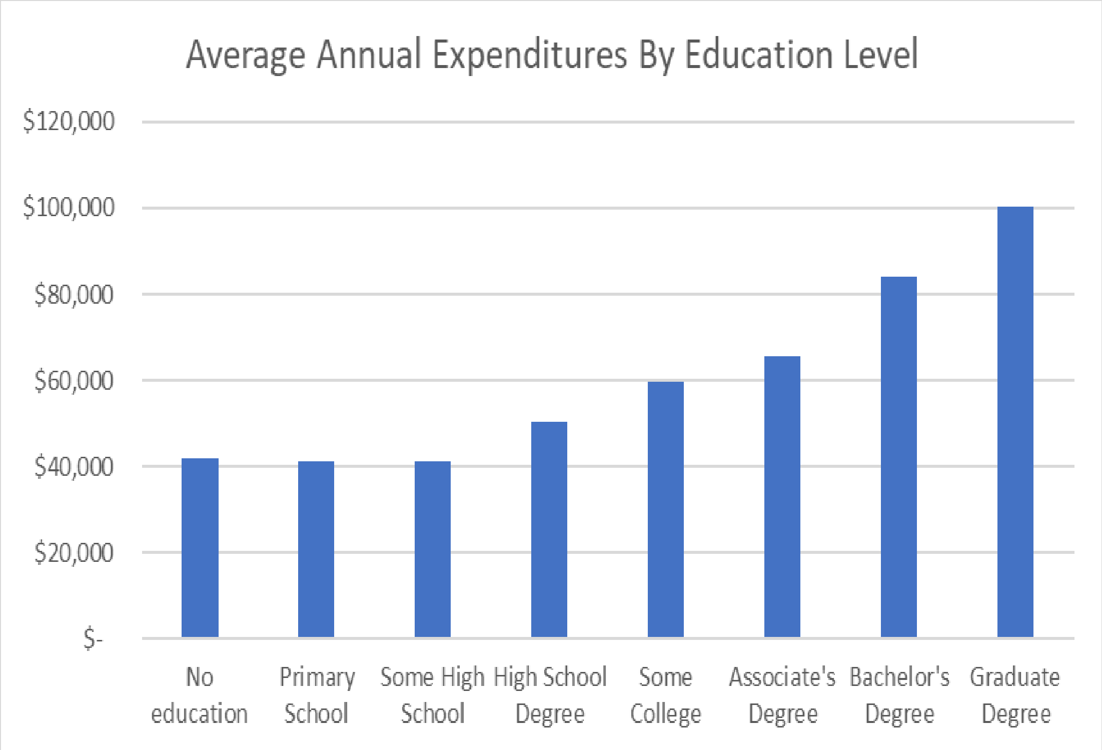
# Income and Expenditures




Income and expenditures seem linearly related – suggesting the marginal propensity to consume is independent of income

# Expenditures and Education




Additional education yields exponential increases to expenditures. Because our categorical variable on education generally increases education years by 2 from category-to-category, we can interpret the coefficient as a marginal return on an additional 2 years of education

# Social Cost of Greenhouse Gases – Overview

- What is SCGHG? Why is it relevant to our estimate?
- What does it capture? What does it not capture?
- What cost value should we use?
- How can we tie that back to our model?

# What is SCGHG? Why is it Relevant to Our Estimate?

- **Definition:** It is a monetized, discounted value of the stream of future, worldwide economic damages from a one-ton change in $CO_2$ emissions released **in a particular year**
- **Relevancy:** Allows us to capture **numerous** cost externalities that one human being may impose on other human beings
  - If we can estimate how much a specific person emits year-over-year, we can estimate how those emissions affect others
  - The corollary statement is also true – I can infer the costs others are imposing upon the specific individual

# What Does it Capture? What Does it Not Capture?

- **Included in Damage Function:**
  - Human health impacts
    - Changes in mortality
  - Damage to ecosystems
    - Animals & climates becoming less resilient to weather, causing costs to build & maintain capital to rise
  - Coastal Damages
    - Damage to capital from floods & other environmental disasters (indirectly)
  - Energy Consumption
    - How energy consumption costs will change due to additional $CO_2$ emissions
  - Change in agricultural output
    - Higher costs of making food due to poorer growing conditions, driving up costs
  - Effects on Labor Productivity
    - How emissions affect worker productivity, which can drive additional costs such as lost wages, higher healthcare costs, etc
    - Example: Higher temperatures' effect on workers who work outside all day – less hours, more damage to human
- **Excluded from Damage Function:**
  - Ocean acidification costs
  - Species & wildlife costs – too difficult to monetize
    - How much is the life of a wild animal worth?

# What Cost Value Is Most Appropriate?

- **Current Value:**
  - $62 a metric ton of $CO_2$ emitted in 2023
  - However, the dollar value changes based on when the emission occurs
  - Since individual emissions occur over time, we must dollarize emissions based on year they occur
- **Other Alternatives:**
  - $190 estimate from EPA in 2022 could be used instead
  - Benefit – The costs are extrapolated into 2080 instead of 2050
  - Cost – These are not the official Whitehouse numbers

**Conclusion:** Using White House official numbers is preferred to draft 2023 EPA estimates since the draft numbers are not official. Draft EPA numbers can be used during sensitivity analysis

# How Should We Tie this Back to Our Model?

- **Integration Logic:**
  - **Objective:** Tie emissions back to some key input parameters in our cost model
  - **Value:** "dollarize" emissions and all the indirect impacts they have on others
- **Integration Options:**
  - **EIA Data:** Use EIA data on average per-capita emissions by state as an estimate of individual's emissions, and dollarize those emissions based on those averages
    - Energy-Related Carbon Dioxide Emissions by State, 2005–2016 (eia.gov)
  - **GDP Per Capita Parametric Equation:** Calculate effect of GDP per capita on CO2 emissions, scale emissions and subsequent cost based on how much individual produces / spends
    - Research body seems mixed on this – is this relationship actually statistically significant?

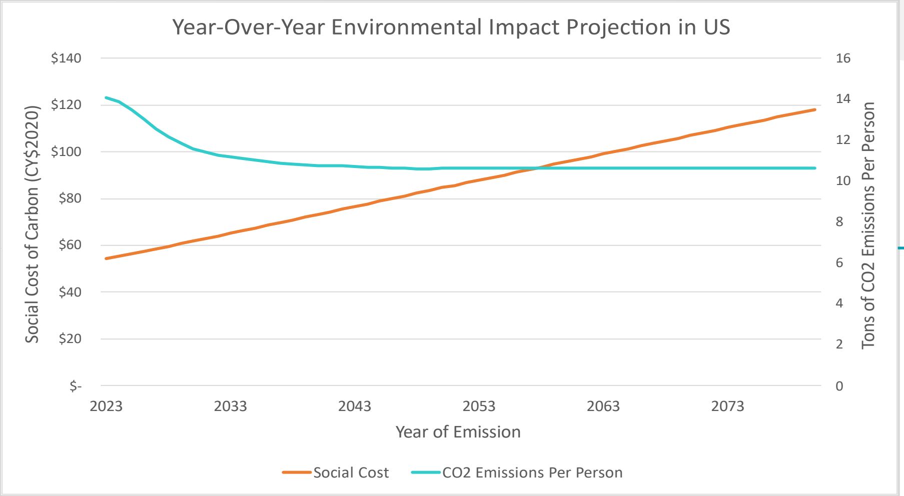
**Conclusion:** Use EIA data over GDP per capita parametric equation

# MODELING APPROACH

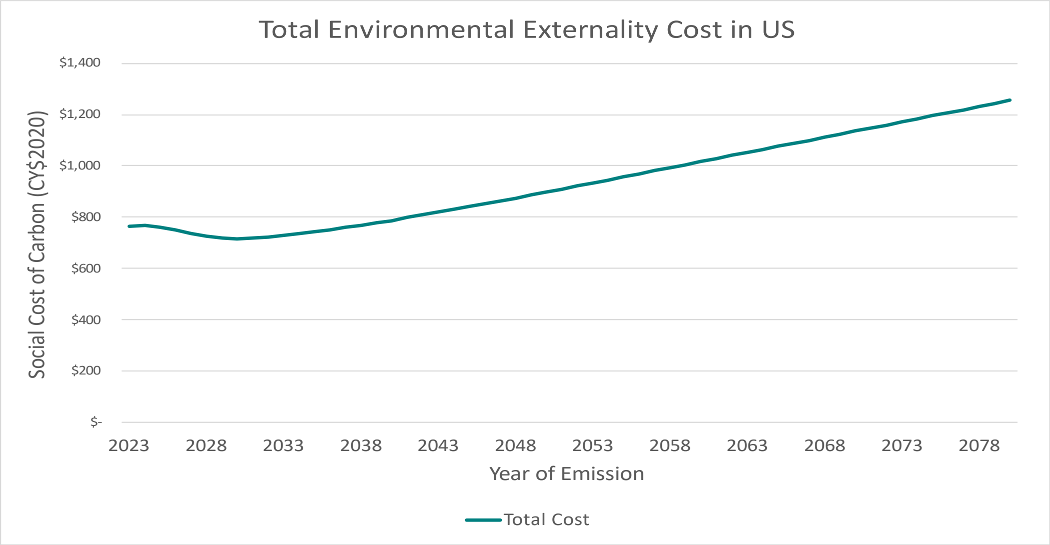
**CO2 Emissions Per Person in Region y:**
Year t

✖

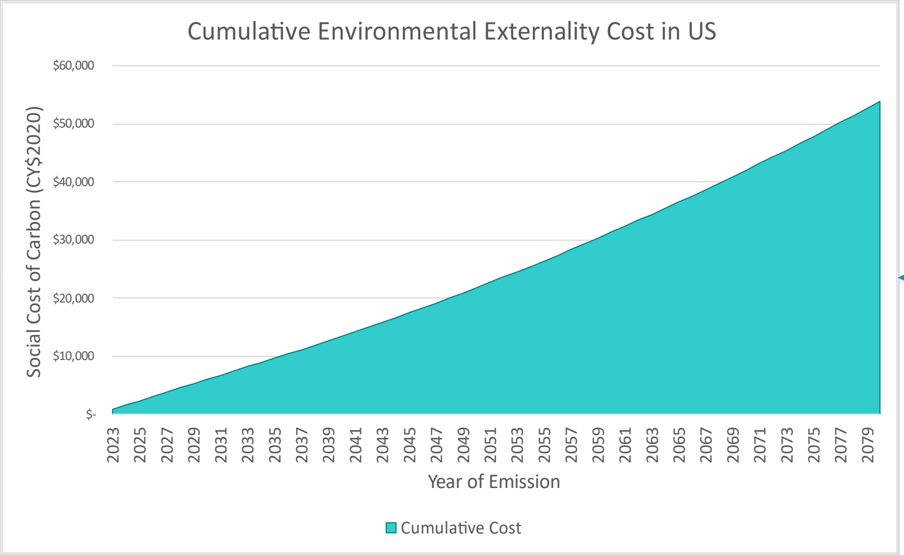
**SCGHG Estimate:**
Year t




**Total Environmental Externality Cost (EEC):**
Year t



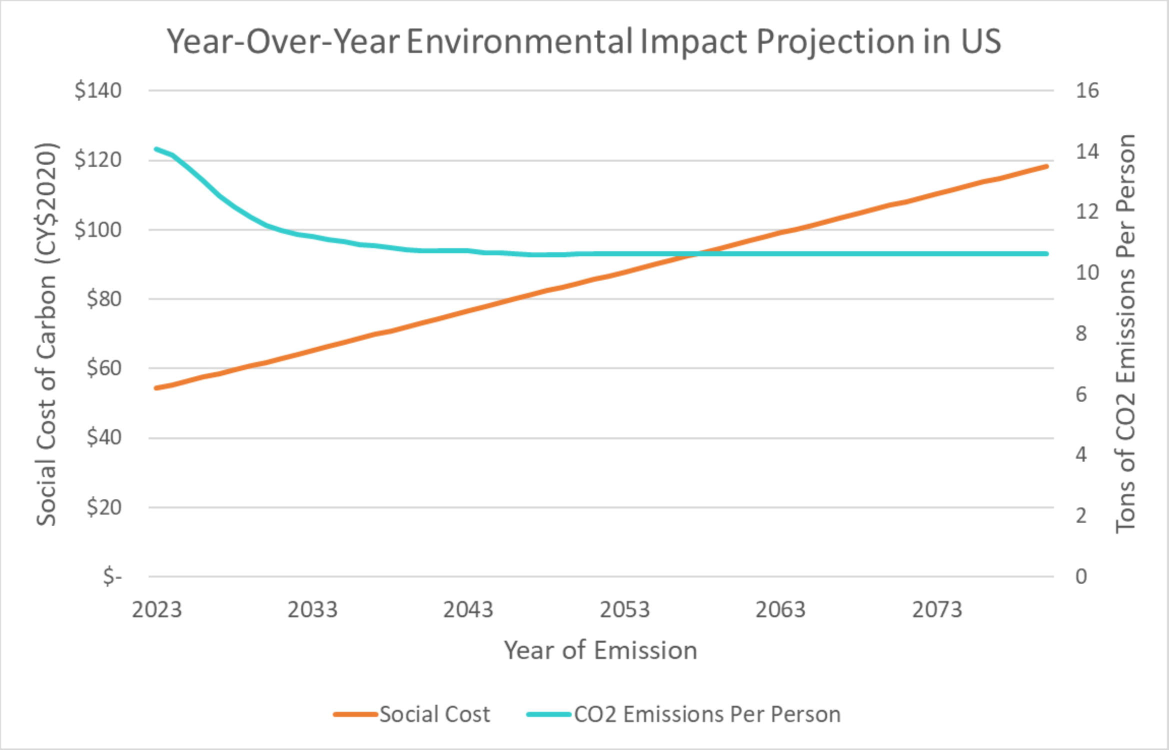

**Cumulative EEC** = $\sum_{t=1}^{n} EEC_{Year\ t}$

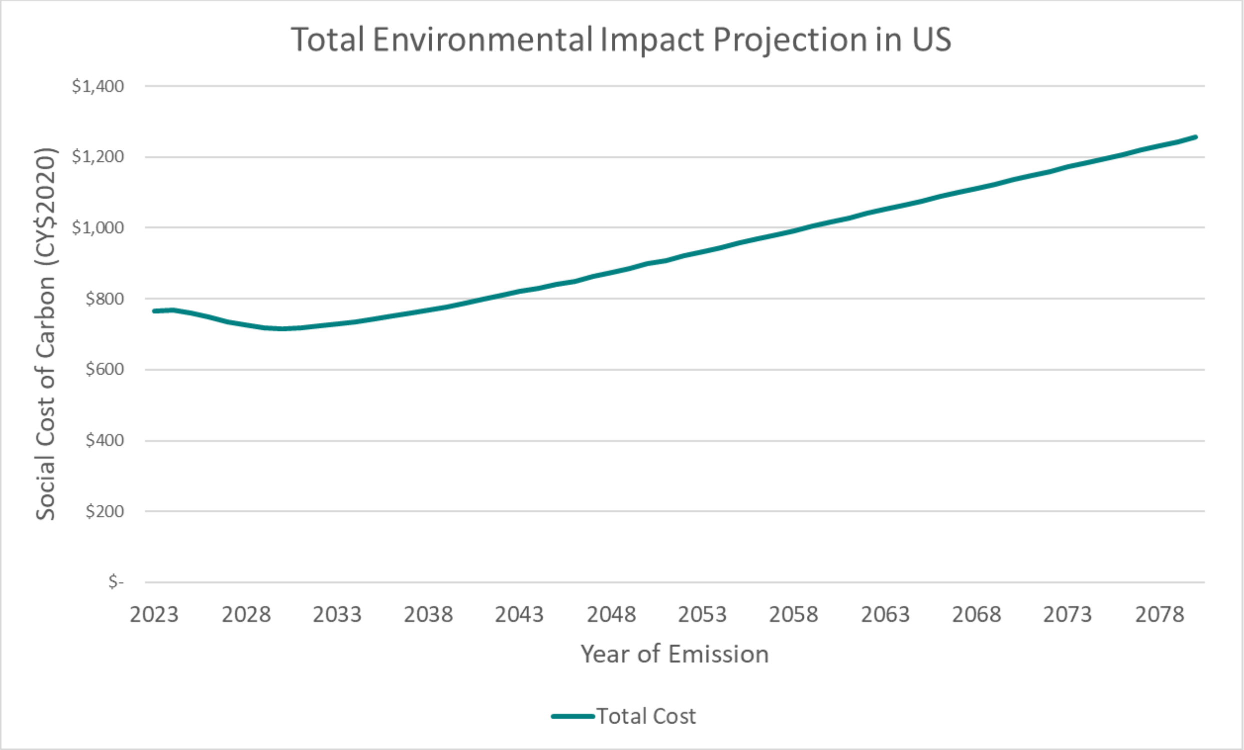



**Cumulative EEC**

$54,000

# Graphical Representation of Environmental Impact Analysis



# SCGHG Values over Time – Official WH Numbers

**Table A-1: Annual SC-$CO_2$, 2020 – 2050 (in 2020 dollars per metric ton of $CO_2$)**

| | Discount Rate and Statistic | | | |
|---|---|---|---|---|
| Emissions Year | 5% Average | 3% Average | 2.5% Average | 3% 95th Percentile |
| 2020 | 14 | 51 | 76 | 152 |
| 2021 | 15 | 52 | 78 | 155 |
| 2022 | 15 | 53 | 79 | 159 |
| 2023 | 16 | 54 | 80 | 162 |
| 2024 | 16 | 55 | 82 | 166 |
| 2025 | 17 | 56 | 83 | 169 |
| 2026 | 17 | 57 | 84 | 173 |
| 2027 | 18 | 59 | 86 | 176 |
| 2028 | 18 | 60 | 87 | 180 |
| 2029 | 19 | 61 | 88 | 183 |
| 2030 | 19 | 62 | 89 | 187 |
| 2031 | 20 | 63 | 91 | 191 |
| 2032 | 21 | 64 | 92 | 194 |
| 2033 | 21 | 65 | 94 | 198 |
| 2034 | 22 | 66 | 95 | 202 |
| 2035 | 22 | 67 | 96 | 206 |
| 2036 | 23 | 69 | 98 | 210 |
| 2037 | 23 | 70 | 99 | 213 |
| 2038 | 24 | 71 | 100 | 217 |
| 2039 | 25 | 72 | 102 | 221 |
| 2040 | 25 | 73 | 103 | 225 |
| 2041 | 26 | 74 | 104 | 228 |
| 2042 | 26 | 75 | 106 | 232 |
| 2043 | 27 | 77 | 107 | 235 |
| 2044 | 28 | 78 | 108 | 239 |
| 2045 | 28 | 79 | 110 | 242 |
| 2046 | 29 | 80 | 111 | 246 |
| 2047 | 30 | 81 | 112 | 249 |
| 2048 | 30 | 82 | 114 | 253 |
| 2049 | 31 | 84 | 115 | 256 |
| 2050 | 32 | 85 | 116 | 260 |

Technical Support Document: Social Cost of Carbon, Methane, (whitehouse.gov)

# SCGHG Values over Time – Updated 2022 Numbers

*EXTERNAL REVIEW DRAFT*

**A.4. Annual Unrounded SC-$CO_2$, SC-$CH_4$, and SC-$N_2O$ Values, 2020-2080**

*Table 4.2.1: Unrounded SC-$CO_2$, SC-$CH_4$, and SC-$N_2O$ Values, 2020-2080*

| | SC-GHG and Near-term Ramsey Discount Rate | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | SC-$CO_2$ (2020 dollars per metric ton of $CO_2$) | | | SC-$CH_4$ (2020 dollars per metric ton of $CH_4$) | | | SC-$N_2O$ (2020 dollars per metric ton of $N_2O$) | | |
| Emission Year | 2.5% | 2.0% | 1.5% | 2.5% | 2.0% | 1.5% | 2.5% | 2.0% | 1.5% |
| 2020 | 117 | 193 | 337 | 1,257 | 1,648 | 2,305 | 35,232 | 54,139 | 87,284 |
| 2021 | 119 | 197 | 341 | 1,324 | 1,723 | 2,391 | 36,180 | 55,364 | 88,869 |
| 2022 | 122 | 200 | 346 | 1,390 | 1,799 | 2,478 | 37,128 | 56,590 | 90,454 |
| 2023 | 125 | 204 | 351 | 1,457 | 1,874 | 2,564 | 38,076 | 57,816 | 92,040 |
| 2024 | 128 | 208 | 356 | 1,524 | 1,950 | 2,650 | 39,024 | 59,041 | 93,625 |
| 2025 | 130 | 212 | 360 | 1,590 | 2,025 | 2,737 | 39,972 | 60,267 | 95,210 |
| 2026 | 133 | 215 | 365 | 1,657 | 2,101 | 2,823 | 40,920 | 61,492 | 96,796 |
| 2027 | 136 | 219 | 370 | 1,724 | 2,176 | 2,910 | 41,868 | 62,718 | 98,381 |
| 2028 | 139 | 223 | 375 | 1,791 | 2,252 | 2,996 | 42,816 | 63,944 | 99,966 |
| 2029 | 141 | 226 | 380 | 1,857 | 2,327 | 3,083 | 43,764 | 65,169 | 101,552 |
| 2030 | 144 | 230 | 384 | 1,924 | 2,403 | 3,169 | 44,712 | 66,395 | 103,137 |
| 2031 | 147 | 234 | 389 | 2,002 | 2,490 | 3,270 | 45,693 | 67,645 | 104,727 |
| 2032 | 150 | 237 | 394 | 2,080 | 2,578 | 3,371 | 46,674 | 68,895 | 106,316 |
| 2033 | 153 | 241 | 398 | 2,157 | 2,666 | 3,471 | 47,655 | 70,145 | 107,906 |
| 2034 | 155 | 245 | 403 | 2,235 | 2,754 | 3,572 | 48,636 | 71,394 | 109,495 |
| 2035 | 158 | 248 | 408 | 2,313 | 2,842 | 3,673 | 49,617 | 72,644 | 111,085 |
| 2036 | 161 | 252 | 412 | 2,391 | 2,929 | 3,774 | 50,598 | 73,894 | 112,674 |
| 2037 | 164 | 256 | 417 | 2,468 | 3,017 | 3,875 | 51,578 | 75,144 | 114,264 |
| 2038 | 167 | 259 | 422 | 2,546 | 3,105 | 3,975 | 52,559 | 76,394 | 115,853 |
| 2039 | 170 | 263 | 426 | 2,624 | 3,193 | 4,076 | 53,540 | 77,644 | 117,443 |
| 2040 | 173 | 267 | 431 | 2,702 | 3,280 | 4,177 | 54,521 | 78,894 | 119,032 |
| 2041 | 176 | 271 | 436 | 2,786 | 3,375 | 4,285 | 55,632 | 80,304 | 120,809 |
| 2042 | 179 | 275 | 441 | 2,871 | 3,471 | 4,394 | 56,744 | 81,714 | 122,586 |
| 2043 | 182 | 279 | 446 | 2,955 | 3,566 | 4,502 | 57,855 | 83,124 | 124,362 |
| 2044 | 186 | 283 | 451 | 3,040 | 3,661 | 4,610 | 58,966 | 84,535 | 126,139 |
| 2045 | 189 | 287 | 456 | 3,124 | 3,756 | 4,718 | 60,078 | 85,945 | 127,916 |
| 2046 | 192 | 291 | 462 | 3,209 | 3,851 | 4,827 | 61,189 | 87,355 | 129,693 |
| 2047 | 195 | 296 | 467 | 3,293 | 3,946 | 4,935 | 62,301 | 88,765 | 131,469 |
| 2048 | 199 | 300 | 472 | 3,378 | 4,041 | 5,043 | 63,412 | 90,176 | 133,246 |
| 2049 | 202 | 304 | 477 | 3,462 | 4,136 | 5,151 | 64,523 | 91,586 | 135,023 |
| 2050 | 205 | 308 | 482 | 3,547 | 4,231 | 5,260 | 65,635 | 92,996 | 136,799 |

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*EXTERNAL REVIEW DRAFT*

*Table 4.2.2: Unrounded SC-$CO_2$, SC-$CH_4$, and SC-$N_2O$ Values, 2020-2080 (continued…)*

| | SC-GHG and Near-term Ramsey Discount Rate | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | SC-$CO_2$ (2020 dollars per metric ton of $CO_2$) | | | SC-$CH_4$ (2020 dollars per metric ton of $CH_4$) | | | SC-$N_2O$ (2020 dollars per metric ton of $N_2O$) | | |
| Emission Year | 2.5% | 2.0% | 1.5% | 2.5% | 2.0% | 1.5% | 2.5% | 2.0% | 1.5% |
| 2050 | 205 | 308 | 482 | 3,547 | 4,231 | 5,260 | 65,635 | 92,996 | 136,799 |
| 2051 | 208 | 312 | 487 | 3,624 | 4,320 | 5,363 | 66,673 | 94,319 | 138,479 |
| 2052 | 211 | 315 | 491 | 3,701 | 4,409 | 5,466 | 67,712 | 95,642 | 140,158 |
| 2053 | 214 | 319 | 496 | 3,779 | 4,497 | 5,569 | 68,750 | 96,965 | 141,838 |
| 2054 | 217 | 323 | 500 | 3,856 | 4,586 | 5,672 | 69,789 | 98,288 | 143,517 |
| 2055 | 220 | 326 | 505 | 3,933 | 4,675 | 5,774 | 70,827 | 99,612 | 145,196 |
| 2056 | 222 | 330 | 510 | 4,011 | 4,763 | 5,877 | 71,866 | 100,935 | 146,876 |
| 2057 | 225 | 334 | 514 | 4,088 | 4,852 | 5,980 | 72,904 | 102,258 | 148,555 |
| 2058 | 228 | 338 | 519 | 4,165 | 4,941 | 6,083 | 73,943 | 103,581 | 150,235 |
| 2059 | 231 | 341 | 523 | 4,243 | 5,029 | 6,186 | 74,981 | 104,904 | 151,914 |
| 2060 | 234 | 345 | 528 | 4,320 | 5,118 | 6,289 | 76,020 | 106,227 | 153,594 |
| 2061 | 236 | 348 | 532 | 4,389 | 5,199 | 6,385 | 76,920 | 107,385 | 155,085 |
| 2062 | 239 | 351 | 535 | 4,458 | 5,280 | 6,480 | 77,820 | 108,542 | 156,576 |
| 2063 | 241 | 354 | 539 | 4,527 | 5,361 | 6,576 | 78,720 | 109,700 | 158,066 |
| 2064 | 244 | 357 | 543 | 4,596 | 5,442 | 6,671 | 79,620 | 110,857 | 159,557 |
| 2065 | 246 | 360 | 547 | 4,666 | 5,523 | 6,767 | 80,520 | 112,015 | 161,048 |
| 2066 | 248 | 363 | 550 | 4,735 | 5,604 | 6,862 | 81,419 | 113,172 | 162,539 |
| 2067 | 251 | 366 | 554 | 4,804 | 5,685 | 6,958 | 82,319 | 114,330 | 164,030 |
| 2068 | 253 | 369 | 558 | 4,873 | 5,765 | 7,053 | 83,219 | 115,487 | 165,521 |
| 2069 | 256 | 372 | 562 | 4,942 | 5,846 | 7,149 | 84,119 | 116,645 | 167,012 |
| 2070 | 258 | 375 | 565 | 5,011 | 5,927 | 7,244 | 85,019 | 117,802 | 168,503 |
| 2071 | 261 | 378 | 569 | 5,085 | 6,013 | 7,344 | 86,012 | 119,027 | 170,013 |
| 2072 | 263 | 382 | 573 | 5,160 | 6,099 | 7,444 | 87,006 | 120,252 | 171,523 |
| 2073 | 266 | 385 | 576 | 5,234 | 6,184 | 7,545 | 87,999 | 121,477 | 173,033 |
| 2074 | 269 | 388 | 580 | 5,309 | 6,270 | 7,645 | 88,992 | 122,702 | 174,543 |
| 2075 | 271 | 391 | 583 | 5,383 | 6,355 | 7,745 | 89,985 | 123,926 | 176,053 |
| 2076 | 274 | 394 | 587 | 5,458 | 6,441 | 7,845 | 90,978 | 125,151 | 177,563 |
| 2077 | 276 | 398 | 591 | 5,532 | 6,527 | 7,946 | 91,971 | 126,376 | 179,073 |
| 2078 | 279 | 401 | 594 | 5,607 | 6,612 | 8,046 | 92,964 | 127,601 | 180,582 |
| 2079 | 282 | 404 | 598 | 5,681 | 6,698 | 8,146 | 93,958 | 128,826 | 182,092 |
| 2080 | 284 | 407 | 601 | 5,756 | 6,783 | 8,246 | 94,951 | 130,050 | 183,602 |

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Using the draft 2022 numbers, enables extrapolation of SCGHG to 2080, unlike 2021 estimates which end in 2050. However the cost estimate is much higher, which will have a huge impact on results

Supplementary Material for the Regulatory Impact Analysis for the Supplemental Proposed Rulemaking, "Standards of Performance for New, Reconstructed, and Modified Sources and Emissions Guidelines for Existing Sources: Oil and Natural Gas Sector Climate Review": EPA External Review Draft of Report on the Social Cost of Greenhouse Gases: Estimates Incorporating Recent Scientific Advances

# US States by Region and Division

| State | Abbreviation | Region | Division |
|---|---|---|---|
| Alabama | AL | East South Central | South |
| Alaska | AK | Pacific | West |
| Arizona | AZ | Mountain | West |
| Arkansas | AR | West South Central | South |
| California | CA | Pacific | West |
| Colorado | CO | Mountain | West |
| Connecticut | CT | New England | Northeast |
| Delaware | DE | South Atlantic | South |
| District of Columbia | DC | South Atlantic | South |
| Florida | FL | South Atlantic | South |
| Georgia | GA | South Atlantic | South |
| Hawaii | HI | Pacific | West |
| Idaho | ID | Mountain | West |
| Illinois | IL | East North Central | Midwest |
| Indiana | IN | East North Central | Midwest |
| Iowa | IA | West North Central | Midwest |
| Kansas | KS | West North Central | Midwest |
| Kentucky | KY | East South Central | South |
| Louisiana | LA | West South Central | South |
| Maine | ME | New England | Northeast |
| Maryland | MD | South Atlantic | South |
| Massachusetts | MA | New England | Northeast |
| Michigan | MI | East North Central | Midwest |
| Minnesota | MN | West North Central | Midwest |
| Mississippi | MS | East South Central | South |
| Missouri | MO | West North Central | Midwest |
| Montana | MT | Mountain | West |
| Nebraska | NE | West North Central | Midwest |
| Nevada | NV | Mountain | West |
| New Hampshire | NH | New England | Northeast |
| New Jersey | NJ | Middle Atlantic | Northeast |
| New Mexico | NM | Mountain | West |
| New York | NY | Middle Atlantic | Northeast |
| North Carolina | NC | South Atlantic | South |
| North Dakota | ND | West North Central | Midwest |
| Ohio | OH | East North Central | Midwest |
| Oklahoma | OK | West South Central | South |
| Oregon | OR | Pacific | West |
| Pennsylvania | PA | Middle Atlantic | Northeast |
| Rhode Island | RI | New England | Northeast |
| South Carolina | SC | South Atlantic | South |
| South Dakota | SD | West North Central | Midwest |
| Tennessee | TN | East South Central | South |
| Texas | TX | West South Central | South |
| Utah | UT | Mountain | West |
| Vermont | VT | New England | Northeast |
| Virginia | VA | South Atlantic | South |
| Washington | WA | Pacific | West |
| West Virginia | WV | South Atlantic | South |
| Wisconsin | WI | East North Central | Midwest |
| Wyoming | WY | Mountain | West |