B. Regression Analysis Results

In this appendix, we present the results of our analysis of changes in total energy intensity and changes in energy intensity by energy-consuming sector over the period of study (1977–1999).

**Total Energy Intensity Regression Results**

Our model of annual energy intensity for any given state (among the 48 contiguous states) measures overall energy intensity as the log of total primary energy consumption\(^1\) divided by total GSP. In measuring overall energy intensity, we control for the following variables:

- Log of population per GSP
- Log of average residential energy price
- Log of average transportation energy price
- Log of average industrial energy price
- Log of average commercial energy price
- Log of square footage of commercial floor space/GSP
- Log of percent of GSP from energy-intensive manufacturing\(^2\)
- Log of air transportation GSP per capita
- Heating-degree days
- Cooling-degree days.

Our regression results for total energy intensity are presented in Table B.1. As seen from the table, population per GSP has a large positive effect on total energy intensity. Higher energy prices have a negative effect on total energy intensity, as expected, except for higher commercial energy prices, which have a positive effect. The magnitude of the commercial energy price coefficient is small relative to the energy price coefficients for residential, transportation, and industrial sectors.

---

\(^1\)As we stated in Appendix A, primary energy consumption includes both energy consumed by end users and energy losses from the generation and distribution of that energy.

\(^2\)Energy-intensive manufacturing includes manufacturing done in the following industries: paper, glass, primary metals, chemicals, and petroleum.
Table B.1
Total Energy Intensity Regression Variables

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Population per GSP&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.8508</td>
<td>0.0574</td>
<td>0.0000</td>
</tr>
<tr>
<td>Residential Energy Prices&lt;sup&gt;a&lt;/sup&gt;</td>
<td>-0.2104</td>
<td>0.0282</td>
<td>0.0000</td>
</tr>
<tr>
<td>Transportation Energy Prices&lt;sup&gt;a&lt;/sup&gt;</td>
<td>-0.1706</td>
<td>0.0393</td>
<td>0.0000</td>
</tr>
<tr>
<td>Industrial Energy Prices&lt;sup&gt;a&lt;/sup&gt;</td>
<td>-0.2575</td>
<td>0.0145</td>
<td>0.0000</td>
</tr>
<tr>
<td>Commercial Energy Prices&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.0542</td>
<td>0.0181</td>
<td>0.0030</td>
</tr>
<tr>
<td>Commercial Floor Space</td>
<td>0.0661</td>
<td>0.0519</td>
<td>0.2030</td>
</tr>
<tr>
<td>Energy-Intensive Manufacturing&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.0783</td>
<td>0.0094</td>
<td>0.0000</td>
</tr>
<tr>
<td>Air Transportation per GSP&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.0129</td>
<td>0.0052</td>
<td>0.0130</td>
</tr>
<tr>
<td>Heating-Degree Days&lt;sup&gt;a&lt;/sup&gt;</td>
<td>2.06E-05</td>
<td>6.07E-06</td>
<td>0.0010</td>
</tr>
<tr>
<td>Cooling-Degree Days&lt;sup&gt;a&lt;/sup&gt;</td>
<td>2.92E-05</td>
<td>1.42E-05</td>
<td>0.0400</td>
</tr>
</tbody>
</table>

Number of Observations 1,104
R-Squared 0.9854
Adjusted R-Squared 0.9843

<sup>a</sup>Significant at the 5% level.

NOTE: All variables except for heating-degree and cooling-degree days are in log form.

energy prices. Also as expected, increases in the share of GSP accounted for by energy-intensive sectors of the economy have a positive effect on energy intensity. Increased numbers of heating-degree and cooling-degree days figure positively in the model but are statistically insignificant.

The adjusted R-squared in this model is very high—more than 0.98. (This is also the case in the sector-specific models described later in this appendix.) Fixed-effect models such as this one tend to have a high R-squared because state and year fixed effects are generally very powerful explanatory variables. That is, much of the variation in energy intensity is fixed across states or over time.

Beyond the issue of bias discussed in Chapter 4, multicollinearity is a potential problem in the regression for overall energy intensity and in the sector-specific regressions discussed later. This is particularly true for residential, commercial, industrial, and transportation energy prices, which no doubt are all influenced by similar factors and therefore vary together over time. Multicollinearity violates no regression assumptions. In practice, though, it can be difficult to obtain precise estimates of the coefficients of correlated variables due to insufficient variation in the data. With high multicollinearity, few coefficients tend to be statistically significant individually, whereas their joint significance is high. In this case, however, our standard errors are reasonable, and most of the variables we include are statistically significant on an individual basis. Also, the coefficient estimates tend to be sensitive to changes in the choice of variables. Our results
are robust even with the omission of particular energy price variables. In any case, we are most interested in the joint explanatory power of the included variables because what we care about is the residual energy intensity rather than the effect of any particular included variable. Multicollinearity does not affect estimation of the residual; variation attributable to the independent variables is picked up jointly.

**Industrial Energy Intensity Regression Results**

The EIA defines the industrial sector as “an energy-consuming sector that consists of all facilities and equipment used for producing, processing, and assembling goods. The industrial sector encompasses the following types of activities: manufacturing; agriculture, forestry, and fisheries; mining; and construction” (EIA, 2000). For our analysis, we use a common measure of industrial energy intensity—energy consumption divided by GSP originating from the industrial sector. The EIA industrial energy consumption data also include fossil fuels used as raw material input for manufactured products. Because nonenergy uses of fuels have little to do with energy efficiency, we made an attempt to exclude nonenergy uses by subtracting fuels that are used solely as feedstock.\(^3\)

We controlled for the following exogenous variables (X) in the industrial energy intensity regression (see Table B.2):

- Sum of heating-degree and cooling-degree days
- Log of industrial energy prices (weighted average)
- Log of percent of petroleum, paper, and metallurgy industries in the industrial sector GSP
- Log of percent of glass and chemical industries in industrial GSP

---

\(^3\)EIA provides energy consumption data by fuel type, not by end use. We are not able to net out all the nonenergy producing uses for fuels because many fuel products can be used as both energy and feedstock. For the purposes of our analysis, we constructed the following energy-consumption variable (also shown in Table A.1):

Industrial primary energy consumption net of feedstocks (Btus) = Total primary energy consumed in the industrial sector (TEICB) less petrochemical feedstocks (naptha less than 401 degrees F [FNICB], other oils equal to or greater than 401 degrees F [FOICB], still gas [FSICB]), asphalt and road oil (ARICB), lubricants (LUICB), special napthas (SNICB), miscellaneous petroleum products (MSICB), and waxes (WXICB).
Table B.2
Industrial Sector Energy Intensity Regression Variables

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Climate</td>
<td>0.0000277</td>
<td>0.0000177</td>
<td>0.117</td>
</tr>
<tr>
<td>Energy Prices&lt;sup&gt;a&lt;/sup&gt;</td>
<td>-0.7082609</td>
<td>0.0423190</td>
<td>0.000</td>
</tr>
<tr>
<td>Percent of Industrial GSP from Petroleum, Paper,</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>and Metallurgy&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.1268425</td>
<td>0.0200773</td>
<td>0.000</td>
</tr>
<tr>
<td>Glass and Chemical</td>
<td>0.0385979</td>
<td>0.0214376</td>
<td>0.072</td>
</tr>
<tr>
<td>Percent of Industrial GSP from Food, Textile, and</td>
<td>0.3253237</td>
<td>0.0274957</td>
<td>0.000</td>
</tr>
<tr>
<td>Lumber&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.0784011</td>
<td>0.0149293</td>
<td>0.000</td>
</tr>
<tr>
<td>Mining&lt;sup&gt;a&lt;/sup&gt;</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Percent of Industrial GSP from Agriculture&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.0943333</td>
<td>0.0238024</td>
<td>0.000</td>
</tr>
<tr>
<td>New Capital Expenditures</td>
<td>0.0180824</td>
<td>0.0182403</td>
<td>0.322</td>
</tr>
<tr>
<td>Deviation from Equilibrium GSP&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.8347203</td>
<td>0.1135579</td>
<td>0.000</td>
</tr>
<tr>
<td>Number of Observations</td>
<td>1,104</td>
<td></td>
<td></td>
</tr>
<tr>
<td>R-Squared</td>
<td>0.940</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adjusted R-Squared</td>
<td>0.940</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<sup>a</sup>Significant at the 5% level.

NOTE: All variables except for climate are in log form.

- Log of percent of food, textile, and lumber industries in industrial GSP
- Log of percent of mining industry in industrial GSP
- Log of percent of agriculture industry in industrial GSP
- Log of new capital expenditures in the manufacturing subsector divided by GSP in the manufacturing subsector
- Log of percent of deviation from equilibrium industrial GSP.

We used the following equation to estimate the regression:

\[
\text{Industrial energy intensity}_{s,t} = a + b_0 \text{Sum of Heating- and Cooling-Degree Days}_{s,t} + b_1 \text{Industrial Energy Prices}_{s,t} + b_2 \text{Percent of Industrial GSP from Petroleum, Paper, and Metallurgy}_{s,t} + b_3 \text{Percent of Industrial GSP from Glass and Chemical}_{s,t} + b_4 \text{Percent of Industrial GSP from Food, Textile, and Lumber}_{s,t} + b_5 \text{Percent of Industrial GSP from Mining}_{s,t} + b_6 \text{Percent of Industrial GSP from Agriculture} + b_7 \text{New Capital Expenditures}_{s,t} + b_8 \text{Percent Deviation from Equilibrium GSP}_{s,t} + \text{State Fixed Effect}_s + \text{Time Fixed Effect}_t
\]
Energy Prices

Higher energy prices are expected to have a negative effect on energy consumption. Higher energy prices should reduce the demand for energy in the industrial sector through more-energy-efficient operations and substituting energy-consuming production methods with methods that use less energy. We use the weighted average of the price of all fuels and find that the effect of prices is significant and has a negative effect on energy intensity.

Structure of Industrial Sector

Structural changes in industrial subsectors that have different energy intensity levels may have a substantial effect on energy use. Using national-level data from the EIA on the energy intensity of industrial subsectors (see Appendix A), we generated five groups of subsectors that are more energy intensive than others to varying degrees. The subsector variables used in this regression are constructed as each subsector’s share of the industrial GSP in a log form.

We would expect the effect of these variables to be positive because these industries are more energy intensive than others. Therefore, if their share of the industrial GSP grows, overall industrial sector energy intensity should increase. In the regression, we find a positive effect from an increase in any subsectors’ share of the industrial GSP, with only the glass and chemical subsector variables being insignificant.

Capital Turnover

Replacing old capital may decrease energy intensity because energy-efficient technologies develop with time. We define new capital investment in the industrial sector as a percentage of the sector’s GSP to approximate the effect of new capital on energy intensity and to control for it. Although this variable also has an effect on energy intensity over later years that diminishes with time, we are not able to account for those changes because our data are limited to the 1977 through 1999 period, and data on the other relevant alternative variable, the age of capital stock, are not available.

Capacity Utilization

Energy consumption per dollar value of output depends on capacity utilization—more energy per output is usually needed when capacity is underutilized because of fixed requirements for energy to run the production
process. There is, of course, a limit to this relationship because older equipment may become less efficient if it is used to full capacity. We approximate this factor with a business-cycle measure—percent deviation from equilibrium industrial GSP. We computed equilibrium industrial GSP by smoothing industrial GSP with a backward- and forward-looking moving average.\(^4\) The capacity underutilization proxy is defined as the log of equilibrium industrial GSP divided by the actual GSP. We would expect the sign of the coefficient on this variable to be positive—the larger the underutilization of capacity, the larger the consumption of energy—and it is in fact positive and significant.

Finally, we use climate—the sum of heating-degree and cooling-degree days—to control for changes in energy intensity due to seasonal changes in the weather that may affect the amount of energy needed for heating and air-conditioning. This variable is not significant.

**Commercial Energy Intensity Regression Results**

Any energy consumption that is not for residential, industrial, or transportation purposes falls into this category, which by convention is referred to as the commercial energy consumption sector.\(^5\) While energy consumed by this sector includes energy used by public offices and for various public purposes, most of the energy use in this sector can be attributed to the production of services. Thus, to measure energy intensity in this sector, we divided energy consumption by the GSP originating from services production (transportation and utilities excluded).

We controlled for the following exogenous variables in the commercial energy intensity regression (see Table B.3):

- Heating-degree days
- Cooling-degree days
- Log of commercial floor space per GSP from services production
- Log of commercial average energy prices
- Log of population per GSP from services production
- Log of commercial sector employment per GSP from services production
- Log of percent of commercial GSP from educational services production

\(^4\)A Hodrick-Prescott filter was used to do this computation.

\(^5\)The commercial sector is defined in the EIA database as “an energy-consuming sector that consists of the service-providing facilities and the equipment of businesses; federal, state, and local governments; and other private and public organizations … [and] institutional living headquarters.”
Table B.3
Commercial Sector Energy Intensity Regression Variables

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heating-Degree Days(^a)</td>
<td>0.0000741</td>
<td>0.0000136</td>
<td>0.000</td>
</tr>
<tr>
<td>Cooling-Degree Days(^a)</td>
<td>0.0000633</td>
<td>0.0000315</td>
<td>0.045</td>
</tr>
<tr>
<td>Floor Space per GSP from Services</td>
<td>-0.1143808</td>
<td>0.1152337</td>
<td>0.321</td>
</tr>
<tr>
<td>Energy Prices(^a)</td>
<td>-0.2044511</td>
<td>0.0368456</td>
<td>0.000</td>
</tr>
<tr>
<td>Population per GSP from Services(^a)</td>
<td>0.1540582</td>
<td>0.1403543</td>
<td>0.273</td>
</tr>
<tr>
<td>Employment per GSP from Services(^a)</td>
<td>0.9142759</td>
<td>0.1171089</td>
<td>0.000</td>
</tr>
<tr>
<td>Commercial GSP from Education</td>
<td>0.0532051</td>
<td>0.0450773</td>
<td>0.238</td>
</tr>
<tr>
<td>Commercial GSP from Retail Trade(^a)</td>
<td>-0.4582944</td>
<td>0.0869897</td>
<td>0.000</td>
</tr>
<tr>
<td>Commercial GSP from F.I.R.E. and Legal(^a)</td>
<td>0.1943485</td>
<td>0.0904856</td>
<td>0.032</td>
</tr>
<tr>
<td>Commercial GSP from Health(^a)</td>
<td>0.2080429</td>
<td>0.0628284</td>
<td>0.001</td>
</tr>
<tr>
<td>Number of Observations</td>
<td>1,104</td>
<td></td>
<td></td>
</tr>
<tr>
<td>R-Squared</td>
<td>0.891</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adjusted R-Squared</td>
<td>0.882</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\(^a\)Significant at the 5% level.

NOTE: All variables except for heating-degree days and cooling-degree days are in log form.

- Log of percent of commercial GSP from retail trade
- Log of percent of commercial GSP from F.I.R.E. and legal services production
- Log of percent of commercial GSP from health industry production.

We used the following equation to estimate the regression:

\[
\text{Commercial Energy Intensity}_{s,t} = a + b_0 \text{Heating-Degree Days}_{s,t} + b_1 \text{Cooling-Degree Days}_{s,t} + b_2 \text{Commercial Floor Space}_{s,t} + b_3 \text{Commercial Energy Prices}_{s,t} + b_4 \text{Population/Commercial GSP}_{s,t} + b_5 \text{Commercial Sector Employment}_{s,t} + b_6 \text{Percent of Commercial GSP from Educational Services (reserve)}_{s,t} + b_7 \text{Percent of Commercial GSP from Retail Trade}_{s,t} + b_8 \text{Percent of Commercial GSP from F.I.R.E. and Legal}_{s,t} + b_9 \text{Percent of Commercial GSP from Health}_{s,t} + \text{State Fixed Effect}_{s} + \text{Time Fixed Effect}_{t}
\]

Energy Prices

Energy prices are expected to have a negative effect on energy consumption because rising energy prices may stimulate energy conservation and efficiency measures in the commercial sector. We use a weighted average of the prices of all
fuels and find that the effect of rising energy prices on energy intensity is significant and negative.

**Commercial Floor Space**

Heating, lighting, and air-conditioning consume a major portion of the energy used by this sector. The consumption of energy for these purposes depends on the square footage of floor space in buildings, which is why commercial floor space is included in the regression. We would expect increasing square footage of floor space to have a positive effect on energy intensity; however, we found in the regression that floor space per GSP in the commercial sector is insignificant. It may be the case that square footage of floor space would be a significant variable if we were able to disaggregate the regression according to building type.

**Employment in the Commercial Sector and Population**

It is possible that the more customers the commercial sector must serve, and the more employees working in the sector, the more energy is required per GSP. To control for these effects, we use population and employment variables, both divided by the GSP from services. Of the two variables, only employment per GSP is significant, and it is positive, an indication that the greater the employment per dollar of economic growth, the more energy intensive a state’s commercial sector is. The insignificance of population and floor space variables may be related to the multicollinearity in these variables and in employment in the commercial sector.

**Structure of the Commercial Sector**

Structural changes in the commercial sector among more-energy-intensive and less-energy-intensive subsectors may have a substantial effect on energy use. Using the available literature and data,\(^6\) we selected four subsectors that may have different energy per GSP ratios: education, retail trade, F.I.R.E and legal services, and health services. Only the retail trade and health sectors are significant. Retail trade is negative (the greater the proportion of the retail trade

---

\(^6\) The literature on energy intensity (i.e., EIA, 1995) identifies building types, such as offices, retail establishments, education facilities, hospitals, and other types of buildings, with varying energy intensity. Because panel data on building types are unavailable, we use the proportion of GSP from the various types of services, which correspond to the various buildings types, to create the variables on the subsectors.
subsector, the lower the energy intensity), and health is positive (the greater the proportion of the health subsector, the higher the energy intensity). The latter makes sense because health services tend to be more energy intensive than other services.

We also use heating-degree and cooling-degree days to control for changes in energy intensity due to seasonal weather changes that may affect the energy required for heating and air-conditioning in the sector.

**Residential Energy Intensity Regression Results**

Energy intensity in the residential sector is usually measured as energy consumption per capita, per household, or per square foot of the residential building space. For our regression model, we use energy consumption per capita as the dependent variable in the regression. It is a reasonable measure because demand for all end uses of energy, including heating, air-conditioning, water heating, and powering appliances, directly or indirectly (i.e., through the size of the dwelling space) depends on the number of people using the energy.

However, the residential demand for energy depends on a number of factors other than population. We used the following variables in the regression analysis for residential energy intensity (see Table B.4). All the variables are significant.

- Heating-degree days
- Cooling-degree days
- Log of residential electricity prices
- Log of residential natural gas prices
- Log of average household size
- Log of real disposable income per capita
- Log of employment per capita.

We used the following equation to estimate the regression:

\[
\text{Residential Energy Intensity}_{s,t} = a + b_0 \text{Heating-Degree Days}_{s,t} + b_1 \text{Cooling-Degree Days}_{s,t} + b_2 \text{Residential Electricity Prices}_{s,t} + b_3 \text{Residential Natural Gas Prices}_{s,t} + b_4 \text{Disposable Income per Capita}_{s,t} + b_5 \text{Employment per Capita}_{s,t} + b_6 \text{Average Household Size}_{s,t} + \text{State Fixed Effects}_s + \text{Time Fixed Effect}_t
\]
### Table B.4

**Residential Sector Energy Intensity Regression Variables**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heating-Degree Days&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.0000742</td>
<td>5.54e-06</td>
<td>0.000</td>
</tr>
<tr>
<td>Cooling-Degree Days&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.0000650</td>
<td>0.0000126</td>
<td>0.000</td>
</tr>
<tr>
<td>Electricity Prices&lt;sup&gt;a&lt;/sup&gt;</td>
<td>–0.1314553</td>
<td>0.0188106</td>
<td>0.000</td>
</tr>
<tr>
<td>Natural Gas Prices&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.0681121</td>
<td>0.0157596</td>
<td>0.000</td>
</tr>
<tr>
<td>Disposable Income per Capita&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.3952117</td>
<td>0.0419841</td>
<td>0.000</td>
</tr>
<tr>
<td>Employment per Capita&lt;sup&gt;a&lt;/sup&gt;</td>
<td>–0.4340120</td>
<td>0.0524521</td>
<td>0.000</td>
</tr>
<tr>
<td>Household Size&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1.8050550</td>
<td>0.1148474</td>
<td>0.000</td>
</tr>
</tbody>
</table>

Number of Observations: 960  
R-Squared: 0.924  
Adjusted R-Squared: 0.918

<sup>a</sup>Significant at the 5% level.  
NOTE: All variables except for heating-degree days and cooling-degree days are in log form.

#### Energy Prices

Demand for energy depends on its price. Increases in the price of energy drive people to reduce their energy consumption. The primary energy sources in the residential sector are electricity and natural gas, plus oil to a lesser extent for heating. If the comparative prices of different fuels change, people may substitute one fuel for another (i.e., if the price of natural gas rises, consumers can switch to electricity for heating). We take this effect into account because primary energy consumption (the dependent variable) is sensitive to changes in the mix of fuels being consumed—a larger share of electricity means greater energy losses in generation and transmission, which may increase primary energy consumption even if consumers use the same amount of energy on site.

We include the prices of two major fuels, electricity and natural gas, to produce the regression. Higher electricity prices have a negative effect on energy intensity, due to both reduced energy use and consumers switching to alternative fuels when price goes up. A priori, the effect of the price of natural gas on energy intensity is ambiguous: A higher price for natural gas may reduce total energy used from natural gas, but if its relative price increases consistently over time, people may switch to electricity, which on a “source energy” basis is less efficient than natural gas. From the regression analysis, we can see that natural gas has positive price elasticity—that is, as the price of natural gas goes up, energy intensity goes up due to the substitution of electricity for gas.
**Household Size**

Household size affects how much energy is needed per person due to economies of scale of heating, air-conditioning, cooking, lighting, and other uses of energy. Also, household size correlates with the floor space in a dwelling per person, an important factor we cannot explicitly account for.\(^7\) We expected the effect of household size on energy intensity to be negative—the larger the household, the less energy is needed per person. The regression in fact shows this to be the case.\(^8\)

**Disposable Income**

Disposable income affects energy consumption in several ways. First, increases in income allow people to buy more energy-consuming appliances, but it also enables them to use more energy for all purposes because energy expenses become a smaller part of their income. Income also correlates with residential living space per person because higher incomes make it possible for people to live in larger houses, which require more energy for heating and air-conditioning. However, higher income may also decrease energy consumption in the residential sector because it enables homeowners to buy new and more-energy-efficient devices to replace older and less-energy-efficient ones. Higher income also enables families to shift some household activities, such as laundry and cooking, to the commercial sector, which reduces energy use in the residential sector. Although increased income per capita affects energy consumption in different ways, on average in the regression the effect is positive.

**Time People Spend at Home**

Another factor that may affect residential energy intensity is the amount of time people spend at home—the less time spent at home, the lower the household energy use. As a proxy for this factor and for possibly capturing other effects, we use employment per capita. It is possible that higher employment results in people spending more time at work than in the home, and may also account for substitution of some energy-consuming services, such as child care, cooking, and laundry, to the commercial sector. In our regression analysis, employment has a negative effect on energy consumption.

---

\(^7\)Good-quality data on residential floor space by state are not available.

\(^8\)The data for this variable are available by state starting from only 1979, which, as we stated earlier in this report, limits the time period we cover in the analysis of the residential sector to 1979–1999.
Climate and Weather

Energy demand for heating and air-conditioning depends on a state’s climate and weather. While we expect climate differences among states to be picked up by the state’s fixed effects in the regression, we have to also account for fluctuations in weather from year to year, the patterns of which may vary across states. We use heating-degree and cooling-degree day\(^9\) variables to capture this effect. Both are expected to have a positive effect on energy consumption. Heating and cooling variables are assumed to have a log-linear relationship with energy intensity, while all other variables are assumed to have a log-log relationship.\(^{10}\)

Transportation Energy Intensity Regression Results

The transportation sector encompasses both private and public passenger transportation as well as freight transportation. We have to deviate from traditional measures of energy intensity in this sector because we do not have data on the denominator variables—vehicle miles, passenger miles, or ton miles traveled—and because there are no separate data on passenger transportation and freight transportation energy consumption. Instead, we use energy consumption per person (because a large portion of energy is consumed by passenger transportation), and population in some ways controls for the size of a state. In this analysis, we subtract the energy used for air transport because it is not clear how much air transport relates to individual state actions. Also, air transport varies widely and significantly influences energy intensity.

We controlled for the following exogenous variables in the regression on transportation energy intensity (see Table B.5):

- Log of transportation energy prices (weighted average)
- Log of disposable income per capita
- Log of employment per capita
- Log of local passenger transit GSP per capita
- Log of trucking GSP per capita

---

\(^9\)These variables are not available by state for the study period; instead, they are by geographical regions that include a group of states.

\(^{10}\)All the variables other than heating-degree days and cooling-degree days are transformed into log form.
Table B.5
Transportation Sector Energy Intensity Regression Variables

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average Price of Energy</td>
<td>-0.333</td>
<td>0.043</td>
<td>0.000</td>
</tr>
<tr>
<td>Disposable Income per Capita</td>
<td>0.127</td>
<td>0.051</td>
<td>0.014</td>
</tr>
<tr>
<td>Employment per Capita</td>
<td>0.878</td>
<td>0.061</td>
<td>0.000</td>
</tr>
<tr>
<td>Public Transit</td>
<td>-0.012</td>
<td>0.011</td>
<td>0.269</td>
</tr>
<tr>
<td>Portion of GSP from Trucking</td>
<td>0.026</td>
<td>0.018</td>
<td>0.152</td>
</tr>
</tbody>
</table>

| Number of Observations            | 1104        |
| R-Squared                         | 0.955       |
| Adjusted R-Squared                | 0.9505      |

*aSignificant at the 5% level.

NOTE: All variables are in log form.

We used the following equation to estimate the regression:

\[
\text{Transportation Energy Intensity}_{s,t} = a + b_0 \text{Average Transportation Energy Prices}_{s,t} + b_1 \text{ Disposable Income per Capita}_{s,t} + b_2 \text{ Employment per Capita}_{s,t} + b_3 \text{ Local Passenger Transit GSP per Capita}_{s,t} + b_4 \text{ Trucking GSP per Capita}_{s,t} + b_4 \text{ Air Transportation GSP per Capita}_{s,t} + \text{ State Fixed Effect}_s + \text{ Time Fixed Effect}_t
\]

Because most of the fuels consumed in transportation sector are based on petroleum, and because it is not easy to substitute fuels in a vehicle, we use a weighted average of all fuel prices for the transportation sector analysis. We expect the coefficient of the average-price-of-energy variable to have a negative sign because energy consumption goes down when the price of energy increases. This variable is significant in the regression.

Disposable income affects vehicle ownership rates and the affordability of traveling. We would expect this variable to have a positive coefficient, which it in fact does. This variable is significant.

Employment increases the number of people who commute to work, which may affect vehicle miles traveled and modes of passenger transport. This variable is positive and significant in the regression.

Public transit has an ambiguous effect on energy consumption. Public transit is less energy intensive per person than individual-vehicle commuting. Therefore, less energy is consumed if mass transportation substitutes for inefficient private-vehicle transportation, and if that mass transit is well used, because an underused public transportation system could increase energy intensity. In the regression, this variable is insignificant.

We also control for a large portion of the transportation sector’s GSP from freight transportation—the portion of the GSP from trucking. The larger the share of the
freight transportation GSP from trucking, the more energy per capita is consumed by the transportation sector; however, this variable is not significant in the regression.

Overall, our analysis of the transportation sector’s energy intensity by state is likely to suffer from measurement errors. A large share of all transportation is interstate, and it is difficult to distribute variables related to interstate transportation among all states.