# Subnational Trade Flows and State-Level Energy Intensity

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**Abstract**

In one strand of research, analysts examine trends in and the determinants of energy usage and intensity. In a second strand, researchers analyze the impact of trade flows on environmental outcomes. Recently, Cole (2006) bridges this gap, analyzing the impact of trade intensity on energy usage utilizing panel data at the country level. Here, we analyze the impact of subnational trade flows across U.S. states on state-level energy usage and intensity, controlling for the endogeneity of trade flows. Our findings indicate that an expansion of subnational trade at worst has no impact on state-level energy usage, and may actually reduce energy usage (contrary to Cole's country-level findings), although the impacts are not uniform across sectors.

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# 1 Introduction

Energy conservation is a continual topic of interest to policymakers, environmentalists, economists, and others, in both the United States and abroad. It represents an issue that not only has ramifications on the welfare of future generations, but also on the current generation. However, while anecdotal evidence suggests that energy use responds to economic factors (e.g., the decline in energy intensity in the US increased in magnitude after the oil shocks in the 1970s), relatively little is known about the determinants of energy use. Nonetheless, the International Energy Agency forecasts that global energy use will increase by 60% over current energy consumption (ICTSD [18]).

Within the US, only two studies (to our knowledge) analyze the spatial and temporal variation in state-level energy intensity using regression techniques. Bernstein et al. [3] analyze panel data across US states from 1977 to 1999, examining the role of Gross State Product (GSP), energy prices, and climate. Metcalf [20] re-visits the issue, using panel data across US states from 1960 to 2001. The analyses point to significant effects of prices and income on state-level energy intensity. Utilizing cross-country data, a few recent studies have explored the role of trade openness and other economic factors on energy efficiency. For instance, Fredriksson et al. [11] use panel data from 12 OECD countries to assess the role of political corruption, lobbying, and industry size on energy intensity. Stern [25] explores the impact of NAFTA on trends in energy intensity and per capita energy use in Canada, Mexico, and the US. Cole [6] uses panel data across 32 countries to explore the role of trade on energy intensity and per capita energy use.

In this paper, we extend the line of inquiry begun in Bernstein et al. [3] and Metcalf [20], merging the literature on interstate variation in energy intensity with the literature on trade and the environment in general (e.g., Antweiler et al. [2]; Chintrakarn and Millimet [4]) and trade and energy intensity in particular (as in Cole [6]). Specifically, we assess the impact of subnational 'trade' on state-level energy intensity. There are several reasons why understanding the link between interstate trade and state-level energy intensity is of relevance to policymakers and economists. First, as noted in Metcalf [20], variation in the *level* of energy intensity across US states at a point in time is quite considerable, as is variation across states in the *change* in energy intensity over time. Moreover, Metcalf [20] finds that most of the variation is related to differences in energy *efficiency*, not differences in the sectoral composition of states. The underlying causes of this variation in energy efficiency are at present a puzzle. Second, knowledge of the determinants of energy use in the US will aid in forecasts of future energy demand. As is well known, energy use – primarily fossil fuel consumption – contributes to air pollution, as well as global warming through the emission of carbon. High energy consumption may also constitute a national security risk, given the reliance of the US on foreign suppliers. In light of these and other externalities associated with energy consumption, improved forecasts of future energy demand should prove valuable (see Metcalf [21] for more discussion).

Third, policies aimed at energy conservation are most likely not cheap (see Metcalf [20] for greater discussion). As such, identifying the determinants of energy use may illuminate more cost-effective energy conservation strategies. For instance, in this analysis, we explore the role of interstate commerce on state-level energy intensity. If expanded trade across states yields improvements (in a *causal* sense) in energy intensity, then policies designed to facilitate interstate commerce would constitute one part of an overall energy conservation strategy. Fourth, given the link between energy consumption and environmental degradation, our analysis builds on previous work concerning the environmental impact of subnational trade. In Chintrakarn and Millimet [4], the authors analyze the impact of interstate commerce on state-level pollution of toxic releases, finding little evidence of harmful effects of trade on the environment on average. Here, besides examining energy intensity instead of pollution levels, we extend the analysis in Chintrakarn and Millimet [4] along three other dimensions. First, we now include a third wave of data on interstate commerce (discussed below). Second, the (second-stage) empirical specification in the current analysis differs from Chintrakarn and Millimet [4], and more in line with the theoretical literature (e.g., Antweiler et al. [2]) by accounting for the relative factor endowments of states (i.e., in theory, greater trade intensity should increase (decrease) energy intensity in capital (labor) abundant states). Third, the first-stage empirical specification of the gravity model for subnational trade – used to generate the instrument for interstate trade – differs, following instead the method recently proposed in Santos Silva and Tenreyro [24]. This method entails estimating the first-stage gravity model in levels (as opposed to logs). As noted in Santos Silva and Tenreyro [24], estimating gravity models in logs may yield biased estimates of the first-stage model, thereby invalidating the second-stage instrumental variable estimates.

The final motivation for the current analysis is that analyzing trade issues at the *subnational* level helps inform the debate over the link between *international* trade and the environment. While some cross-country evidence suggests that trade openness does not contribute to, and may actually mitigate, environmental problems (e.g., Antweiler et al. [2]; Dean [9]; Harbaugh et al. [14]; Frankel and Rose [12]), issue remains far from settled. Copeland and Taylor [8] (p. 7) state that "for the last ten years environmentalists and the trade policy community have engaged in a heated debate over the environmental consequences of liberalized trade." Taylor [26] (p. 1) argues that this constitutes "one of the most important debates in trade policy." Moreover, the fact that Cole [6] finds a positive impact of trade intensity on per capita energy consumption and energy intensity *ceteris paribus* indicates that the results from the trade and pollution literature may not extend to the impact of trade on energy consumption. However, since Stern [25] fails to find a detrimental impact of NAFTA on energy intensity, the link between international trade and energy intensity is also unclear. Thus, the current analysis builds on a growing literature using subnational trade data to assess open questions international trade arena since data obtained from a single country (i) ensures consistent measurement of the variables of interest, and (ii) yields a more homogeneous sample, mitigating concern over the omission of confounders (e.g., Wolf [28]; Hillberry and Hummels [17]; Combes et al. [7]; Millimet and Osang [22]; Knaap [19]).

To proceed, we follow Cole [6] and Antweiler et al. [2] and estimate several panel data specifications, where state-level energy intensity depends on price, income, the capital-labor ratio, and trade intensity, where the latter is allowed to be potentially endogenous. The findings are noteworthy. While consistent with many previous works on the environmental effects of trade, our findings also confirm the role of economic factors in explaining at least a portion of the cross-state variation in energy use in the US, as discussed in Metcalf [20]. However, the results are in stark contrast with those in Cole [6], thus confirming the importance of additional analysis. The remainder of the paper is organized as follows: Section 2 describes the empirical model and data. Section 3 presents empirical results. Section 4 concludes.

# 2 Methods & Data

## 2.1 Econometric Model

To assess the impact of subnational trade intensity on state-level energy intensity, we closely follow the specification used in Cole [6], which is derived from the trade and environment framework developed in Antweiler et al. [2]. Specifically, our estimating equation is

$$\begin{aligned}\ln(E_{it}) \;=\;& \alpha_t + \alpha_0 \ln(P_{it}) + \alpha_1 \ln(Y_{it}) + \alpha_2 \ln(Y_{it})^2 + \alpha_3 \ln(KL_{it}) + \alpha_4 \ln(KL_{it})^2 \\ & + \alpha_5 \ln(Y_{it}) \ln(KL) + \alpha_6 \ln(T_{it}) + \alpha_7 \ln(T_{it}) \ln(RY_{it}) + \alpha_8 \ln(T_{it}) \ln(RY_{it})^2_{it} \\ & + \alpha_9 \ln(T_{it}) \ln(RKL_{it}) + \alpha_{10} \ln(T_{it}) \ln(RKL_{it})^2 + \varepsilon_{it} \end{aligned} \quad (1)$$

where $i$ indexes states, $t$ indexes year, $E$ is a measure of energy intensity, $P$ is price, $Y$ is one-period lagged, three-year moving average of per capita Gross State Product (GSP), $T$ is a measure of trade intensity, $RY_{it} \equiv Y_{it}/Y_{\cdot t}$ and $RKL_{it} \equiv KL_{it}/KL_{\cdot t}$, where the subscript "$\cdot t$" indicates the average over all $i$ for year $t$, $\alpha_t$ is a time-specific intercept, and $\varepsilon$ is a mean zero error term.[1] The error term is allowed to be heteroskedastic in an arbitrary manner, and some specifications decompose the error term into a state-specific fixed effect as well as a heteroskedastic idiosyncratic component.

Following Metcalf [20], we measure energy intensity as energy consumption per unit of economic activity (discussed in more detail below). In addition to reporting the coefficient estimates, we also test the joint significance of the five trade intensity variables, as well as report the elasticity of energy intensity with

[1]Metcalf [20] allows for lagged energy prices to also impact current energy intensity. He tends to find sigificant effects of current and one-period lagged prices. Given our sample size (discussed below), we include only current price in the analysis.

respect to $Y$, $KL$, and $T$ (evaluated at the sample mean). These correspond to the technique, composition, and trade elasticities, respectively. Standard errors for the elasticities are computed via the delta method.

As is well known, spatial and temporal variation in trade intensity is unlikely to be exogenous in general (e.g., Copeland and Taylor [8], Frankel and Rose [12], Chintrakarn and Millimet [4]), and energy and other environmental regulations and trade flows are likely to be jointly determined (Cole [6]; Ederington and Minier [10]).[2] To cope with the possible endogeneity of trade and per capita income, we instrument for these variables in equation (1) using a General Methods of Moments (GMM) approach. The instruments are equivalent to those utilized in Frankel and Rose [12], Chintrakarn and Millimet [4], and Cole [6]. Specifically, in the first-stage, we estimate a gravity model for bilateral shipments between pairs of states and form the predicted level of shipments. Next, we aggregate the predicted values across bilateral trading partners to obtain a prediction of total interstate shipments for a given state. In general, the gravity model stipulates that trade is determined by the size (physical size as well as economic) of trading partners and of distance between trading partners (physical distance as well as other determinants of 'distance' such as a common border, landlocked status, common language, common currency, etc.). Here, we specify the first-stage equation as

$$Shipments_{ijt} = \lambda_i \lambda_j \exp\left(x_{ijt}\beta\right) u_{ijt} \tag{2}$$

where $Shipments_{ijt}$ is shipments from state $i$ to state $j$ in year $t$, $\lambda_i$ ($\lambda_j$) are state $i$ ($j$) fixed effects, $x_{ijt}$ is a vector of controls corresponding to trading partners $i$ and $j$ in year $t$, and $u_{ijt}$ is a possibly heteroskedastic error term with mean one. The control vector includes the (log) population of states $i$ and $j$, (log) measures of how remote state $i$ ($j$) are relative to all other states excluding state $j$ ($i$), the (log) physical distance between the states, a dummy variable indicating whether states $i$ and $j$ are contiguous neighbors, three regional dummies for states $i$ and $j$, a home dummy variable equal to one if $i = j$ (implying intrastate shipments), the (log) area of state $i$, and time dummies.[3] Thus, we are implicitly using exogenous geographical determinants of bilateral shipments to identify the causal effect of trade intensity in (1).

Equation (2) may be estimated using standard fixed effects methods after taking logs of both sides. This is the conventional strategy, and such an estimation procedure will yield consistent estimates of the parameters if $\mathrm{E}[\ln(u_{ijt})|x_{ijt}, \lambda_i, \lambda_j] = 0$. However, as pointed out in Santos Silva and Tenreyro [24], the assumption that $\mathrm{E}[\ln(u_{ijt})|x_{ijt}] = 0$ *does not follow* from the assumption $\mathrm{E}[u_{ijt}|x_{ijt}, \lambda_i, \lambda_j] = 1$ since Jensen's Inequality implies that $\mathrm{E}[\ln(z)] \neq \ln(\mathrm{E}[z])$ for some random variable $z$. Moreover, if $u_{ijt}$ is

[2]Metcalf [20] investigates the possibility that energy prices are also endogenously determined. However, he fails to reject to the exogeneity of prices. Thus, we treat prices as exogenous.

[3]As in Wolf [28], $Remote_{ij} = \sum_{k=1,k\neq j}^{48} \frac{D_{ik}}{GSP_k}$, where $D$ is the physical difference between states. Similarly, $Remote_{ji} = \sum_{k=1,k\neq i}^{48} \frac{D_{jk}}{GSP_k}$. In general, a state located in the middle of a country will be less 'remote' than coastal or international border states (on average, Iowa is the least remote, while Oregon is the most remote).

heteroskedastic and its *variance* depends on $x_{ijt}$, then the *expectation* of $\ln(u_{ijt})$ will in general also depend on $x_{ijt}$, implying that fixed effects estimates based on the log-linear model will be biased. Instead, Santos Silva and Tenreyro [24] proposes estimation in levels using a Poisson pseudo-maximum likelihood (PPML) estimator. Henderson and Millimet [16] find that the estimation of (2) in levels using PPML outperforms the log-linear model using US subnational trade data. Thus, we utilize the same estimator for the first-stage.

### 2.2 Data

The data come from several different sources. The data on energy consumption are obtained from the US Energy Information Administration's (EIA) State Energy Data System (SEDS). The goal in maintaining SEDS is to maintain historical time series data on energy consumption, prices, and expenditures by state that are defined as consistently as possible over time and across sectors. SEDS exists for two principal reasons: (i) to provide state energy consumption, price, and expenditure estimates to the US Congress, federal and state agencies, and the general public, and (ii) to maintain the historical data necessary for EIA's energy models. For the purposes of the current analysis, the consumption data are aggregated along two dimensions. First, the data are aggregated to the state level. Second, while the data are available at the level of the individual energy source, all energy sources are aggregated together to form four end-use sector energy consumption estimates: commercial, industrial, transportation, and residential sectors.[4] For comparison to the results from the separate analysis of the four end-use sectors, we also analyze the aggregate of these four sectors (referred to as 'total').

To convert the data from energy consumption to energy intensity, we follow Metcalf [20]. This entails scaling total and residential energy use by aggregate personal income. Commercial (industrial) sector energy use is scaled by earnings by place of work in the commercial (industrial) sector. The commercial sector includes transportation, communication, wholesale and retail trade, finance, services, and government. The industrial sector includes manufacturing, agriculture, forestry, fishing, mining, and construction. Aggregate personal income, as well as earnings by place of work, are obtained from the BEA. Finally, transportation energy use is scaled by annual vehicles miles travelled obtained from various years of the US Department of Transportation's *Highway Statistics*.

[4]Individual energy sources can be categorized broadly as coal, natural gas, petroleum, nuclear electric power, and hydroelectric power, as well as net interstate flow of electricity/losses. Net interstate flow of electricity is the difference between the amount of energy in the electricity sold within a state (including associated losses) and the energy input at the electric utilities within the state. A positive number indicates that more electricity (including associated losses) was imported than exported during the year. Comsumption is measured in Btu (British thermal units), which is the amount of energy required to raise the temperature of one pound of water by one degree Fahrenheit.

As noted in Metcalf [20], changes in energy intensity can arise for two reasons: changes in energy efficiency and changes in economic activity. Changes in intensity due to energy efficiency refer to changes in energy consumption per unit of economic activity *within* a particular sector. Changes in intensity due to economic activity refer to changes in the allocation of economic activities *across* sectors. As a result, analyzing the impact of trade on energy intensity by sector yields insight into trade effects on energy efficiency, while analyzing the impact of trade on total energy intensity captures trade effects on efficiency as well as economic activity.

The EIA also provides state-level energy price estimates. The estimates, expressed in nominal dollars per million Btu, are consumption-weighted averages of the prices of the individual energy sources (see footnote 4). The EIA calculation is performed by summing expenditures across the various energy sources – coal (the sum of coking coal and steam coal), natural gas, petroleum (the sum of all petroleum products used by the sector), wood, waste, alcohol fuels (in years when they are not included in motor gasoline), and electricity – and dividing by total consumption.[5]

The inter- and intrastate shipments data are from the 1993, 1997 and 2002 Commodity Flow Survey (CFS), collected by the Bureau of Transportation Statistics within the US Department of Transportation. Chintrakarn and Millimet [4] utilize the 1993 and 1997 CFS data to explore the impact of subnational trade on pollution; thus, we provide limited details and refer the reader to our previous work. The CFS tracks all shipments across 25 two-digit and two three-digit SIC industries, measured in dollars and in tons. Total shipments from one state to another (or within state) are reported. The CFS data have been used frequently to assess the impact of borders on bilateral shipment patterns.[6] With the CFS data in hand, we define trade intensity in equation (1) as

$$Trade_{it} = \frac{\sum_{j,i\neq j}(Shipments_{ijt} + Shipments_{jit})}{\sum_j Shipments_{ijt}} \tag{3}$$

where the numerator reflects the sum of 'exports' plus 'imports' and the denominator is the sum of 'exports'

[5]Consumption entails end users only; energy consumed by the electric power sector to generate electricity is excluded.

[6]Although frequently used, there are nonetheless noteworthy limitations to the public-use CFS data. First, the commodity flow data measure all shipments: intermediate and final. In addition, goods shipped to harbors that are then to be exported are also included in the CFS. To deal with these inconsistencies, Anderson and van Wincoop [1] attempt to eliminate wholesale shipments by multiplying all bilateral shipment values from the CFS by a constant factor equal to the ratio of total US merchandise trade to total US shipments as measured by the CFS. Employing the private-use CFS data, Hillberry and Hummels [17] find that wholesale shipments are less likely to cross state borders. Because wholesale shipments are highly localized, Anderson and van Wincoop's [1] adjustment using a fixed scalar may result in overvaluing (undervaluing) short (long) shipments. Despite this caveat, we follow Chintrakarn and Millimet [4] and use the unadjusted CFS data.

plus intrastate shipments.[7,8]

The final variable meriting serious discussion is the capital-labor ratio. Given the theoretical framework in Antweiler et al. [2], measurement of the capital-labor ratio is crucial. However, the US Bureau of Economic Analysis (BEA) only provides capital stock estimates for the US as a whole, not at the state-level. To circumvent this shortcoming, we utilize two sources for state-level data on capital stocks. The first source is Garofalo and Yamarik [13] (hereafter referred to as GY). GY construct US state-level capital stocks from 1947 to 1996; a revised and extended series (through 2001) are available online.[9] GY allocate the national capital stock to the states using annual income shares. Specifically, for each of the nine one-digit BEA industries, the authors allocate the national capital stock for that industry according to the relative income generated within each state. Each state's total capital stock estimate is given by the sum of the industry estimates. Formally, the GY procedure is defined by the following equations:

$$k_{ist} = \left( \frac{y_{ist}}{\sum_{j=1}^{51} y_{jst}} \right) k_{st} \quad (4)$$

$$k_{it} = \sum_{s=1}^{9} k_{ist} \quad (5)$$

where $i$ indexes states, $s$ indexes industry sectors, $t$ indexes year, and $k$ and $y$ denote capital and income, respectively, where $k_{st}$ is the national capital stock for industry $s$ in year $t$.[10]

Concerned that this algorithm may not be yielding any new information, GY employ a regression analysis of state income-to-capital ratios on the national income-to-capital ratio for the 1947-1996 period. GY reject the null hypothesis that the coefficient on the national income-to-capial ratio equals one at the $p < 0.01$ level. In addition, including state-level relative income shares for each industry in the regression changes the coefficient on the national income-to-capital ratio very little, but the adjusted-$R^2$ rises from 0.09 to 0.43. These results imply that more of the cross-state variation in the income-to-capital ratios is attributable to variation in relative industry shares rather than the national income-to-capital ratio. More importantly, the main findings in GY are consistent with long-held beliefs that constant returns to scale is appropriate in a two factor model and the rate of convergence is approximately two percent per annum

[7] Note, adjustment of a covariate by a constant factor, as in Anderson and van Wincoop [1], will affect the estimated coefficient, but not inference regarding the statistical significance of the coefficient (i.e., the $t$-statistic does not change). Thus, one should be cautious interpreting the magnitude of our results, but not the direction and statistical significance.

[8] Due to data limitations and the specification of the gravity model in (2), we follow Combes et al. [7] and neglect shipments between states and the rest of the world. We view this as a measurement error issue and since we utilize instrumental variable techniques, this omission should not impact the results.

[9] See http://www.csulb.edu/~syamarik/.

[10] The nine industries with their BEA codes are farming (81); agricultural services, forestry, fishing, and other (100); mining (200); construction (300); manufacturing (400); transportation (500); wholesale and retail trade (610); finance, insurance, and real estate (700); and services (800). Data for $y$ and $k_{st}$ are from the BEA.

among regions in the US. These results give us confidence that the GY state-level capital stock measure is appropriate for our purposes. Finally, to construct the capital-labor ratio, state labor quantity is measured by total full-time and part-time employment in each of the nine one-digit BEA industries. In our analysis, we utilize GY's capital-labor ratios from 1993, 1997, and 2001.[11]

The second source for data on state-level capital stocks is Cohen and Morrison [5] (hereafter referred to as CM). To construct state-level private capital stocks for the period 1982-1996, CM apply the perpetual inventory method to data on state-level new capital expenditures obtained from the US Census Bureau's Annual Survey of Manufactures (ASM), with the initial capital stock values (corresponding to the year 1982) taken from Morrison and Schwartz (1996). To form state-level capital-labor ratios, state labor quantity is given by the number of full-time and part-time employees on the payrolls of these manufacturing establishments (obtained from the ASM Geographic Area Statistics). In our analysis, we utilize CM's capital-labor ratios from 1993 and 1996.[12] When comparing the two capital-labor ratio data series, the CM method is more refined in the sense that the capital stocks are constructed using state-level data on capital expenditures, instead of apportioning the national capital stock to the states. However, the GY data enables us to utilize all three years of CFS data in the analysis, which is a significant benefit given the sample size.

For the remaining variables, data on GSP come from the BEA, while state population is from the Statistical Abstract of the United States (various editions). The measure of distance used in the first-stage gravity model, equation (2), is borrowed from Wolf [28] and Millimet and Osang [22]. Summary statistics are provided in Table 1.

# 3 Results

## 3.1 First-Stage Results

Table 2 reports the first-stage results corresponding to equations (2). Two specifications are reported; one using three years of data (for the subsequent models using three years of the GY capital-labor ratio data) and one using only two years of data (for the subsequent models using two years of the CM or GY capital-labor ratio data). The results indicate a statistically and economically significant effect of distance and adjacency on interstate shipments. In addition, intrastate shipments are significantly greater than inter-state shipments *ceteris paribus*. Thus, the first-stage indicates that there should be little cause for concern over weak instruments (although we test for this more formally below).

[11] Due to data limitations, we use the GY state-level capital stock from 2001 for 2002.

[12] Due to data limitations, we use the CM state-level capital stock from 1996 for 1997.

### 3.2 Second-Stage Results

#### 3.2.1 Baseline Model

**Estimates** Results from our baseline model are presented in Tables 3 and 4, with Table 3 (4) displaying the results obtained by estimating (1) via OLS (GMM). Each table presents the results using total energy intensity, as well energy intensity for each of the four sectors. Moreover, for each measure of energy intensity, Model I (II) uses the CM (GY) capital-labor ratio. Finally, in both tables, we utilize only two periods of data – 1993 and 1997 – for comparability.

Turning to the OLS results for the total energy intensity (Table 3), three consistent findings emerge regardless of which capital-labor ratio measure is used. First, consonant with Metcalf [20], the elasticity of energy consumption is significantly, negatively related to price (Model I: $\widehat{\alpha}_0 = -1.29$, s.e. $= 0.11$; Model II: $\widehat{\alpha}_0 = -1.80$, s.e. $= 0.17$). Second, consistent with Cole [6], we reject the null of no effect of trade intensity (p $= 0.00$ in both models). Finally, consistent with Cole [6] and Antweiler et al. [2], we find a negative and statistically significant technique elasticity (Model I: elasticity = -0.66, s.e. = 0.11; Model II: elasticity = -0.82, s.e. = 0.23). Metcalf [20] also finds state-level energy intensity to be declining with income levels. In terms of the remaining elasticities, we obtain positive and statistically significant composition and trade elasticities using the CM capital-labor ratio; both are statistically insignificant at conventional levels using the GY capital-labor ratio, although the trade elasticity is nearly identical to that obtained using the CM measure. The positive elasticities obtained using the CM measure are consonant with the results in Cole [6], however the magnitudes are much smaller. Thus, without accounting for the potential endogeneity of subnational trade, we find a positive association on average between trade and energy intensity.

Examining the OLS results for the individual sectors yields several interesting findings. First, energy intensity is negatively and significantly related to price in each sector and in each model, with energy intensity in the industrial and transportation sectors being most price sensitive. Second, we reject the null of no trade effects on energy intensity at the $p < 0.10$ level using both capital-labor ratios for the industrial, commercial, and residential sectors. Third, the technique elasticity is negative in all eight specifications, and statistically significant in six. Thus, within each sector, higher incomes are associated with lower energy intensity. Fourth, the composition elasticity is positive and statistically significant in six of the eight specifications as well. Finally, the trade elasticity is positive and relatively large for the industrial sector using either capital-labor ratio, although it is statistically significant only when using the CM measure (Model I: elasticity = 0.41, s.e. = 0.24; Model II: elasticity = 0.37, s.e. = 0.34). For the remaining sectors, the trade elasticity is close to zero and statistically insignificant. Given the pattern of results and the fact that industrial sector energy consumption comprises over one-third of total energy consumption, it appears that most of the positive association between trade and total energy intensity is due to a positive association between trade and energy inefficiency in the industrial sector, and not due to correlation between trade intensity and the sectoral composition of economic activity.

To determine if the positive association between trade and total and industrial energy intensity represents a causal relationship, we turn to the GMM results in Table 4. In terms of total energy intensity, the two models fair well in terms of the diagnostic test performed: the Anderson underidentification test (see Hall et al. [15]). Rejection of the null in both cases at the $p < 0.01$ level implies that the models are not underidentified. As far as the actual results, the estimates are qualitatively similar to those reported in Table 3. In fact, using the CM capital-labor ratio, we fail to reject the null that trade is exogenous. Specifically, in both models, we continue to find large, negative, and statistically significant price and technique elasticities, as well as reject the null of no trade effects at the $p < 0.01$ level. Moreover, the composition elasticity continues to be positive and statistically significant using the CM measure; the point estimate is now also positive, albeit statistically insignificant, using the GY measure. Finally, while both trade elasticities are positive, neither are statistically significant.

Turning to the GMM results for the individual sectors, we obtain similar conclusions as in the OLS estimations. First, in all eight models the Anderson tests reject the null of underidentification, and we reject the null that trade is exogenous at the $p < 0.10$ level in four specifications. Second, energy intensity is negatively and significantly related to price in each sector and in each model, with energy intensity in the industrial and transportation sectors being most price sensitive. Third, we reject the null of no trade effects on energy intensity at the $p < 0.03$ level using both capital-labor ratios for the industrial, commercial, and residential sectors. However, now we also obtain a statistically significant effect of trade on energy intensity in the transportation sector as well (p = 0.00 in both models). Fourth, the technique elasticity is negative and statistically significant in five of the eight specifications. While energy intensity in the transportation sector is unresponsive on average to income using both capital-labor ratio measures, there is at least some evidence that higher incomes reduce energy intensity in the other three sectors. Fifth, the composition elasticity is positive and statistically significant in five of the eight specifications as well, with at least one estimate being statistically significant for each sector. Sixth, the trade elasticity is positive and statistically significant using either capital-labor ratio measure for the industrial and transportation sectors. Moreover, although the point estimates are large in all four models, one should be cautious in assigning too much influence to trade given the large standard errors.

Finally, as a rough measure of the relative contribution of trade effects on energy efficiency and economic activity in explaining the trade elasticity for total energy intensity, we compute the weighted average of the four sector-specific trade elasticities using the share of energy consumption in each sector for the 'average' state as weights. Using the CM (GY) capital labor ratio, this yields an average trade elasticity of 0.62 (0.94), with a standard error of 0.46 (0.66). Since the point estimates for the trade elasticities obtained using total energy intensity are much smaller (CM: elasticity = 0.24, s.e. = 0.22; GY: elasticity = 0.36, s.e. = 0.41), this implies that greater trade intensity may shift state economic activity to sectors in which energy intensity is not affected by trade (i.e., the commercial and residential sectors). However, given the standard errors, we also cannot reject that there is no impact of trade on the composition of economic activity. Nonetheless, we do conclude that trade raises energy intensity (i.e., decreases energy efficiency) in the industrial and transportation sectors.

In the end, then, the baseline model treating trade as endogenous confirms the cross-country result in Cole [6]; trade causes energy intensity to rise on average. However, the impact is not homogeneous across sectors as the increase in intensity is concentrated in the industrial and transportation sectors. Moreover, while some of our empirical results are sensitive to which measure of the state-level capital-labor ratio is used, this conclusion is not. Finally, our analysis also confirms the results in Metcalf [20] that state-level energy intensity is quite sensitive to price and income, with the effects of both being negative on average. The positive effect of trade on energy intensity on average is surprising given the results in Chintrakarn and Millimet [4], which find negative effects on average of state-level trade intensity on toxic releases in general, and toxic releases to the air in particular. If this baseline result holds up to the robustness tests discussed below, this implies that the beneficial effects of greater interstate trade on toxic releases is more than sufficient to offset the higher level of energy intensity.

**Heterogeneous Effects** Prior to discussing the sensitivity tests, we delve a bit deeper into the results from the baseline model. One of the primary insights of Antweiler et al. [2] is that trade liberalization has differential effects on the environment depending on whether such liberalization leads to greater imports or exports of pollution-intensive goods. While the empirical model allows for such heterogeneity – as the impact of trade intensity is allowed to vary non-linearly with relative income and relative factor endowments – the preceding results focus on the average impact of trade on energy intensity. To assess this heterogeneity, rather than simply focusing on average effects, we use the results from Table 4 to calculate the trade elasticity of energy intensity for each state-year observation. Table A1 in the Appendix reports the average elasticity for each state and sector, along with its ranking, using both capital-labor ratio measures.

Examining the elasticities for total energy intensity using CM's capital-labor ratio, we find only three states with negative trade elasticities, and the majority of states are clustered around the elasticity computed at the mean reported in Table 4 (elasticity = 0.24, s.e. = 0.22). Delaware has the largest elasticity, with a point estimate of 0.72; Vermont, Wyoming, and Louisiana have the three negative elasticities (-0.06, -0.39, and -0.60, respectively). Using GY's capital-labor ratio yields much more heterogeneity across the states. In particular, we find more instances of negative trade elasticities (14), and several instances of extremely large positive elasticities (e.g., Wyoming, New York, and Connecticut each have an elasticity above 1.50). Moreover, we note that while the results using the two capital-labor ratio measures are predominantly similar, there are a few large discrepancies. For example, Wyoming's elasticity changes from -0.39 (ranking = 47) to 2.86 (ranking = 1); Oklahoma's elasticity changes from 0.32 (ranking = 9) to -0.29 (ranking = 48). However, because we do not report standard errors for these averages, one should view these discrepancies with caution.

Turning to the industrial sector, we obtain results broadly consistent with the those obtained using total energy intensity. However, the point estimates do exhibit substantially greater variation. As when using total energy intensity, we obtain three negative trade elasticities using CM's capital-labor ratio; only four using GY's measure. Across both measures, Mississippi's elasticity is consistently very large (CM: elasticity = 4.90, ranking = 1; GY: elasticity = 4.99, ranking = 2), whereas Louisiana's is consistently low (CM: elasticity = -1.74, ranking = 47; GY: elasticity = -0.30, ranking = 48). The results for the transportation sector – the other sector with a statistically significant trade elasticity computed at the mean in Table 3 – are fairly similar to those for the industrial sector, although there are more instances of negative elasticities. Specifically, using CM's (GY's) capital-labor ratio, we obtain 13 (five) states with negative elasticities. However, using CM's capital-labor ratio, the five states with the highest trade elasticities in the industrial sector, continue to have the five largest elasticities in the transportation sector (Mississippi, Montana, West Virginia, Arkansas, and Oklahoma).

For the commercial sector, the distribution of elasticities obtained using the CM measure is relatively symmetric around the trade elasticity computed at the mean reported in Table 4 (elasticity = 0.48, s.e. = 0.32); there are eight states with negative elasticities, and eight states with elasticities above unity. The distribution obtained using the GY measure is more skewed, with a long upper tail. While eight states have negative elasticities as with the CM measure, four (ten) states have an elasticity above 1.90 (one). Finally, for the residential sector, we find the greatest evidence of a beneficial effect of interstate trade on energy intensity; we also find the most amount of consistency across the two capital-labor ratios. Using the CM (GY) capital-labor ratio, only 17 (15) of 48 states have positive trade elasticities. In terms of particular states, Montana, West Virginia, and Mississippi have the lowest point estimates across both capital-labor ratio measures, with elasticities below -1.80; Connecticut is the only state with an elasticity greater than unity according to both capital-labor ratio measures.

In sum, there is substantial variation in the point estimates of the state-specific trade elasticities, as well as variation in the rankings of states across the different sectors. For instance, Mississippi consistently ranks in the top ten states in terms of largest trade elasticity in the industrial, commercial, and transportation sectors, but is among the bottom two states in the residential sector. Illinois, on the other hand, has the eleventh highest trade elasticity overall using either capital-labor ratio (CM: elasticity = 0.30; GY: elasticity = 0.51), but predominantly ranks in the bottom one-third of states in the industrial, commercial, and transportation sectors, and in the top ten in the residential sector (CM: elasticity = 0.42; GY: elasticity = 0.51). That said, the results indicate that the elasticities computed at the mean reported in Table 4 are not driven by one or two states, but rather represent a good description of the general effects of trade on energy intensity.

#### 3.2.2 Sensitivity Analysis

As stated previously, the positive effect of trade on energy intensity on average found in the baseline model is unexpected in light of the results obtained in Chintrakarn and Millimet [4]. To assess the robustness of the baseline findings, we conduct a number of sensitivity analyses. We discuss each in turn.

**Alternative Definition of Energy Intensity** Our first sensitivity analysis uses an alternative definition of energy intensity. As noted in Metcalf [20], it may be preferable to use GSP to measure economic activity in the denominator of the energy intensity measures. However, the series has a structural break in 1997 due to the change from SIC to NAICS industry definitions. Nonetheless, since our analysis thus far has only utilized data up to 1997, we re-define state-level energy intensity as follows. Total and residential energy use is scaled by GSP (aggregated over all industries). Commercial (industrial) sector energy use is scaled by GSP in the commercial (industrial) sector. The commercial sector includes transportation, communication, wholesale and retail trade, finance, services, and government. The industrial sector includes manufacturing, agriculture, forestry, fishing, mining, and construction. All data are obtained from BEA for 1993, 1997 and 2002. Transportation energy use is scaled by GSP in the transportation sector. The results are reported in Table 5; in the interest of brevity, we report only the technique, composition, and trade elasticities computed at the sample mean, as well as any diagnostic tests.[13]

In terms of the OLS results (Table 5, Panel I), while the results are quite similar, two noteworthy differences arise. First, we continue to find strong evidence of a negative and statistically significant technique elasticity across all sectors, as well as strong evidence of positive composition elasticity using total, industrial, and commercial energy intensity. However, we now obtain a negative and statistically significant composition elasticity using GY's capital-labor ratio (Model II) in the transportation and residential sectors. Second, we now reject the null of no association between of trade and energy intensity at the $p < 0.10$ level in nine of the ten specifications, including both models for the transportation sector. Moreover, the trade elasticity is positive and statistically significant in both models for the transportation sector, contrary to the baseline results. However, the trade elasticities for total and industrial energy intensity using CY's capital-labor ratio (Model I) are both now statistically insignificant (although the point estimates remain positive).

[13] All unreported results are available from the authors upon request.

In terms of the GMM results (Table 5, Panel II), the results continue to be quite similar. Again, two main changes arise relative to the baseline results in Table 3. First, while we continue to find that the majority of the technique (composition) elasticity estimates are negative (positive) and statistically significant, we find a negative and statistically significant composition elasticity using GY's capital-labor ratio (Model II) in the transportation sector as in the OLS results (Panel I). Second, we reject the null of no association between of trade and energy intensity at the $p < 0.10$ level in eight of the ten specifications; the two exceptions are both models for the transportation sector (Model I: p = 0.40; Model II: p = 0.76). Nonetheless, the point estimates are positive in all specifications except for the two models for the residential sector. In sum, then, defining energy intensity as consumption per unit of economic activity measured by GSP, we find broadly similar results. In particular, we continue to find strong, negative effects of income, as well as, if anything, a positive effect of interstate trade on energy intensity in all sectors except for the residential sector.

**Unobserved Heterogeneity** Our second sensitivity analysis follows Cole [6] and estimates (1) via fixed effects (FE) methods. Inclusion of state FE controls for state-specific variables that do not vary over the short time horizon considered in the analysis (e.g., topography and climate). FE and GMM-FE results are presented in Table 6, again reporting only the elasticities of primary interest as well as the results of the various diagnostic tests. Note, we now utilize all three years of data available when using GY's capital-labor ratio – 1993, 1997, and 2002 – given the limited sample size.

In terms of the FE results (Table 6, Panel I), while many of the individual elasticities are no longer statistically significant, the pattern of results for the technique and composition elasticities are unchanged from the previous results. In particular, we obtain a negative (positive) technique (composition) elasticity in eight (six) of the ten specifications, with three (two) of the estimates being statistically significant. However, the trade elasticity estimates are very different. Specifically, six of the ten point estimates are negative, with two being statistically significant. The four positive point estimates occur for the commercial and transportation sectors, while the two statistically significant estimates occur in the industrial sector (Model I) and the residential sector (Model II). Moreover, we only reject the null on no trade effects on energy intensity in half of the specifications (five of ten). Thus, controlling for time invariant, state-specific unobservables reverses the findings of the baseline specifications, indicating, if anything, a *beneficial* impact of interstate trade on energy intensity, particularly outside the commercial and transportation sectors.

Examining the GMM-FE results (Table 6, Panel II), the first result that stands out is the fact that we *fail to reject* the exogeneity of trade at the $p < 0.10$ level in nine of the ten specifications. Model II for the transportation sector is the lone exception. Thus, one should focus on the FE estimates in Panel I on efficiency grounds. Nonetheless, viewing the results, we continue to find similar results as in Panel I, with the main difference being that fewer estimates are statistically significant. However, we continue to obtain primarily negative point estimates for the technique and trade elasticities (seven of ten specifications for each), and positive point estimates for the composition elasticity (seven of ten specifications as well). The only two statistically significant elasticity estimates found are for the technique elasticity using total and residential energy intensity (Model II in both cases).

As a result, when we control for time invariant heterogeneity across states, the results concerning the technique and composition effects are unaltered, but the our conclusion regarding the effect of interstate trade is reversed. Consequently, we conclude that interstate trade has at worst no impact on average on state-level energy intensity, and potentially has a negative effect. To move beyond the average effect, Table A2 in the Appendix replicates Table A1 using the GMM-FE results.[14] In addition, Figures A1 and A2 plot kernel density estimates of the distributions of the (average) state-specific elasticities from the baseline OLS and GMM models (Tables 3 and 4), and the FE and GMM-FE models (Table 6). Figure 1 (2) displays the results using CM's (GY's) capital-labor ratio measure.

The results in Table A2 indicate that the negative trade elasticities evaluated at the sample mean reported in Table 6 are not driven by a few outliers. For total energy intensity, the trade elasticity using CM's (GY's) capital-labor ratio measure is negative for all but eight (five) states. Moreover, the relative ranking of states is not overly different – at least among the states with the highest and lowest elasticities – between Tables A1 and A2; the distribution of elasticities seems to be simply shifted to the left when time invariant heterogeneity is removed (see Figures 1 and 2). In terms of particular states, Delaware, Connecticut, New Jersey, New York, and Massachusetts consistently suffer the greatest increase in total energy intensity from expanded interstate trade across both capital-labor ratio measures; Montana, West Virginia, and Louisiana consistently reap the greatest decline in total energy intensity from expanded interstate trade across both capital-labor ratio measures. For industrial and transportation energy intensity, the trade elasticity is negative for at least 44 of the 48 states in each case. Conversely, for commercial energy intensity, the trade elasticity is positive for at least 46 states. For residential energy intensity, the results differ fairly substantially across the two capital-labor ratio measures.

For completeness, Table 7 presents FE and GMM-FE estimates using the alternative definitions of energy intensity discussed in the previous sensitivity analysis. Relative to the results in Table 6, the qualitative findings are not significantly altered. However, we do find many more instances of statistically significant elasticities. Specifically, using the FE results, we obtain a negative (positive) technique (composition) elasticity in eight (seven) of the ten specifications, with seven (one) of the estimates being statistically significant. It should be noted that one (two) of the technique (composition) elasticity estimates are positive

[14] We choose to use the GMM-FE results rather than FE results since many might suspect trade to be endogenous despite the results of the endogeneity tests, given the small sample size.

(negative) and statistically significant as well. In addition, the trade elasticity estimates are negative in seven specifications, and statistically significant in two (Model I for the transportation sector and Model II for the residential sector). Finally, we reject the null of no trade effects on energy intensity in only four of the ten specifications. Examination of the GMM-FE results also yields quite similar conclusions to those gained from Table 6. First, we *fail to reject* the null of exogeneity of trade in all ten specifications at the $p < 0.10$ level. Second, we obtain a negative (positive) technique (composition) elasticity in eight (seven) of the ten specifications, with five (none) of the estimates being statistically significant; one of the composition elasticities is negative and statistically significant (Model II for the transportation sector). Moreover, the trade elasticity estimates are negative in seven specifications, and statistically significant in two (Model II for total energy intensity and Model II for the transportation sector). Finally, we reject the null of no trade effects on energy intensity at the $p < 0.10$ level in but one specification. Thus, using our alternative definitions for energy intensity and does not alter the conclusions from the previous models controlling for time invariant, state-specific heterogeneity.

**Per Capita Energy Consumption** As a final sensitivity analysis, we follow Stern [25] and Cole [6] and assess the impact of interstate trade on per capita energy consumption, rather than energy intensity. As noted in Cole [6], when the dependent variable is measured in per capita terms, the elasticity with respect to per capita GSP captures both scale and technique effects. The results are reported in Tables 8 and 9, with Table 8 providing the results obtained using OLS and GMM and Table 9 reporting the FE and GMM-FE results. In general, the implications from the preceding results are unaltered.

In Table 8, we obtain a negative combined scale and technique elasticity in seven of ten specifications using either OLS (Panel I) or GMM (Panel II), with three of the seven being statistically significant in both cases. One estimate is positive and statistically significant in each panel (Model I for commercial energy consumption per capita). Thus, the negative technique effect tends to dominate the scale effect. In addition, the composition (trade) elasticity estimate is positive in nine (seven) of ten specifications in Panels I and II of Table 8. The composition elasticity is positive (negative) and statistically significant in five (one) specifications in each panel, whereas the trade elasticity is positive (negative) and statistically significant in four (one) specification in Panel II; the trade elasticity is always statistically insignificant in Panel I. Finally, according to the GMM estimates, we reject the null of no trade effects in nine of ten specifications, and we reject the null of trade being exogenous in six cases. As a result, the OLS and GMM per capita results largely confirm the previous results based on energy intensity reported in Tables 3 and 4.

In Table 9, we obtain a positive combined scale and technique elasticity in seven of ten specifications using FE (Panel I), with one being statistically significant (Model I for the commercial sector). Thus, the negative technique effect tends to be more than offset by the scale effect once time invariant, state-specific heterogeneity is removed. The composition elasticity estimate is positive in seven of ten specifications in Panel I; one estimate is positive and statistically significant (Model I for the industrial sector), while one estimate is negative and statistically significant (Model I for the residential sector). As in Panel I of Table 6, the trade elasticity is positive and statistically insignificant for the commercial and transportation sector, and negative in the remaining six specifications with one being statistically significant (Model II for the residential sector). Lastly, while the GMM-FE results in Panel II are consonant with the FE results, we *fail to reject* the null of trade being exogenous in nine of ten cases (the lone exception is Model I for the transportation sector). As a result, the more efficient FE estimates confirm our previous conclusions: failing to account for unobserved heterogeneity suggests *at best* no impact of interstate trade on state-level energy use, and *at worst* a positive impact of interstate trade on energy use; however, controlling for time invariant heterogeneity indicates *at worst* no impact of interstate trade on state-level energy use, and *at best* a negative impact of interstate trade on energy use.

# 4 Conclusion

Analyzing the role of interstate commerce on energy consumption provides insight into many open questions, ranging from the determinants of the cross-state variation in energy use patterns to the impact of subnational trade on the environment to the impact of international trade on energy use and the environment. Our examination of this issue yields two primary conclusions. First, once time invariant, state-specific heterogeneity is accounted for, greater subnational trade reduces, or at least does not raise, overall state-level energy intensity or per capita energy consumption. This conclusion holds regardless of the capital-labor ratio measure utilized, and whether trade is treated as endogenous. Second, our analysis reveals a number of sources of heterogeneity. As is well known from the Antweiler et al. [2] framework, the impact of trade liberalization depends on an economy's relative endowments. This is confirmed by our findings; the impact of trade on energy consumption is heterogeneous across states, typically ranging from positive to negative point estimates. However, the impact of trade on energy use is also heterogeneous across sectors. We tend to find negative trade elasticities for energy use in the industrial and residential sectors, but positive elasticities in the commercial and transportation sector. The sign of the elasticity for the transportation sector, however, is particularly sensitive to how energy consumption is scaled, be it by vehicle miles driven or income/GSP or population. Given that two-thirds of petroleum consumption occurs in the transportation sector, and the link between fossil fuel consumption and global warming, a more detailed analysis of the transportation sector is perhaps warranted (Metcalf [21]).

In general, our findings are consonant with previous results in the literature. Specifically, our analysis provides further evidence against a harmful environmental effect of expanded trade, as documented in, among others, Antweiler et al. [2], Harbaugh et al. [14], Frankel and Rose [12], and Stern [25] using cross-country data and Chintrakarn and Millimet [4] using subnational data. Our findings also confirm the role of economic factors in explaining at least a portion of the cross-state variation in energy use in the US, as discussed in Metcalf [20]. However, our results do contrast starkly with those in Cole [6]. Thus, assuming this discrepancy is not driven by inconsistencies that may arise in cross-country panel data, what accounts for the differential impact of cross-country trade on country-level energy intensity, as opposed to interstate trade on state-level energy intensity, is an open question, deserving attention.

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**Table A1. Average Trade Elasticities by State: GMM**

| State | Total | | | | Industrial | | | | Commerical | | | | Transportation | | | | Residential | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | CM | | GY | | CM | | GY | | CM | | GY | | CM | | GY | | CM | | GY | |
| | Est. | Rk. | Est. | Rk. | Est. | Rk. | Est. | Rk. | Est. | Rk. | Est. | Rk. | Est. | Rk. | Est. | Rk. | Est. | Rk. | Est. | Rk. |
| **DE** | 0.723 | (1) | 1.138 | (5) | 2.231 | (6) | 4.437 | (5) | 0.410 | (21) | 1.220 | (9) | -0.242 | (41) | 0.297 | (38) | 0.898 | (3) | 1.222 | (5) |
| **CT** | 0.632 | (2) | 1.553 | (3) | 1.938 | (10) | 4.307 | (6) | 0.050 | (39) | 2.089 | (3) | -0.247 | (43) | 0.651 | (28) | 1.096 | (1) | 1.660 | (3) |
| **MS** | 0.512 | (3) | 0.211 | (22) | 4.904 | (1) | 4.988 | (2) | 1.887 | (1) | 1.091 | (10) | 3.508 | (1) | 3.835 | (1) | -2.368 | (48) | -1.900 | (47) |
| **NJ** | 0.464 | (4) | 1.371 | (4) | 1.083 | (19) | 2.872 | (12) | -0.050 | (43) | 1.936 | (4) | -0.297 | (45) | 0.528 | (32) | 0.910 | (2) | 1.475 | (4) |
| **NY** | 0.432 | (5) | 2.563 | (2) | 0.843 | (27) | 4.937 | (3) | 0.080 | (37) | 4.058 | (2) | -0.329 | (46) | 1.981 | (10) | 0.738 | (5) | 2.560 | (2) |
| **MA** | 0.393 | (6) | 0.534 | (10) | 0.820 | (30) | 1.399 | (22) | -0.115 | (44) | 0.437 | (17) | -0.242 | (42) | -0.127 | (48) | 0.826 | (4) | 0.594 | (6) |
| **AR** | 0.391 | (7) | 0.040 | (33) | 3.381 | (4) | 3.035 | (10) | 1.342 | (4) | 0.560 | (15) | 2.539 | (4) | 2.622 | (6) | -1.683 | (45) | -1.523 | (45) |
| **NV** | 0.351 | (8) | 0.457 | (13) | 0.685 | (34) | 1.639 | (19) | -0.125 | (46) | 0.220 | (25) | -0.179 | (40) | 0.157 | (41) | 0.735 | (6) | 0.401 | (9) |
| **OK** | 0.323 | (9) | -0.294 | (48) | 2.615 | (5) | 0.370 | (42) | 1.117 | (6) | 0.189 | (27) | 2.041 | (5) | 1.142 | (18) | -1.384 | (43) | -1.408 | (44) |
| **MT** | 0.308 | (10) | -0.113 | (43) | 3.474 | (3) | 3.001 | (11) | 1.607 | (3) | 0.491 | (16) | 2.682 | (3) | 2.669 | (5) | -2.065 | (46) | -1.830 | (46) |
| **IL** | 0.301 | (11) | 0.513 | (11) | 0.416 | (39) | 0.608 | (34) | 0.091 | (36) | 0.641 | (13) | -0.140 | (39) | -0.056 | (44) | 0.422 | (9) | 0.505 | (8) |
| **CA** | 0.300 | (12) | 0.397 | (16) | 0.467 | (38) | 0.479 | (40) | 0.068 | (38) | 0.433 | (18) | -0.085 | (38) | -0.104 | (47) | 0.418 | (10) | 0.362 | (10) |
| **AZ** | 0.297 | (13) | -0.141 | (44) | 1.872 | (12) | 0.766 | (31) | 0.645 | (15) | -0.002 | (41) | 1.443 | (12) | 1.075 | (19) | -0.759 | (34) | -1.020 | (38) |
| **WV** | 0.295 | (14) | -0.229 | (47) | 3.834 | (2) | 1.654 | (18) | 1.762 | (2) | 0.793 | (12) | 2.937 | (2) | 2.124 | (9) | -2.302 | (47) | -1.914 | (48) |
| **FL** | 0.293 | (15) | 0.058 | (29) | 1.778 | (14) | 1.489 | (21) | 0.564 | (16) | 0.198 | (26) | 1.357 | (13) | 1.419 | (15) | -0.655 | (33) | -0.841 | (37) |
| **UT** | 0.288 | (16) | -0.102 | (42) | 1.968 | (9) | 1.182 | (24) | 0.805 | (12) | 0.088 | (31) | 1.556 | (8) | 1.355 | (16) | -0.961 | (37) | -1.093 | (41) |
| **MN** | 0.278 | (17) | 0.184 | (24) | 0.606 | (37) | 0.452 | (41) | -0.040 | (42) | 0.037 | (38) | 0.120 | (34) | 0.044 | (43) | 0.402 | (11) | 0.015 | (15) |
| **SD** | 0.274 | (18) | 0.877 | (7) | 1.880 | (11) | 4.137 | (8) | -0.007 | (41) | 1.250 | (8) | 1.288 | (14) | 2.799 | (4) | -0.091 | (18) | -0.154 | (18) |
| **ID** | 0.261 | (19) | -0.216 | (46) | 2.160 | (7) | 1.119 | (25) | 1.036 | (8) | 0.053 | (35) | 1.763 | (7) | 1.432 | (14) | -1.284 | (41) | -1.342 | (43) |
| **NH** | 0.259 | (20) | 0.447 | (14) | 0.828 | (29) | 1.885 | (16) | -0.219 | (48) | 0.340 | (19) | 0.315 | (31) | 0.945 | (24) | 0.473 | (7) | 0.056 | (13) |
| **MO** | 0.256 | (21) | -0.002 | (35) | 1.064 | (20) | 0.504 | (38) | 0.290 | (28) | -0.034 | (47) | 0.762 | (19) | 0.608 | (30) | -0.216 | (23) | -0.542 | (30) |
| **WI** | 0.255 | (22) | 0.114 | (27) | 0.973 | (24) | 0.921 | (28) | 0.226 | (33) | 0.062 | (34) | 0.664 | (25) | 0.761 | (26) | -0.117 | (20) | -0.412 | (24) |
| **MI** | 0.255 | (23) | -0.062 | (40) | 1.014 | (21) | -0.134 | (46) | 0.284 | (29) | -0.031 | (46) | 0.718 | (21) | 0.270 | (39) | -0.195 | (21) | -0.513 | (28) |
| **OR** | 0.250 | (24) | 0.012 | (34) | 0.986 | (23) | 0.560 | (37) | 0.353 | (24) | -0.022 | (45) | 0.717 | (22) | 0.617 | (29) | -0.266 | (27) | -0.524 | (29) |
| **NE** | 0.248 | (25) | 0.133 | (26) | 0.627 | (36) | 0.613 | (33) | 0.189 | (35) | 0.023 | (39) | 0.341 | (30) | 0.393 | (35) | 0.038 | (16) | -0.215 | (20) |
| **RI** | 0.246 | (26) | 0.288 | (17) | 1.351 | (18) | 1.691 | (17) | -0.204 | (47) | 0.301 | (22) | 0.840 | (17) | 1.225 | (17) | 0.232 | (12) | -0.344 | (23) |
| **WA** | 0.242 | (27) | 0.199 | (23) | 0.270 | (43) | 0.227 | (43) | 0.234 | (32) | 0.126 | (30) | -0.024 | (37) | -0.064 | (46) | 0.143 | (13) | 0.066 | (12) |
| **PA** | 0.240 | (28) | -0.039 | (38) | 0.838 | (28) | -0.177 | (47) | 0.335 | (26) | -0.005 | (42) | 0.609 | (26) | 0.214 | (40) | -0.221 | (24) | -0.451 | (26) |
| **KS** | 0.238 | (29) | -0.028 | (36) | 1.003 | (22) | 0.496 | (39) | 0.440 | (20) | -0.038 | (48) | 0.786 | (18) | 0.657 | (27) | -0.394 | (28) | -0.611 | (33) |
| **CO** | 0.237 | (30) | 0.265 | (19) | 0.287 | (42) | 0.096 | (44) | 0.219 | (34) | 0.316 | (20) | 0.010 | (35) | -0.059 | (45) | 0.137 | (14) | 0.140 | (11) |
| **OH** | 0.233 | (31) | 0.052 | (31) | 0.739 | (33) | 0.563 | (36) | 0.340 | (25) | -0.018 | (44) | 0.534 | (27) | 0.536 | (31) | -0.206 | (22) | -0.413 | (25) |
| **VA** | 0.233 | (32) | 0.251 | (20) | 0.239 | (44) | 0.951 | (26) | 0.255 | (31) | 0.072 | (32) | -0.015 | (36) | 0.314 | (37) | 0.105 | (15) | 0.019 | (14) |
| **IA** | 0.229 | (33) | 0.498 | (12) | 0.934 | (25) | 2.562 | (13) | 0.478 | (19) | 0.614 | (14) | 0.752 | (20) | 1.763 | (13) | -0.429 | (29) | -0.260 | (22) |
| **MD** | 0.228 | (34) | 0.213 | (21) | 0.384 | (41) | 0.939 | (27) | 0.261 | (30) | 0.067 | (33) | 0.162 | (33) | 0.462 | (34) | 0.018 | (17) | -0.107 | (17) |
| **ND** | 0.227 | (35) | 0.055 | (30) | 1.786 | (13) | 1.962 | (15) | 0.966 | (9) | 0.315 | (21) | 1.518 | (9) | 1.817 | (12) | -1.173 | (40) | -1.056 | (39) |
| **AL** | 0.225 | (36) | -0.065 | (41) | 2.158 | (8) | 1.974 | (14) | 1.157 | (5) | 0.274 | (23) | 1.812 | (6) | 1.931 | (11) | -1.454 | (44) | -1.331 | (42) |
| **NC** | 0.222 | (37) | 0.285 | (18) | 0.654 | (35) | 1.534 | (20) | 0.367 | (23) | 0.245 | (24) | 0.485 | (28) | 1.039 | (20) | -0.226 | (25) | -0.257 | (21) |
| **GA** | 0.216 | (38) | 0.065 | (28) | 0.414 | (40) | -0.068 | (45) | 0.324 | (27) | 0.044 | (37) | 0.251 | (32) | 0.064 | (42) | -0.099 | (19) | -0.209 | (19) |
| **SC** | 0.206 | (39) | 0.447 | (15) | 1.660 | (15) | 3.309 | (9) | 0.961 | (10) | 0.828 | (11) | 1.447 | (11) | 2.545 | (7) | -1.168 | (39) | -0.759 | (35) |
| **KY** | 0.197 | (40) | -0.175 | (45) | 1.411 | (17) | 0.643 | (32) | 0.860 | (11) | -0.017 | (43) | 1.255 | (15) | 1.033 | (21) | -1.015 | (38) | -1.064 | (40) |
| **IN** | 0.196 | (41) | 0.048 | (32) | 0.793 | (31) | 0.887 | (29) | 0.552 | (17) | 0.048 | (36) | 0.704 | (23) | 0.874 | (25) | -0.522 | (32) | -0.581 | (32) |
| **TN** | 0.196 | (42) | 0.139 | (25) | 0.754 | (32) | 1.219 | (23) | 0.535 | (18) | 0.144 | (29) | 0.667 | (24) | 1.030 | (22) | -0.492 | (31) | -0.502 | (27) |
| **NM** | 0.140 | (43) | -0.060 | (39) | 0.880 | (26) | 0.812 | (30) | 0.745 | (13) | 0.020 | (40) | 0.890 | (16) | 1.000 | (23) | -0.842 | (36) | -0.836 | (36) |
| **ME** | 0.137 | (44) | 0.735 | (9) | 1.639 | (16) | 4.526 | (4) | 1.066 | (7) | 1.303 | (6) | 1.506 | (10) | 3.286 | (2) | -1.363 | (42) | -0.662 | (34) |
| **TX** | 0.001 | (45) | 0.748 | (8) | -0.544 | (46) | 0.590 | (35) | 0.398 | (22) | 1.350 | (5) | -0.259 | (44) | 0.517 | (33) | -0.227 | (26) | 0.543 | (7) |
| **VT** | -0.063 | (46) | 0.919 | (6) | 0.073 | (45) | 4.231 | (7) | 0.651 | (14) | 1.291 | (7) | 0.449 | (29) | 2.821 | (3) | -0.820 | (35) | -0.096 | (16) |
| **WY** | -0.389 | (47) | 2.859 | (1) | -2.073 | (48) | 5.291 | (1) | -0.116 | (45) | 4.645 | (1) | -1.632 | (48) | 2.469 | (8) | 0.436 | (8) | 2.777 | (1) |
| **LA** | -0.597 | (48) | -0.035 | (37) | -1.740 | (47) | -0.295 | (48) | 0.020 | (40) | 0.179 | (28) | -0.575 | (47) | 0.339 | (36) | -0.436 | (30) | -0.546 | (31) |

NOTES: Averages computed over 1993 and 1997.

**Table A2. Average Trade Elasticities by State: GMM-FE**

| State | Total | | | | Industrial | | | | Commerical | | | | Transportation | | | | Residential | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | CM | | GY | | CM | | GY | | CM | | GY | | CM | | GY | | CM | | GY | |
| | Est. | Rk. | Est. | Rk. | Est. | Rk. | Est. | Rk. | Est. | Rk. | Est. | Rk. | Est. | Rk. | Est. | Rk. | Est. | Rk. | Est. | Rk. |
| **DE** | 0.318 | (1) | 0.149 | (4) | -1.217 | (8) | 0.348 | (1) | -0.188 | (47) | 0.931 | (5) | -0.420 | (44) | -0.156 | (17) | 0.836 | (1) | 0.290 | (1) |
| **CT** | 0.243 | (2) | 0.210 | (3) | -0.336 | (4) | 0.015 | (2) | -0.534 | (48) | 1.180 | (3) | -0.321 | (42) | -0.078 | (4) | 0.559 | (2) | 0.221 | (2) |
| **NJ** | 0.144 | (3) | 0.064 | (5) | -0.939 | (5) | -0.398 | (9) | 0.199 | (44) | 1.051 | (4) | -0.289 | (39) | -0.058 | (3) | 0.399 | (4) | 0.064 | (5) |
| **NY** | 0.134 | (4) | 0.350 | (1) | -1.635 | (17) | -0.183 | (5) | 0.695 | (40) | 1.472 | (1) | -0.328 | (43) | -0.014 | (1) | 0.464 | (3) | 0.202 | (3) |
| **MA** | 0.093 | (5) | -0.100 | (6) | -0.973 | (6) | -0.489 | (15) | 0.388 | (43) | 0.663 | (8) | -0.251 | (35) | -0.089 | (5) | 0.292 | (13) | -0.005 | (8) |
| **NV** | 0.061 | (6) | -0.157 | (9) | -1.051 | (7) | -0.487 | (14) | 0.544 | (41) | 0.302 | (20) | -0.229 | (31) | -0.112 | (10) | 0.237 | (25) | -0.024 | (9) |
| **IL** | 0.035 | (7) | -0.207 | (11) | -2.020 | (24) | -0.797 | (34) | 1.266 | (33) | 0.687 | (7) | -0.274 | (37) | -0.092 | (6) | 0.317 | (8) | -0.137 | (15) |
| **CA** | 0.029 | (8) | -0.225 | (14) | -1.865 | (20) | -0.798 | (35) | 1.183 | (37) | 0.636 | (11) | -0.252 | (36) | -0.098 | (7) | 0.285 | (14) | -0.142 | (16) |
| **MN** | -0.006 | (9) | -0.268 | (18) | -1.264 | (9) | -0.755 | (29) | 0.902 | (39) | 0.408 | (18) | -0.167 | (23) | -0.119 | (12) | 0.139 | (38) | -0.144 | (17) |
| **WA** | -0.016 | (10) | -0.278 | (20) | -2.562 | (36) | -0.823 | (37) | 1.765 | (20) | 0.500 | (13) | -0.291 | (40) | -0.115 | (11) | 0.322 | (7) | -0.169 | (22) |
| **CO** | -0.024 | (11) | -0.236 | (15) | -2.474 | (33) | -0.821 | (36) | 1.730 | (22) | 0.648 | (9) | -0.278 | (38) | -0.103 | (9) | 0.298 | (11) | -0.157 | (20) |
| **VA** | -0.025 | (12) | -0.247 | (16) | -2.654 | (38) | -0.673 | (21) | 1.848 | (17) | 0.317 | (19) | -0.296 | (41) | -0.125 | (13) | 0.324 | (6) | -0.114 | (13) |
| **NE** | -0.037 | (13) | -0.338 | (23) | -1.877 | (21) | -0.794 | (33) | 1.400 | (30) | 0.291 | (22) | -0.173 | (25) | -0.161 | (18) | 0.183 | (32) | -0.196 | (25) |
| **MD** | -0.040 | (14) | -0.286 | (21) | -2.436 | (32) | -0.709 | (23) | 1.758 | (21) | 0.264 | (26) | -0.249 | (34) | -0.145 | (15) | 0.268 | (15) | -0.147 | (19) |
| **NH** | -0.051 | (15) | -0.215 | (12) | -0.331 | (3) | -0.541 | (16) | 0.411 | (42) | 0.174 | (39) | -0.076 | (10) | -0.147 | (16) | -0.044 | (45) | -0.076 | (11) |
| **GA** | -0.056 | (16) | -0.349 | (25) | -2.563 | (37) | -0.921 | (44) | 1.886 | (16) | 0.476 | (15) | -0.246 | (32) | -0.141 | (14) | 0.267 | (16) | -0.233 | (29) |
| **WI** | -0.058 | (17) | -0.339 | (24) | -1.476 | (12) | -0.730 | (25) | 1.203 | (36) | 0.215 | (32) | -0.099 | (14) | -0.182 | (23) | 0.106 | (44) | -0.187 | (24) |
| **MI** | -0.062 | (18) | -0.413 | (32) | -1.594 | (15) | -0.954 | (45) | 1.291 | (32) | 0.412 | (17) | -0.101 | (15) | -0.177 | (20) | 0.122 | (41) | -0.278 | (37) |
| **OH** | -0.063 | (19) | -0.364 | (27) | -2.145 | (27) | -0.790 | (31) | 1.644 | (24) | 0.253 | (28) | -0.170 | (24) | -0.182 | (22) | 0.199 | (31) | -0.212 | (27) |
| **PA** | -0.063 | (20) | -0.416 | (34) | -1.990 | (23) | -0.958 | (46) | 1.548 | (27) | 0.414 | (16) | -0.147 | (20) | -0.178 | (21) | 0.177 | (36) | -0.281 | (39) |
| **OR** | -0.065 | (21) | -0.395 | (30) | -1.843 | (18) | -0.825 | (38) | 1.457 | (28) | 0.269 | (25) | -0.124 | (16) | -0.196 | (25) | 0.160 | (37) | -0.240 | (32) |
| **MO** | -0.065 | (22) | -0.403 | (31) | -1.538 | (14) | -0.835 | (41) | 1.262 | (34) | 0.269 | (24) | -0.092 | (13) | -0.199 | (26) | 0.112 | (42) | -0.247 | (33) |
| **NC** | -0.068 | (23) | -0.277 | (19) | -2.338 | (31) | -0.620 | (20) | 1.781 | (19) | 0.173 | (40) | -0.194 | (27) | -0.170 | (19) | 0.222 | (29) | -0.130 | (14) |
| **KS** | -0.080 | (24) | -0.424 | (35) | -2.067 | (25) | -0.871 | (42) | 1.641 | (25) | 0.297 | (21) | -0.135 | (17) | -0.205 | (27) | 0.180 | (35) | -0.267 | (35) |
| **IA** | -0.085 | (25) | -0.250 | (17) | -2.271 | (30) | -0.468 | (13) | 1.784 | (18) | 0.090 | (45) | -0.158 | (21) | -0.210 | (29) | 0.206 | (30) | -0.098 | (12) |
| **FL** | -0.086 | (26) | -0.413 | (33) | -1.385 | (11) | -0.677 | (22) | 1.217 | (35) | 0.169 | (41) | -0.018 | (5) | -0.263 | (35) | 0.109 | (43) | -0.234 | (31) |
| **AZ** | -0.090 | (27) | -0.478 | (40) | -1.501 | (13) | -0.834 | (40) | 1.301 | (31) | 0.258 | (27) | -0.021 | (6) | -0.260 | (34) | 0.131 | (40) | -0.299 | (41) |
| **TN** | -0.109 | (28) | -0.373 | (28) | -2.661 | (41) | -0.727 | (24) | 2.090 | (12) | 0.197 | (35) | -0.208 | (29) | -0.212 | (30) | 0.242 | (23) | -0.211 | (26) |
| **UT** | -0.110 | (29) | -0.455 | (37) | -1.845 | (19) | -0.733 | (26) | 1.565 | (26) | 0.204 | (34) | -0.049 | (8) | -0.276 | (36) | 0.183 | (33) | -0.269 | (36) |
| **IN** | -0.112 | (30) | -0.386 | (29) | -2.656 | (40) | -0.766 | (30) | 2.094 | (11) | 0.219 | (31) | -0.205 | (28) | -0.208 | (28) | 0.241 | (24) | -0.225 | (28) |
| **RI** | -0.113 | (31) | -0.297 | (22) | 0.448 | (2) | -0.614 | (19) | 0.075 | (45) | 0.152 | (42) | 0.048 | (3) | -0.191 | (24) | -0.215 | (46) | -0.145 | (18) |
| **AR** | -0.125 | (32) | -0.531 | (43) | -1.604 | (16) | -0.454 | (12) | 1.410 | (29) | 0.180 | (38) | 0.036 | (4) | -0.433 | (45) | 0.255 | (18) | -0.288 | (40) |
| **SD** | -0.126 | (33) | -0.139 | (7) | 0.582 | (1) | -0.205 | (7) | 0.025 | (46) | 0.021 | (47) | 0.109 | (1) | -0.229 | (32) | -0.223 | (47) | 0.000 | (6) |
| **OK** | -0.133 | (34) | -0.640 | (47) | -1.919 | (22) | -0.964 | (47) | 1.649 | (23) | 0.505 | (12) | -0.027 | (7) | -0.361 | (43) | 0.234 | (27) | -0.443 | (47) |
| **MS** | -0.133 | (35) | -0.534 | (44) | -1.269 | (10) | -0.091 | (3) | 1.158 | (38) | 0.185 | (37) | 0.105 | (2) | -0.565 | (48) | 0.349 | (5) | -0.247 | (34) |
| **ID** | -0.166 | (36) | -0.538 | (45) | -2.237 | (29) | -0.736 | (27) | 1.934 | (15) | 0.241 | (29) | -0.091 | (12) | -0.341 | (42) | 0.230 | (28) | -0.328 | (45) |
| **ND** | -0.171 | (37) | -0.425 | (36) | -2.519 | (34) | -0.602 | (17) | 2.133 | (10) | 0.149 | (43) | -0.136 | (18) | -0.299 | (39) | 0.243 | (22) | -0.234 | (30) |
| **KY** | -0.172 | (38) | -0.515 | (41) | -2.693 | (42) | -0.831 | (39) | 2.251 | (8) | 0.271 | (23) | -0.174 | (26) | -0.291 | (38) | 0.243 | (21) | -0.325 | (44) |
| **SC** | -0.186 | (39) | -0.349 | (26) | -2.654 | (39) | -0.429 | (11) | 2.254 | (7) | 0.092 | (44) | -0.160 | (22) | -0.306 | (40) | 0.247 | (20) | -0.165 | (21) |
| **NM** | -0.193 | (40) | -0.467 | (38) | -3.031 | (44) | -0.749 | (28) | 2.517 | (6) | 0.221 | (30) | -0.248 | (33) | -0.279 | (37) | 0.251 | (19) | -0.280 | (38) |
| **AL** | -0.214 | (41) | -0.524 | (42) | -2.557 | (35) | -0.609 | (18) | 2.241 | (9) | 0.197 | (36) | -0.138 | (19) | -0.373 | (44) | 0.256 | (17) | -0.302 | (43) |
| **TX** | -0.242 | (42) | -0.188 | (10) | -3.863 | (47) | -0.902 | (43) | 3.124 | (4) | 0.931 | (6) | -0.498 | (46) | -0.102 | (8) | 0.311 | (9) | -0.186 | (23) |
| **MT** | -0.248 | (43) | -0.559 | (46) | -2.163 | (28) | -0.398 | (10) | 2.019 | (14) | 0.208 | (33) | -0.074 | (9) | -0.475 | (46) | 0.298 | (10) | -0.301 | (42) |
| **ME** | -0.276 | (44) | -0.219 | (13) | -2.898 | (43) | -0.139 | (4) | 2.601 | (5) | 0.031 | (46) | -0.222 | (30) | -0.319 | (41) | 0.235 | (26) | -0.051 | (10) |
| **WV** | -0.307 | (45) | -0.734 | (48) | -2.097 | (26) | -0.792 | (32) | 2.085 | (13) | 0.643 | (10) | -0.089 | (11) | -0.504 | (47) | 0.294 | (12) | -0.495 | (48) |
| **VT** | -0.378 | (46) | -0.146 | (8) | -3.599 | (46) | -0.184 | (6) | 3.283 | (3) | 0.019 | (48) | -0.430 | (45) | -0.243 | (33) | 0.181 | (34) | -0.004 | (7) |
| **WY** | -0.640 | (47) | 0.236 | (2) | -3.959 | (48) | -0.369 | (8) | 3.913 | (2) | 1.360 | (2) | -0.978 | (48) | -0.027 | (2) | 0.137 | (39) | 0.110 | (4) |
| **LA** | -0.902 | (48) | -0.478 | (39) | -3.430 | (45) | -1.027 | (48) | 4.303 | (1) | 0.500 | (14) | -0.779 | (47) | -0.216 | (31) | -0.275 | (48) | -0.343 | (46) |

NOTES: Estimates using CM capital-labor ratio use data from 1993 and 1997. Estimates using GY capital-labor ratio use data from 1993, 1997, and 2002.

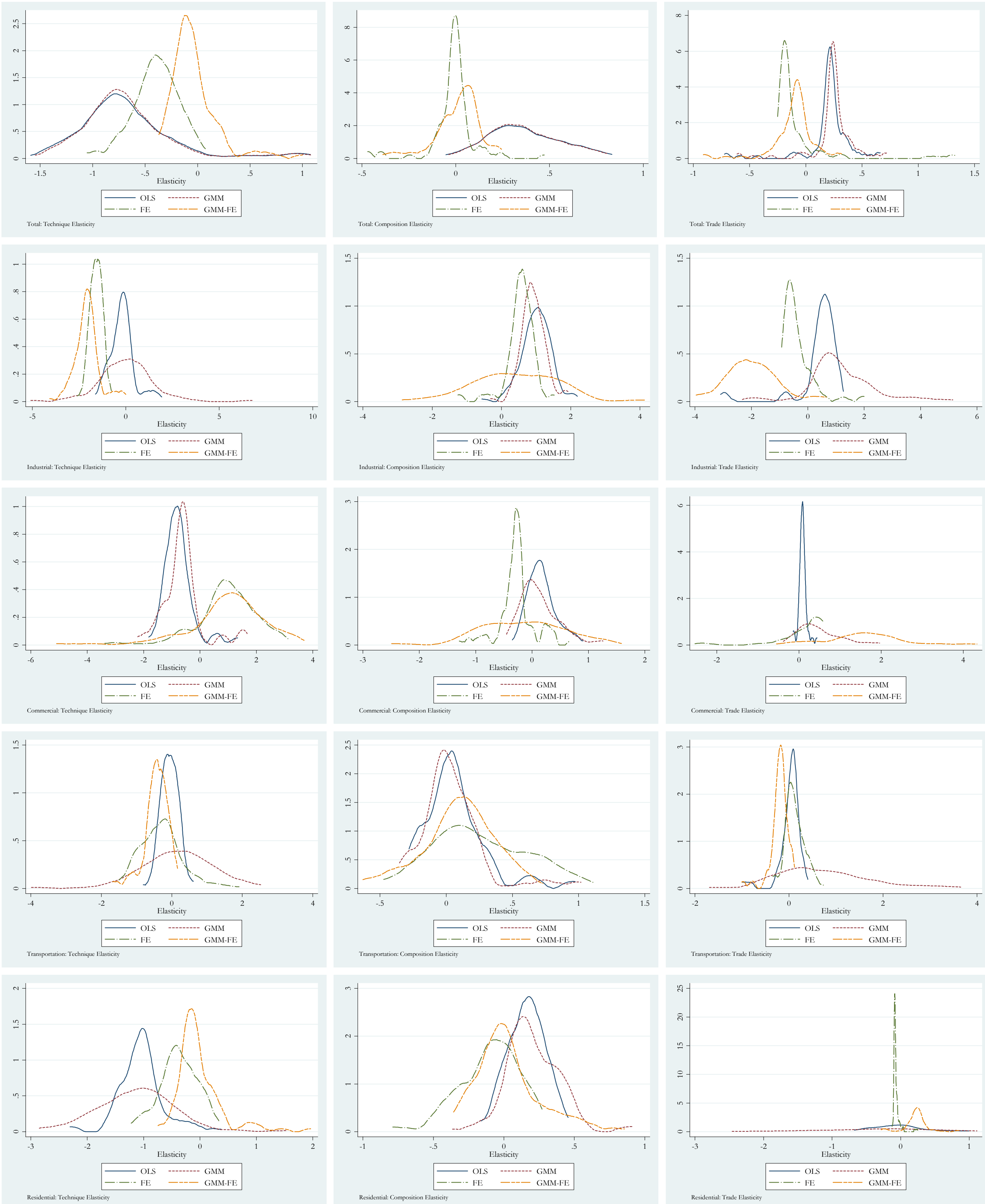


**Figure A1. Distribution of Technique, Composition, and Trade Elasticities by Sector: CM Capital-Labor Ratio.**
NOTES: Data from 1993 and 1997. Plots are kernel density estimates using an optimal bandwidth and Epanechnikov kernel.

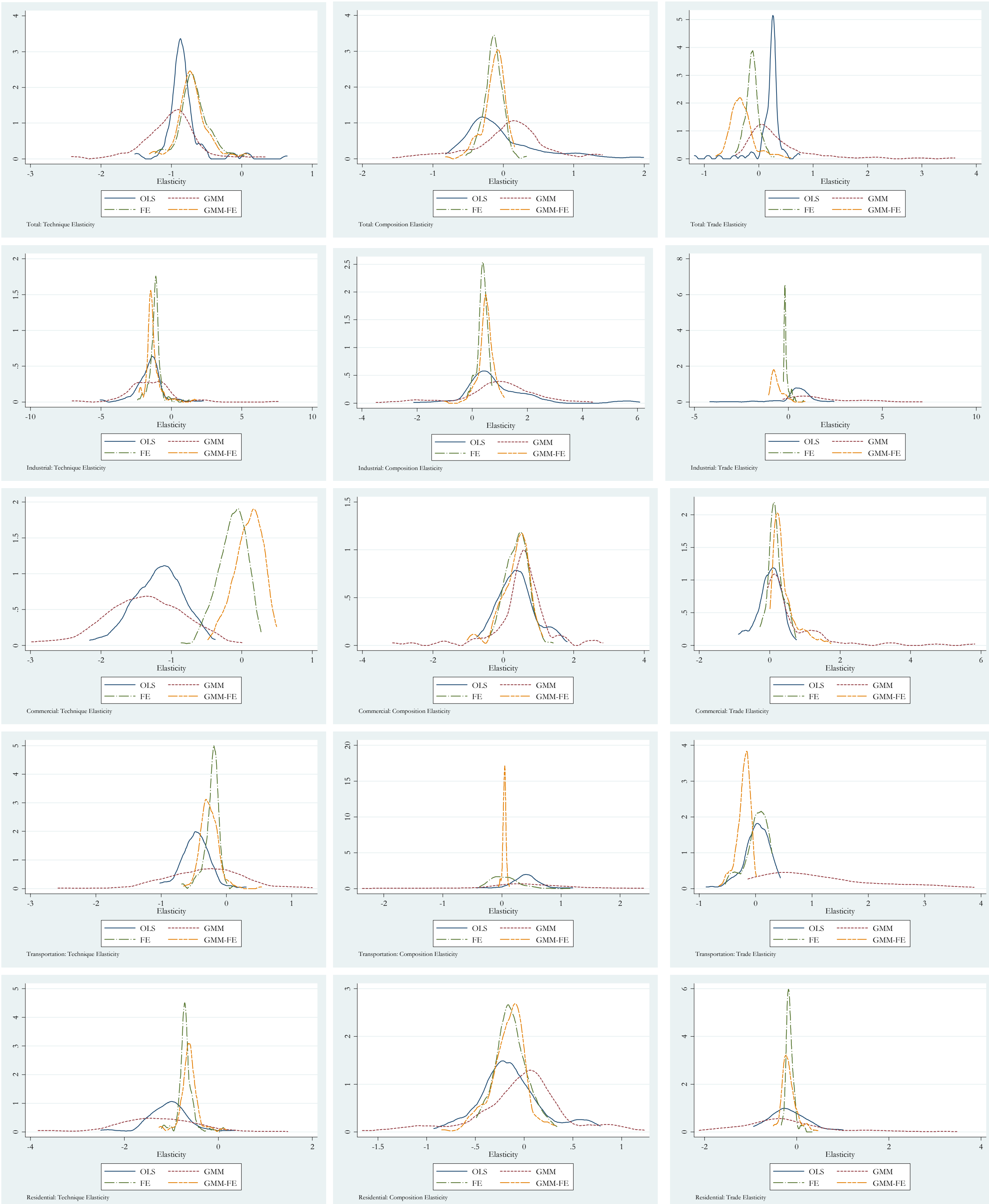


**Figure A2. Distribution of Technique, Composition, and Trade Elasticities by Sector: GY Capital-Labor Ratio.**
NOTES: Data from 1993 and 1997 in OLS & GMM models; 1993, 1997, and 2002 in FE and GMM-FE models. Plots are kernel density estimates using an optimal bandwidth and Epanechnikov kernel.

**Table 1. Summary Statistics**

| Variable | Mean | Std. Dev. | Years | Description & Source |
|---|---|---|---|---|
| ***Energy Measures*** | | | | |
| Total Usage | 1925008.00 | 2013756.00 | 1993, 1997, 2002 | U.S. Energy Information Administration |
| Commerical Usage | 322182.10 | 315117.90 | 1993, 1997, 2002 | U.S. Energy Information Administration |
| Industrial Usage | 690530.80 | 984176.00 | 1993, 1997, 2002 | U.S. Energy Information Administration |
| Transportation Usage | 509486.20 | 538507.00 | 1993, 1997, 2002 | U.S. Energy Information Administration |
| Residential Usage | 402345.00 | 354313.30 | 1993, 1997, 2002 | U.S. Energy Information Administration |
| ***Control Variables*** | | | | |
| Trade Intensity | 1.29 | 0.23 | 1993, 1997, 2002 | Commodity Flow Survey |
| Predicted Trade Intensity | 1.51 | 0.47 | 1993, 1997, 2002 | Commodity Flow Survey |
| Lagged Per Capita GSP (3-year moving average) | 17591.81 | 3169.02 | 1992, 1996, 2001 | Bureau of Economic Analysis |
| Capital-Labor Ratio (#1) | 1.85 | 0.70 | 1993, 1997 | Cohen and Morrison Paul (2004) |
| Capital-Labor Ratio (#2) | 0.06 | 0.01 | 1993, 1997, 2001 | Garofalo and Yamarik (2002) |
| Relative Income | 1.00 | 0.17 | 1992, 1996, 2001 | |
| Relative Capital-Labor Ratio (#1) | 1.00 | 0.38 | 1993, 1997 | |
| Relative Capital-Labor Ratio (#2) | 1.00 | 0.20 | 1993, 1997, 2001 | |
| Energy Price (Total) | 9.19 | 1.68 | 1993, 1997, 2002 | U.S. Energy Information Administration |
| Energy Price (Commerical) | 12.54 | 2.72 | 1993, 1997, 2002 | U.S. Energy Information Administration |
| Energy Price (Industrial) | 6.20 | 1.81 | 1993, 1997, 2002 | U.S. Energy Information Administration |
| Energy Price (Transportation) | 9.11 | 1.04 | 1993, 1997, 2002 | U.S. Energy Information Administration |
| Energy Price (Residential) | 13.12 | 2.94 | 1993, 1997, 2002 | U.S. Energy Information Administration |

NOTES: 1. Energy usage measured in millions of Btu. 2. Energy prices measured in nominal dollars per million Btu.

**Table 2. Gravity Equation Results (PPML Estimates)**

| Variable | Model I Coefficient | Model I Robust Standard Error | Model II Coefficient | Model II Robust Standard Error |
|---|---|---|---|---|
| ln(Distance) | **-0.51** | 0.02 | **-0.53** | 0.02 |
| ln($Population_1$) | 0.37 | 0.70 | 0.40 | 0.35 |
| ln($Population_2$) | 0.95 | 0.60 | 0.36 | 0.31 |
| ln($Remoteness_1$) | 0.64 | 0.59 | 0.51 | 0.38 |
| ln($Remoteness_2$) | 0.02 | 0.29 | -0.02 | 0.25 |
| $North_1$ (1 = Yes) | -1.06 | 2.50 | 1.97 | 1.34 |
| $North_2$ (1 = Yes) | 0.18 | 0.33 | -0.57 | 0.41 |
| $South_1$ (1 = Yes) | -0.87 | 1.27 | 1.21 | 1.10 |
| $South_2$ (1 = Yes) | -0.34 | 1.28 | -0.29 | 0.29 |
| $East_1$ (1 = Yes) | 0.11 | 0.32 | 1.43 | 1.51 |
| $East_2$ (1 = Yes) | -0.60 | 2.21 | -1.94 | 1.28 |
| 1997 Dummy | **0.28** | 0.15 | **0.26** | 0.10 |
| 2002 Dummy | | | **0.50** | 0.17 |
| Border (1 = Yes) | **0.70** | 0.04 | **0.68** | 0.03 |
| ln(Area) | 0.35 | 0.53 | 0.33 | 0.26 |
| Home Dummy | **1.65** | 0.04 | **1.64** | 0.03 |
| Constant | -14.36 | 10.33 | -5.78 | 5.93 |
| Observations | 4228 | | 6267 | |

NOTES: 1. Bold indicates statistical significance at at least the $p < 0.10$ level. 2. Origin and destination state fixed effects also included.

3. '1' indicates origin (exporting) state; '2' indicates destination (importing) state. 4. PPML = Poisson Pseudo-Maximum Likelihood Estimation

5. Model I (II) uses data from 1993 and 1997 (1993, 1997, and 2002).

**Table 3. Determinants of State-Level Energy Intensity: 1993, 1997 (OLS)**

| Variable | Total | | Industrial | | Commerical | | Transportation | | Residential | |
|---|---|---|---|---|---|---|---|---|---|---|
| | **Model I** | **Model II** | **Model I** | **Model II** | **Model I** | **Model II** | **Model I** | **Model II** | **Model I** | **Model II** |
| ln(Income) | -10.19 | 7.67 | -1.67 | 39.45 | -18.74 | **32.64** | -5.65 | -12.96 | -1.29 | 1.32 |
| | (13.57) | (23.22) | (41.83) | (52.32) | (14.17) | (19.56) | (14.74) | (18.15) | (18.04) | (20.37) |
| ln(Income)$^2$ | 0.46 | -0.44 | 0.07 | -2.16 | 0.87 | **-1.70** | 0.30 | 0.60 | -0.03 | -0.31 |
| | (0.69) | (1.11) | (2.14) | (2.53) | (0.72) | (0.95) | (0.75) | (0.86) | (0.92) | (1.00) |
| ln(KL Ratio) | **-11.15** | 12.94 | -10.51 | 24.29 | **-16.04** | 12.01 | 0.68 | 2.71 | **-5.39** | **20.32** |
| | (3.00) | (11.98) | (7.19) | (25.13) | (3.38) | (9.79) | (3.34) | (10.65) | (2.96) | (9.48) |
| ln(KL Ratio)$^2$ | 0.21 | **2.30** | 0.22 | 4.10 | 0.18 | **2.65** | **0.46** | 0.04 | -0.04 | 1.77 |
| | (0.13) | (1.27) | (0.37) | (3.05) | (0.21) | (1.07) | (0.20) | (1.42) | (0.15) | (1.13) |
| ln(Income)*ln(KL Ratio) | **1.17** | 0.02 | **1.21** | 0.07 | **1.64** | 0.29 | -0.10 | -0.17 | **0.59** | -1.11 |
| | (0.31) | (0.91) | (0.72) | (1.69) | (0.35) | (0.74) | (0.32) | (0.71) | (0.29) | (0.68) |
| ln(Trade) | 0.16 | 0.26 | 0.30 | 0.55 | 0.09 | 0.17 | 0.01 | 0.03 | -0.04 | -0.07 |
| | (0.13) | (0.18) | (0.30) | (0.39) | (0.13) | (0.14) | (0.16) | (0.18) | (0.15) | (0.16) |
| ln(Trade)*ln(RKL) | **-0.43** | -0.78 | **-2.12** | **-5.03** | 0.24 | **1.67** | -0.50 | **-1.57** | -0.40 | 0.98 |
| | (0.24) | (0.88) | (0.72) | (2.08) | (0.33) | (0.74) | (0.31) | (0.87) | (0.30) | (0.84) |
| ln(Trade)*ln(RKL)$^2$ | -0.57 | -4.28 | -1.74 | -11.01 | -0.26 | -6.12 | -0.50 | 0.26 | -0.14 | -2.85 |
| | (0.61) | (4.42) | (1.65) | (10.21) | (0.78) | (3.86) | (0.89) | (5.00) | (0.67) | (3.94) |
| ln(Trade)*ln(RI) | -0.14 | 0.70 | -1.85 | 4.82 | 0.48 | 0.54 | -1.16 | 1.46 | **2.00** | **2.06** |
| | (0.70) | (1.49) | (1.64) | (3.06) | (0.74) | (1.12) | (0.96) | (1.47) | (0.87) | (1.08) |
| ln(Trade)*ln(RI)$^2$ | **3.56** | 2.91 | 6.36 | 6.36 | 1.87 | 2.05 | 0.81 | -1.70 | 1.42 | 1.77 |
| | (1.60) | (2.62) | (7.28) | (8.57) | (1.97) | (2.51) | (2.35) | (2.55) | (2.52) | (2.64) |
| ln(Energy Price) | **-1.29** | **-1.80** | **-1.14** | **-1.68** | **-0.27** | **-0.29** | **-0.92** | **-1.04** | **-0.25** | **-0.26** |
| | (0.11) | (0.17) | (0.20) | (0.19) | (0.10) | (0.11) | (0.20) | (0.24) | (0.08) | (0.08) |
| *Estimated Elasticity* | | | | | | | | | | |
| Technique | **-0.66** | **-0.82** | -0.20 | **-1.56** | **-0.76** | **-1.19** | -0.06 | **-0.47** | **-1.04** | **-1.07** |
| | (0.11) | (0.23) | (0.24) | (0.45) | (0.12) | (0.17) | (0.10) | (0.18) | (0.12) | (0.15) |
| Composition | **0.36** | -0.06 | **1.00** | **0.80** | **0.17** | **0.31** | 0.06 | **0.40** | **0.16** | -0.16 |
| | (0.07) | (0.19) | (0.18) | (0.40) | (0.08) | (0.16) | (0.06) | (0.16) | (0.06) | (0.13) |
| Trade | **0.21** | 0.19 | **0.41** | 0.37 | 0.09 | -0.01 | 0.02 | 0.01 | -0.02 | -0.16 |
| | (0.12) | (0.17) | (0.24) | (0.34) | (0.10) | (0.11) | (0.15) | (0.15) | (0.11) | (0.11) |
| Joint Sign. of Trade Vars. | [p=0.00] | [p=0.00] | [p=0.01] | [p=0.00] | [p=0.10] | [p=0.00] | [p=0.31] | [p=0.43] | [p=0.00] | [p=0.00] |

NOTES: 1. N = 96 in each model. Robust standard errors reported; delta method used for standard errors of elasticities. 2. Additional controls a time dummy. 3. Model I (II) uses our first (second) KL ratio measure. 4. P-value for the joint significance of the endogenous trade variables is obtained using an F-test. 5. Bold indicates statistical significance at at least the p < 0.10 level.

**Table 4. Determinants of State-Level Energy Intensity: 1993, 1997 (GMM)**

| Variable | Total | | Industrial | | Commerical | | Transportation | | Residential | |
|---|---|---|---|---|---|---|---|---|---|---|
| | **Model I** | **Model II** | **Model I** | **Model II** | **Model I** | **Model II** | **Model I** | **Model II** | **Model I** | **Model II** |
| ln(Income) | -7.77 | 13.39 | 119.60 | 188.38 | 12.65 | **65.87** | 54.14 | 66.43 | -39.52 | -27.44 |
| | (21.49) | (39.27) | (84.33) | (115.41) | (31.91) | (37.11) | (35.41) | (44.30) | (36.11) | (39.05) |
| $\ln(\text{Income})^2$ | 0.33 | -0.74 | -6.09 | **-9.52** | -0.71 | **-3.33** | -2.69 | -3.24 | 1.90 | 1.07 |
| | (1.09) | (1.90) | (4.27) | (5.65) | (1.61) | (1.85) | (1.78) | (2.14) | (1.83) | (1.91) |
| ln(KL Ratio) | **-10.95** | -12.43 | -9.52 | -56.51 | **-18.20** | -31.52 | -1.47 | -35.91 | -2.83 | 6.39 |
| | (3.36) | (22.43) | (9.98) | (50.26) | (4.32) | (28.14) | (5.13) | (25.49) | (4.67) | (19.97) |
| $\ln(\text{KL Ratio})^2$ | 0.21 | -1.94 | 0.20 | -7.27 | 0.45 | -4.10 | 0.47 | -4.81 | -0.32 | -1.38 |
| | (0.19) | (3.31) | (0.56) | (7.71) | (0.31) | (4.61) | (0.33) | (3.43) | (0.29) | (2.99) |
| ln(Income)*ln(KL Ratio) | **1.15** | 0.20 | 1.09 | 1.90 | **1.82** | 0.94 | 0.12 | 1.05 | 0.37 | -1.45 |
| | (0.34) | (1.18) | (1.00) | (2.35) | (0.44) | (1.00) | (0.50) | (1.22) | (0.45) | (0.96) |
| ln(Trade) | 0.19 | -0.01 | 0.47 | 0.11 | **0.43** | -0.06 | **0.39** | 0.28 | **-0.29** | **-0.41** |
| | (0.21) | (0.33) | (0.44) | (0.60) | (0.25) | (0.30) | (0.23) | (0.25) | (0.18) | (0.24) |
| ln(Trade)*ln(RKL) | -0.38 | -0.59 | **-1.86** | -6.28 | 0.59 | 0.25 | **-0.85** | -3.04 | -0.71 | 0.11 |
| | (0.32) | (1.56) | (0.89) | (4.18) | (0.52) | (2.10) | (0.43) | (1.99) | (0.55) | (1.28) |
| $\ln(\text{Trade})*\ln(\text{RKL})^2$ | -0.53 | 10.60 | -1.04 | 26.74 | -1.28 | 16.87 | -0.64 | 15.69 | 0.90 | 8.91 |
| | (0.82) | (11.10) | (2.32) | (26.04) | (1.07) | (15.26) | (1.40) | (11.05) | (1.28) | (9.80) |
| ln(Trade)*ln(RI) | -0.08 | 2.15 | -6.74 | 2.18 | -2.24 | 0.62 | **-6.80** | -3.45 | **4.77** | **5.31** |
| | (1.62) | (2.64) | (5.11) | (6.30) | (2.70) | (2.19) | (3.01) | (2.78) | (2.61) | (2.13) |
| $\ln(\text{Trade})*\ln(\text{RI})^2$ | 3.69 | 1.79 | **28.17** | 28.78 | 7.93 | 5.28 | **12.44** | 10.41 | -6.16 | -3.67 |
| | (3.40) | (5.31) | (16.86) | (20.46) | (6.15) | (5.59) | (7.37) | (7.27) | (6.94) | (5.86) |
| ln(Energy Price) | **-1.31** | **-1.81** | **-1.25** | **-1.82** | **-0.27** | **-0.27** | **-1.02** | **-1.30** | **-0.28** | **-0.24** |
| | (0.11) | (0.19) | (0.24) | (0.27) | (0.11) | (0.11) | (0.25) | (0.32) | (0.08) | (0.09) |
| *Estimated Elasticity* | | | | | | | | | | |
| Technique | **-0.66** | **-1.01** | 0.00 | **-1.57** | **-0.63** | **-1.40** | 0.16 | -0.34 | **-1.13** | **-1.31** |
| | (0.14) | (0.29) | (0.32) | (0.64) | (0.15) | (0.25) | (0.14) | (0.24) | (0.14) | (0.17) |
| Composition | **0.36** | 0.18 | **0.91** | **1.21** | 0.12 | **0.66** | 0.04 | **0.55** | **0.22** | 0.04 |
| | (0.07) | (0.21) | (0.22) | (0.52) | (0.10) | (0.26) | (0.08) | (0.30) | (0.08) | (0.15) |
| Trade | 0.24 | 0.36 | **1.17** | **1.69** | 0.48 | 0.59 | **0.73** | **1.11** | -0.36 | -0.27 |
| | (0.22) | (0.41) | (0.64) | (0.97) | (0.32) | (0.41) | (0.34) | (0.42) | (0.27) | (0.29) |
| Joint Sign. of Trade Vars. | [p=0.00] | [p=0.00] | [p=0.00] | [p=0.00] | [p=0.03] | [p=0.00] | [p=0.00] | [p=0.00] | [p=0.00] | [p=0.00] |
| Endogeneity Test | [p=0.48] | [p=0.02] | [p=0.21] | [p=0.07] | [p=0.17] | [p=0.06] | [p=0.02] | [p=0.00] | [p=0.20] | [p=0.21] |
| Anderson Underidentification Test | [p=0.00] | [p=0.00] | [p=0.00] | [p=0.00] | [p=0.00] | [p=0.00] | [p=0.00] | [p=0.00] | [p=0.00] | [p=0.00] |

NOTES: 1. Trade intensity is instrumented with predicted trade intensity. 2. P-value for the joint significance of the endogenous trade variables is obtained using the Anderson-Rubin test. 3. See Table 3 for further details.

**Table 5. Sensitivity Analysis I: Alternative Definition of Energy Intensity**

| Variable | Total | | Industrial | | Commerical | | Transportation | | Residential | |
|---|---|---|---|---|---|---|---|---|---|---|
| | **Model I** | **Model II** | **Model I** | **Model II** | **Model I** | **Model II** | **Model I** | **Model II** | **Model I** | **Model II** |
| **I. OLS (1993, 1997)** | | | | | | | | | | |
| *Estimated Elasticity* | | | | | | | | | | |
| Technique | **-0.93** | **-1.12** | -0.35 | **-1.44** | **-0.80** | **-1.39** | **-1.03** | **-0.51** | **-1.28** | **-1.15** |
| | (0.09) | (0.17) | (0.21) | (0.39) | (0.13) | (0.17) | (0.23) | (0.24) | (0.12) | (0.13) |
| Composition | **0.31** | 0.01 | **0.88** | **0.53** | **0.19** | **0.49** | -0.03 | **-0.71** | 0.08 | **-0.19** |
| | (0.06) | (0.16) | (0.15) | (0.30) | (0.08) | (0.17) | (0.11) | (0.21) | (0.06) | (0.10) |
| Trade | 0.08 | 0.06 | 0.02 | -0.12 | 0.07 | 0.00 | **0.62** | **0.60** | -0.12 | -0.21 |
| | (0.08) | (0.11) | (0.16) | (0.22) | (0.11) | (0.12) | (0.23) | (0.24) | (0.15) | (0.14) |
| Joint Sign. of Trade Vars. | [p=0.00] | [p=0.00] | [p=0.00] | [p=0.00] | [p=0.47] | [p=0.00] | [p=0.01] | [p=0.00] | [p=0.06] | [p=0.02] |
| **II. GMM (1993, 1997)** | | | | | | | | | | |
| *Estimated Elasticity* | | | | | | | | | | |
| Technique | **-0.92** | **-1.12** | -0.27 | **-1.45** | **-0.69** | **-1.54** | **-1.06** | -0.38 | **-1.36** | **-1.17** |
| | (0.11) | (0.22) | (0.26) | (0.47) | (0.15) | (0.25) | (0.30) | (0.27) | (0.14) | (0.15) |
| Composition | **0.30** | 0.09 | **0.85** | **0.76** | 0.13 | **0.79** | -0.04 | **-0.73** | **0.12** | -0.19 |
| | (0.06) | (0.16) | (0.18) | (0.37) | (0.10) | (0.25) | (0.14) | (0.24) | (0.07) | (0.12) |
| Trade | 0.14 | 0.28 | 0.45 | 0.75 | 0.39 | 0.58 | 0.32 | 0.73 | -0.42 | -0.31 |
| | (0.15) | (0.29) | (0.44) | (0.68) | (0.35) | (0.42) | (0.60) | (0.47) | (0.26) | (0.26) |
| Joint Sign. of Trade Vars. | [p=0.00] | [p=0.00] | [p=0.00] | [p=0.00] | [p=0.03] | [p=0.00] | [p=0.40] | [p=0.76] | [p=0.08] | [p=0.02] |
| Endogeneity Test | [p=0.40] | [p=0.04] | [p=0.13] | [p=0.18] | [p=0.08] | [p=0.08] | [p=0.00] | [p=0.07] | [p=0.22] | [p=0.46] |
| Anderson Underidentification Test | [p=0.00] | [p=0.00] | [p=0.00] | [p=0.00] | [p=0.00] | [p=0.00] | [p=0.00] | [p=0.00] | [p=0.00] | [p=0.00] |

NOTES: 1. Total and Residential energy intensity defined as energy consumption per unit of GSP. Industrial, Commercial, and Transportation energy intensity defined as energy consumption per unit of GSP in the industrial, commercial, and transportion sector, respectively. 2. See Tables 3 and 4, and the text, for further details.

**Table 6. Sensitivity Analysis II: Fixed Effect Specifications**

| Variable | Total | | Industrial | | Commerical | | Transportation | | Residential | |
|---|---|---|---|---|---|---|---|---|---|---|
| | **Model I** | **Model II** | **Model I** | **Model II** | **Model I** | **Model II** | **Model I** | **Model II** | **Model I** | **Model II** |
| **I. FE** | | | | | | | | | | |
| *Estimated Elasticity* | | | | | | | | | | |
| Technique | **-0.40** | -0.21 | **-1.60** | -0.68 | 0.96 | -0.13 | -0.30 | 0.15 | -0.38 | **-0.33** |
| | (0.20) | (0.16) | (0.73) | (0.49) | (0.77) | (0.38) | (0.42) | (0.19) | (0.25) | (0.15) |
| Composition | 0.00 | -0.01 | **0.58** | 0.53 | -0.31 | 0.38 | **0.26** | 0.11 | -0.10 | -0.05 |
| | (0.08) | (0.16) | (0.32) | (0.45) | (0.30) | (0.58) | (0.11) | (0.22) | (0.06) | (0.16) |
| Trade | -0.08 | -0.06 | **-0.37** | -0.05 | 0.11 | 0.18 | 0.12 | 0.05 | -0.06 | **-0.11** |
| | (0.05) | (0.07) | (0.17) | (0.25) | (0.27) | (0.18) | (0.09) | (0.09) | (0.08) | (0.06) |
| Joint Sign. of Trade Vars. | [p=0.07] | [p=0.65] | [p=0.16] | [p=0.07] | [p=0.37] | [p=0.37] | [p=0.01] | [p=0.01] | [p=0.87] | [p=0.03] |
| **II. GMM-FE** | | | | | | | | | | |
| *Estimated Elasticity* | | | | | | | | | | |
| Technique | -0.04 | **-0.30** | -2.07 | -0.74 | 0.98 | 0.16 | -0.44 | 0.07 | -0.02 | **-0.32** |
| | (0.34) | (0.16) | (1.37) | (0.52) | (1.40) | (0.48) | (0.72) | (0.23) | (0.40) | (0.18) |
| Composition | 0.00 | -0.02 | 0.45 | 0.52 | -0.18 | 0.28 | 0.09 | 0.11 | 0.02 | -0.08 |
| | (0.12) | (0.16) | (0.49) | (0.50) | (0.46) | (0.59) | (0.20) | (0.22) | (0.16) | (0.18) |
| Trade | -0.11 | -0.16 | -1.98 | -0.20 | 1.59 | 0.56 | -0.20 | -0.16 | 0.22 | -0.09 |
| | (0.28) | (0.10) | (1.47) | (0.37) | (1.32) | (0.40) | (0.43) | (0.15) | (0.36) | (0.10) |
| Joint Sign. of Trade Vars. | [p=0.74] | [p=0.07] | [p=0.00] | [p=0.01] | [p=0.04] | [p=0.07] | [p=0.82] | [p=0.26] | [p=0.22] | [p=0.14] |
| Endogeneity Test | [p=0.24] | [p=0.33] | [p=0.23] | [p=0.77] | [p=0.37] | [p=0.37] | [p=0.62] | [p=0.03] | [p=0.21] | [p=0.83] |
| Anderson Underidentification Test | [p=0.06] | [p=0.00] | [p=0.04] | [p=0.00] | [p=0.12] | [p=0.00] | [p=0.09] | [p=0.00] | [p=0.06] | [p=0.00] |

NOTES: 1. FE = Fixed Effects. 2. Model I (II) uses data from 1993, 1997 (and 2002). 3. See Tables 3 and 4 for details.

**Table 7. Sensitivity Analysis III: Fixed Effect Specifications With Alternative Definition of Energy Intensity**

| Variable | Total | | Industrial | | Commerical | | Transportation | | Residential | |
|---|---|---|---|---|---|---|---|---|---|---|
| | **Model I** | **Model II** | **Model I** | **Model II** | **Model I** | **Model II** | **Model I** | **Model II** | **Model I** | **Model II** |
| **I. FE** | | | | | | | | | | |
| *Estimated Elasticity* | | | | | | | | | | |
| Technique | **-0.89** | **-0.91** | **-2.27** | **-1.61** | 1.05 | -0.17 | **-0.71** | **0.54** | **-0.86** | **-1.03** |
| | (0.20) | (0.15) | (0.81) | (0.48) | (0.78) | (0.36) | (0.32) | (0.31) | (0.25) | (0.14) |
| Composition | 0.00 | 0.10 | **0.72** | 0.21 | -0.38 | 0.28 | 0.11 | **-0.66** | **-0.10** | 0.07 |
| | (0.06) | (0.15) | (0.26) | (0.41) | (0.31) | (0.57) | (0.12) | (0.32) | (0.05) | (0.15) |
| Trade | -0.06 | -0.05 | -0.21 | 0.02 | 0.10 | 0.25 | **-0.25** | -0.10 | -0.05 | **-0.09** |
| | (0.05) | (0.06) | (0.20) | (0.26) | (0.28) | (0.18) | (0.10) | (0.11) | (0.07) | (0.06) |
| Joint Sign. of Trade Vars. | [p=0.22] | [p=0.41] | [p=0.87] | [p=0.00] | [p=0.52] | [p=0.18] | [p=0.00] | [p=0.04] | [p=0.89] | [p=0.03] |
| **II. GMM-FE** | | | | | | | | | | |
| *Estimated Elasticity* | | | | | | | | | | |
| Technique | **-0.58** | **-1.02** | -2.71 | **-1.75** | 1.08 | -0.04 | **-0.96** | 0.44 | -0.54 | **-1.05** |
| | (0.33) | (0.15) | (1.77) | (0.52) | (1.38) | (0.49) | (0.44) | (0.32) | (0.41) | (0.16) |
| Composition | -0.01 | 0.14 | 0.52 | 0.38 | -0.26 | 0.18 | 0.02 | **-0.62** | 0.01 | 0.09 |
| | (0.10) | (0.15) | (0.43) | (0.46) | (0.45) | (0.58) | (0.18) | (0.35) | (0.13) | (0.16) |
| Trade | -0.12 | **-0.17** | -1.69 | -0.11 | 1.54 | 0.36 | -0.45 | **-0.32** | 0.20 | -0.11 |
| | (0.27) | (0.09) | (1.57) | (0.38) | (1.31) | (0.40) | (0.37) | (0.18) | (0.33) | (0.09) |
| Joint Sign. of Trade Vars. | [p=0.47] | [p=0.06] | [p=0.07] | [p=0.00] | [p=0.03] | [p=0.02] | [p=0.00] | [p=0.03] | [p=0.10] | [p=0.10] |
| Endogeneity Test | [p=0.19] | [p=0.21] | [p=0.11] | [p=0.77] | [p=0.40] | [p=0.61] | [p=0.53] | [p=0.19] | [p=0.43] | [p=0.39] |
| Anderson Underidentification Test | [p=0.06] | [p=0.00] | [p=0.19] | [p=0.00] | [p=0.12] | [p=0.00] | [p=0.09] | [p=0.00] | [p=0.06] | [p=0.00] |

NOTES: See Tables 5 and 6 for details.

**Table 8. Sensitivity Analysis IV: Per Capita Energy Usage**

| Variable | Total | | Industrial | | Commerical | | Transportation | | Residential | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Model I | Model II | Model I | Model II | Model I | Model II | Model I | Model II | Model I | Model II |
| **I. OLS (1993, 1997)** | | | | | | | | | | |
| *Estimated Elasticity* | | | | | | | | | | |
| Scale & Technique | 0.07 | -0.11 | 0.00 | -0.98 | **0.44** | -0.05 | **-0.30** | **-0.72** | **-0.27** | -0.14 |
| | (0.09) | (0.17) | (0.34) | (0.52) | (0.12) | (0.14) | (0.16) | (0.21) | (0.12) | (0.14) |
| Composition | **0.31** | 0.01 | **1.01** | 0.51 | **0.12** | **0.43** | **0.30** | 0.20 | 0.08 | **-0.20** |
| | (0.06) | (0.15) | (0.20) | (0.44) | (0.07) | (0.10) | (0.09) | (0.23) | (0.06) | (0.10) |
| Trade | 0.09 | 0.06 | 0.00 | -0.13 | 0.08 | 0.03 | 0.28 | 0.21 | -0.11 | -0.21 |
| | (0.08) | (0.12) | (0.27) | (0.37) | (0.10) | (0.08) | (0.17) | (0.20) | (0.15) | (0.13) |
| Joint Sign. of Trade Vars. | [p=0.00] | [p=0.00] | [p=0.00] | [p=0.00] | [p=0.39] | [p=0.00] | [p=0.34] | [p=0.08] | [p=0.12] | [p=0.05] |
| **II. GMM (1993, 1997)** | | | | | | | | | | |
| *Estimated Elasticity* | | | | | | | | | | |
| Scale & Technique | 0.09 | -0.13 | -0.27 | **-1.71** | **0.69** | 0.01 | -0.02 | **-0.88** | **-0.35** | -0.17 |
| | (0.11) | (0.22) | (0.43) | (0.73) | (0.21) | (0.21) | (0.21) | (0.41) | (0.14) | (0.15) |
| Composition | **0.30** | 0.10 | **1.06** | **1.27** | 0.05 | **0.56** | **0.27** | 0.76 | 0.12 | **-0.20** |
| | (0.06) | (0.16) | (0.24) | (0.54) | (0.10) | (0.20) | (0.12) | (0.49) | (0.07) | (0.12) |
| Trade | 0.14 | 0.25 | -0.60 | 0.30 | **0.88** | **0.78** | **1.19** | **1.94** | **-0.42** | -0.34 |
| | (0.15) | (0.29) | (0.64) | (1.11) | (0.53) | (0.38) | (0.41) | (0.82) | (0.26) | (0.26) |
| Joint Sign. of Trade Vars. | [p=0.00] | [p=0.00] | [p=0.00] | [p=0.00] | [p=0.01] | [p=0.00] | [p=0.00] | [p=0.00] | [p=0.15] | [p=0.06] |
| Endogeneity Test | [p=0.68] | [p=0.04] | [p=0.11] | [p=0.09] | [p=0.05] | [p=0.09] | [p=0.02] | [p=0.00] | [p=0.22] | [p=0.53] |
| Anderson Underidentification Test | [p=0.00] | [p=0.00] | [p=0.00] | [p=0.00] | [p=0.00] | [p=0.00] | [p=0.00] | [p=0.00] | [p=0.00] | [p=0.00] |

NOTES: 1. Dependent variable is state-level per capita energy usage in logs. 2. See Tables 3 and 4 for further details.

**Table 9. Sensitivity Analysis V: Per Capita Energy Usage (Fixed Effects Specifications)**

| Variable | Total | | Industrial | | Commerical | | Transportation | | Residential | |
|---|---|---|---|---|---|---|---|---|---|---|
| | **Model I** | **Model II** | **Model I** | **Model II** | **Model I** | **Model II** | **Model I** | **Model II** | **Model I** | **Model II** |
| **I. FE** | | | | | | | | | | |
| *Estimated Elasticity* | | | | | | | | | | |
| Scale & Technique | 0.10 | 0.04 | 0.25 | -0.08 | **1.47** | 0.20 | -0.10 | 0.17 | 0.15 | -0.08 |
| | (0.23) | (0.16) | (0.72) | (0.49) | (0.79) | (0.41) | (0.32) | (0.19) | (0.19) | (0.12) |
| Composition | -0.01 | 0.06 | **0.44** | 0.48 | -0.35 | 0.59 | 0.10 | 0.08 | **-0.10** | 0.04 |
| | (0.07) | (0.16) | (0.24) | (0.43) | (0.29) | (0.59) | (0.11) | (0.20) | (0.05) | (0.13) |
| Trade | -0.04 | -0.04 | -0.26 | -0.02 | 0.18 | 0.19 | 0.10 | 0.07 | -0.01 | **-0.08** |
| | (0.06) | (0.07) | (0.19) | (0.26) | (0.30) | (0.18) | (0.09) | (0.09) | (0.06) | (0.05) |
| Joint Sign. of Trade Vars. | [p=0.16] | [p=0.55] | [p=0.67] | [p=0.05] | [p=0.26] | [p=0.07] | [p=0.24] | [p=0.00] | [p=0.82] | [p=0.01] |
| **II. GMM-FE** | | | | | | | | | | |
| *Estimated Elasticity* | | | | | | | | | | |
| Scale & Technique | 0.28 | -0.12 | -0.67 | -0.57 | 1.39 | 0.44 | -0.34 | 0.03 | 0.33 | -0.14 |
| | (0.45) | (0.16) | (2.39) | (0.53) | (1.43) | (0.51) | (0.57) | (0.18) | (0.24) | (0.15) |
| Composition | -0.08 | 0.11 | 0.10 | 0.73 | -0.25 | 0.47 | -0.08 | 0.16 | -0.07 | 0.07 |
| | (0.12) | (0.16) | (0.62) | (0.48) | (0.45) | (0.59) | (0.20) | (0.22) | (0.08) | (0.14) |
| Trade | -0.29 | **-0.20** | -2.66 | -0.51 | 1.67 | 0.51 | -0.24 | -0.10 | 0.02 | -0.12 |
| | (0.31) | (0.09) | (1.89) | (0.39) | (1.37) | (0.40) | (0.45) | (0.12) | (0.22) | (0.08) |
| Joint Sign. of Trade Vars. | [p=0.39] | [p=0.04] | [p=0.00] | [p=0.04] | [p=0.02] | [p=0.13] | [p=0.12] | [p=0.03] | [p=0.13] | [p=0.02] |
| Endogeneity Test | [p=0.06] | [p=0.38] | [p=0.10] | [p=0.57] | [p=0.32] | [p=0.45] | [p=0.06] | [p=0.37] | [p=0.32] | [p=0.28] |
| Anderson Underidentification Test | [p=0.06] | [p=0.00] | [p=0.19] | [p=0.00] | [p=0.12] | [p=0.00] | [p=0.09] | [p=0.00] | [p=0.06] | [p=0.00] |

NOTES: See Tables 5, 6, and 8 for details.