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TRACING TARIFF IMPACTS THROUGH ELECTRICITY SUPPLY CHAINS: ASSESSMENT OF THE EFFECTS OF TRADE POLICY ON RETAIL ELECTRICITY PRICES[1]

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Abstract: This study examines the relationship between tariffs on electricity supply chain products and retail electricity prices in the United States, with a focus on Minnesota. Using a two-stage regression framework, we first estimate how a 1% increase in tariffs on 440 key electricity supply chain product categories—ranging from fuels and raw materials to advanced generation and grid technologies—affects imports of these products. We find that such a tariff increase is associated with a 4.55% reduction in imports. In the second stage, we link tariff-induced changes in imports to retail electricity prices across residential, commercial, and industrial sectors. Statistically significant and robust results are found only for the residential sector, where a 1% tariff increase corresponds to a 0.78 cent/kWh rise in retail prices. Applying these results to recent U.S. trade agreements with major partners—including the European Union, Japan, South Korea, and the United Kingdom—we project that Minnesota's electricity sector will incur an additional $2.29 billion annually or an average increase of $0.035/kWh, translating into an increase of $316 per year in electricity bills for an average residential ratepayer if these tariffs are maintained for a substantial period of time. The findings highlight strong historical co-movement between upstream input costs and residential electricity prices, underscoring the need for targeted policy responses to mitigate potential impacts on households, especially low-income consumers.

Key words: *Minnesota, Tariff, Wholesale Electricity Prices, Electricity Supply Chain, Lagged Effects, Fixed Effects Regression, Residential Sector.*

Introduction

Domestic prices of products that are part of the supply chain for electricity production can have significant impacts on the prices that retail consumers pay for electric energy.

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These products range from basic materials for the construction of electricity networks, such as aluminum, copper, iron, steel and nickel, to various fuels, such as natural gas, coal, uranium and petroleum, as well as more sophisticated products that are used in the construction of electricity-generating equipment, such as turbines, photovoltaic cells, glass for use in solar panels, industrial-size batteries, etc.

We consider 440 product categories in the six-digit Harmonized System (HS) classification of products that are most related to electricity supply chains. These product categories cover a wide-ranging array of tangible and intangible goods that we believe are most relevant in electricity price formation in the U.S. The period of analysis spans more than two decades – 2000 through 2023. During this period, the U.S. electricity grid underwent drastic changes, by transitioning from mainly fossil fuel-based sources of energy to more renewable and emission-free sources, such as wind, solar and nuclear. The mix of these products has also shifted, and increasing amounts of novel technologies have been incorporated into the grid. The ever-changing landscape of electricity supply chains in the U.S. has introduced new supply chain products to the electricity sector. In the 2000s, these supply chains were dominated by imports of fossil fuels, electricity transmission equipment, and large turbines used in coal- and gas-fired plants. The 2010s saw a steady rise in renewable sources of energy, including solar and wind, and since then this mix has been supplemented with imports of products such as photovoltaic panels and cells, wind turbines, large-scale energy storage equipment and smart grid components. The United States also imports electrical power from its neighbors. These imports of electrical power from neighboring countries can have a direct impact on retail electricity prices, so we include these electrical power imports as one of the 440 categories used in our analysis. The “Data and Methodology” section presents graphical representation of data on U.S. imports in the period of analysis in more detail.

The goal of this study is to estimate the pass-through of tariffs on these supply chain products to retail electricity prices in the U.S. For this, we collected data from multiple sources. Data on tariffs were collected from the UNCTAD TRAINS database using online tools from the World Bank, whereas data on yearly U.S. imports of relevant goods were collected from the website of the U.S. International Trade Commission (ITC). This dataset encompasses the period 2000-2023. Data on retail electricity prices was collected using the U.S. Energy Information Administration’s (EIA) online tools.

This study conducts a two-stage mapping exercise in order to understand how increased tariffs on supply chain products are correlated with retail electricity prices. We make use of standard gravity models of trade, as well as linear regressions with lagged effects, in order to estimate this association. The ultimate goal is to estimate the change[2] in retail electricity prices associated with a 1% average increase in tariffs on electricity supply chain products, and apply the results obtained to evaluating the increases in costs associated with the recent changes in U.S. trade policy with key trading partners. This analysis had been done for three sectors – residential, commercial and industrial. We do not find any statistically significant effects in the commercial and industrial sectors, but retail electricity prices in the residential sector are significantly affected by tariff hikes on supply chain products. Using these estimates, we project the cost increases associated with recent U.S. trade agreements with its key trading partners.

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[2] This change will be measured in cents per kWh.

Prior work has examined several channels through which trade policy and tariffs influence energy markets, though few papers estimate the direct pass-through from tariffs on upstream supply-chain inputs to retail electricity rates. Shapiro (2021) documents that trade policy is not neutral across industries: tariffs and non-tariff barriers tend to be systematically lower for more carbon-intensive ("dirty") industries, implying that tariff changes can reshape input price incentives and the relative competitiveness of clean versus dirty technologies. This environmental bias in trade policy suggests an important indirect channel by which tariffs could affect electricity supply costs and generation mixes. The author estimates that the environmental bias represents an implicit subsidy to CO_2 emissions in the amount of $550 to $800 billion per year (Shapiro, 2021). On the other hand, Zuo and Majeed (2024) investigate the effects of trade policy uncertainty on renewable energy consumption in China. The authors find that higher uncertainty negatively affects renewable energy consumption, and given the rise of protectionism and rising trade barriers in the modern world, they analyze how rapidly changing trade policies can impact the development of renewable energy.

Our study complements and extends these strands by providing a direct, supply-chain–focused estimate of tariff pass-through to residential electricity prices. We estimate a quantifiable mapping from a 1% average increase in tariffs on 440 electricity-relevant HS6 product categories to a 0.78 cents per kWh rise in average residential retail prices. Using data on recent tariff changes of the U.S., we estimate that these new trade policies will cost the State of Minnesota **$2.29 billion USD** annually, or an average cost of $0.035 per kWh of electricity sales in the state. Thus, while Shapiro's (2020) mechanism and Zuo and Majeed's (2024) findings emphasize composition and investment channels that operate over longer horizons, our results show empirically that upstream tariff shocks are associated with measurable near-term changes in retail bills, with distributional implications for households (particularly low-income ones) that complement the longer-run effects emphasized in the literature.

The case of Minnesota provides a well-suited context for examining how tariff shocks propagate through electricity supply chains and ultimately affect retail electricity prices. First, the state maintains a transparent and detailed regulatory environment, with extensive publicly available data on utility costs, generation inputs, and rate filings. This allows for precise tracking of how changes in fuel prices, equipment costs, and capital expenditures translate into retail rates.

Second, Minnesota's electricity sector represents a microcosm of broader U.S. trends. The state relies on a diverse resource mix—including coal, natural gas, wind, solar, and nuclear power—making it possible to trace tariff effects across multiple generation technologies. At the same time, Minnesota utilities participate in the Midcontinent Independent System Operator (MISO) wholesale market, exposing them to region-wide cost dynamics while retaining retail regulation at the state level. This hybrid structure enables analysis of both regulated and market-driven channels of cost pass-through.

Third, Minnesota has undergone significant infrastructure investment and generation turnover in recent years, particularly in renewable energy and transmission. Many of these projects depend on imported steel, aluminum, solar panels, and other tariff-sensitive inputs, making the state an informative case for studying the relationship between trade policy and electricity pricing.

In the next two sections, we explain Minnesota's electricity market and regulations, discuss the exact methodology we use in this study to conduct the mapping of tariffs on supply chain products to changes in retail electricity prices, as well as provide details concerning the dataset used and results obtained.

Overview of Electricity Markets in Minnesota

Minnesota's electricity market is characterized by vertically integrated investor-owned utilities, municipal utilities, and electric cooperatives. Investor-owned utilities—primarily Xcel Energy, Minnesota Power, and Otter Tail Power—serve the majority of customers and operate under cost-of-service regulation administered by the Minnesota Public Utilities Commission (PUC). Under this framework, utilities recover prudently incurred costs through regulated retail rates, which makes Minnesota an ideal environment for identifying how input cost changes feed into customer prices.

While retail regulation remains at the state level, Minnesota utilities participate in MISO's organized wholesale market. MISO centrally dispatches generation and determines locational marginal prices, influencing utility procurement costs. This connection to wholesale market dynamics introduces an additional channel through which tariff-induced cost shifts may affect retail prices.

The state's generation portfolio is diversified. As of recent years, Minnesota's electricity comes from roughly one-third coal, one-third renewables (primarily wind), and the remainder natural gas and nuclear. Ongoing coal retirements and rapid growth in wind and solar have increased reliance on imported equipment and materials—many of which were subject to trade actions during the period studied. These structural characteristics make Minnesota a compelling and policy-relevant setting for tracing the impact of tariff changes on electricity prices.

Data

As part of this study, we collected a list of 440 product codes in the six-digit Harmonized System (HS) classification of products, which is a standardized system of product classification used worldwide by government authorities and developed by the World Customs Organization. These include key fuels (natural gas, coal, uranium, and refined petroleum products), base materials (aluminum, copper, iron, steel, and nickel), and components essential for electricity generation and transmission (turbines, photovoltaic cells and panels, batteries, AC/DC motors, insulators, and other electrical equipment). Tariffs on these products, which raise their domestic prices, are likely to ripple through the supply chains and affect the final electricity bills of retail customers, even if it may take some time for these effects to become noticeable.

For this study, we employ a two-staged regression framework to estimate the desired effects of tariffs on retail electricity prices. We used a variety of data sources to estimate our first- and second-stage models. For the first stage, we use data on tariffs and imports of relevant supply chain products. Data on tariffs were collected using the World Bank's World Integrated Trade Solution (WITS)[3] online software, from the UNCTAD TRAINS database, and data on yearly U.S. imports of relevant goods was collected using the

[3] World Bank's World Integrated Trade Solution (WITS) online tool is available at: https://wits.worldbank.org/.

online DataWeb[4] tool of the U.S. International Trade Commission (ITC).[5] This dataset encompasses the period 2000-2023.

For the second stage, we collected data on state-level monthly imports of relevant electricity supply chain product categories and retail electricity prices in various sectors of the economy – including residential, industrial and commercial sectors. State-level data on imports was collected using the online DataWeb tool of the U.S. International Trade Commission (ITC). This online tool lists import data by trading hub, and we had to manually sum the trading hubs of each state to arrive at statewide import data. Additionally, we collected state-level retail electricity price data and matched this with state-level import data. Data on retail electricity prices was collected from the U.S. Energy Information Administration's (EIA)[6] Electricity Data Browser[7] online tool.

Comparing U.S. imports of high-tech products in 2000 and 2023, including batteries, AC/DC motors, transformers, and wind turbines (Figure 1), we can see a dramatic increase in imports across all categories: each category at least doubled, while imports of batteries grew eightfold. Overall, this demonstrates that U.S. imports of high-tech goods related to electricity production have become much more prevalent compared to two decades ago.

Figure 1

Total Annual U.S. Imports in Four Key Product Categories, Inflation-Adjusted, 2000 vs 2023

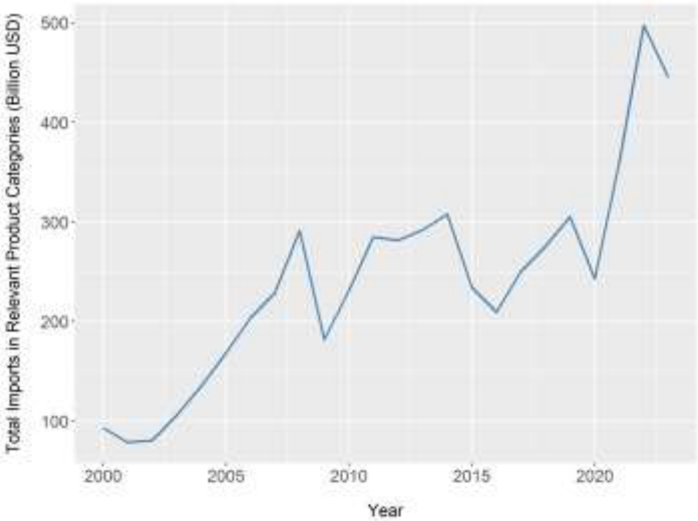
Source: *https://dataweb.usitc.gov/. Seen 20.07.25*

Next, we summarize total U.S. imports in the 440 product categories used for this study in the period of analysis – 2000-2023. U.S. imports of these products have steadily

[4] USITC's online DataWeb tool is available at: https://dataweb.usitc.gov/.
[5] USITC's main website is hosted at: https://www.usitc.gov/.
[6] USEIA's main website is hosted at: https://www.eia.gov/.
[7] USEIA's online Electricity Data Browser tool is available at: https://www.eia.gov/electricity/data/browser/.

increased over the period of analysis, rising from $93 billion in 2000 to over $445 billion in 2023 (Figure 2).

Figure 2
Total Annual U.S. Imports in 440 Electricity Supply Chain-Related Product Categories (HS-6), 2000-2023

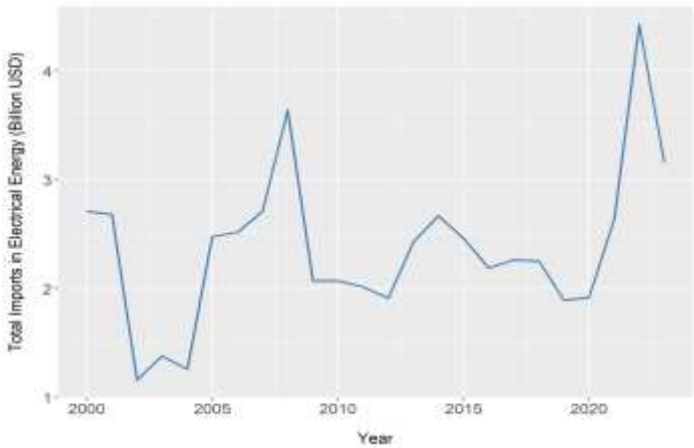


Source:https://dataweb.usitc.gov/. *Seen 20.07.25*

The United States is also a major importer of electrical power. The imports mainly come from Canada, as the United States electricity grid has major interconnections with some Canadian provinces. However, in some years, the U.S. also imported electric energy from Mexico. These imports of electrical power from neighboring countries can have a direct impact on retail electricity prices, and contribute to price formation in wholesale electricity markets as well. We thus included these electrical power imports as one of the 440 categories which factor into the electricity supply chains, even though the imports are not a tangible product, but are in the form of electrical energy and capacity supplied by generators located abroad. Historically, the U.S. imports about 2% of local electricity consumption. The total value of U.S. imports of electricity from its neighboring countries have been increasing from the 2000s into 2023 (Figure 3): however, it is less pronounced than the upward trend of the overall imports of electricity supply chain products.

Figure 3

Value of Total Annual U.S. Imports of Electrical Energy (HS-6 Code: 271600), 2000-2023

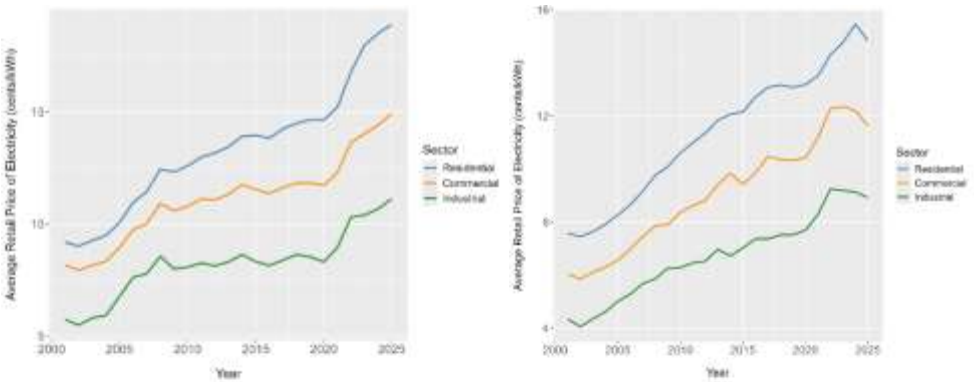


Source: https://dataweb.usitc.gov/ *. Seen 25.07.25*

In Figure 4, we summarize average retail electricity prices in the 30 states available in our dataset in 2001-2025, broken down by three sectors – residential, commercial and industrial. The residential prices have historically been the highest, followed by the commercial and industrial sectors, respectively. It is obvious that there is a trend of increasing prices from 2001 through 2025 – the period for which data on retail electricity prices was available in our dataset.

Figure 4

Average Annual Retail Prices of Electricity by Sector, in the U.S. (left) and in Minnesota (right), 2001-2025



Source: https://www.eia.gov/. *Seen 20.07.25*

In Minnesota, the retail electricity prices have historically been cheaper compared to the U.S. average in all sectors – residential, commercial and industrial. There is an upward trend in retail prices in the period 2001-2025, as with the U.S. average retail prices in all three sectors. Examining Minnesota's retail electricity prices in detail provides valuable insights into how the state's energy market compares with national trends and how different consumer groups experience price changes. Breaking prices down by sector—residential, commercial, and industrial—allows us to identify which segments are most sensitive to cost drivers, such as trade policy and input prices that we examine as part of this study.

Methodology

In order to map the effect of tariffs on supply-chain products to retail electricity prices, we adopt a two-stage approach. In the first stage, we estimate how tariffs on these supply chain products influence imports of those goods. *Since imports are a function of prices—and tariffs effectively raise prices—this stage allows us to quantify the implied price increases of supply chain inputs resulting from tariff hikes.*

We use a linear regression model to estimate the impact of a 1% increase in average tariffs on these 440 product categories on the import of these supply chain products, expressed as a percentage change. We employ a standard gravity model of trade in order to estimate this effect. The gravity model of trade[8] is analogous to Newton's Law of Universal Gravitation, which states that the gravitational force between two objects is proportional to the product of their masses and inversely proportional to their distance (Feenstra & Taylor, 2021). Similarly, trade between two countries depends on the size of their respective economies (measured by GDP) and is inversely proportional to their distance (Feenstra & Taylor, 2021).

Cheong, Kwak & Tang (2018) utilize a gravity model of trade in order to estimate the impact of trade agreements on the intensive and extensive margins of trade volume between countries. We use modified versions of the gravity model presented in Cheong, Kwak & Tang (2018) to estimate *the first stage* of our model – which is to understand how increased tariffs are correlated with changes in imports in relevant product categories related to electricity supply chains. *In the second stage*, we examine how these tariff-induced changes in imports of relevant intermediate products are correlated with retail electricity prices across the residential, commercial, and industrial sectors. This stage provides estimates of the pass-through from higher input costs to end-user electricity prices, helping us understand the broader economic effects of trade policy on retail electricity markets.

A key assumption that we make in the second-stage regression model is that the effects of changes in imports of supply chain products on retail electricity prices in each state are homogeneous, after controlling for state and time fixed effects. Making this assumption significantly simplifies the analysis and makes sense, given that we are controlling for unobserved, state-level variables by including state-level fixed effects in the regression model.

We estimate the second-stage effects using a lagged imports framework, where retail electricity prices are linear functions of 3- to 10-month lagged imports in relevant electricity supply chain product categories. In addition, we include 0- to 4-month lagged gas prices as control variables, and also include time and state fixed effects. We then sum the effects of all lagged imports that are significant at least at the 1% level: this gives us an estimate of the overall impact of changes in imports in relevant supply chain product categories on retail electricity prices. We run this model for three different

[8] Bergstrand (1985) is a seminal work discussing the standard gravity model of trade in more detail.

sectors – residential, commercial and industrial. We only get statistically significant effects that are robust to model specification for residential retail electricity prices.

Gravity Model of Trade

The standard gravity model of trade takes the following form:

$$T_{i,j} = G \cdot \frac{GDP_i^{\beta_1} \cdot GDP_j^{\beta_2}}{Dist_{i,j}^{\beta_3}} \eta_{i,j} \quad (1)$$

where G, β_1, β_2 and β_3 are constants to be estimated, GDP_i and GDP_j are the gross domestic products of countries i and j, respectively, representing the size of each respective economy, $Dist_{i,j}$ is the physical distance between countries i and j[9], and $\eta_{i,j}$ is an error term. Taking a logarithmic transformation of both sides, we can express the above equation in a linear form:

$$\log(T_{i,j}) = \alpha + \beta_1 \cdot GDP_i + \beta_2 \cdot GDP_j + \gamma \cdot Dist_{i,j} + \epsilon_{i,j} \quad (2)$$

where $-\beta_3 \equiv \gamma$, $\log(\eta_{i,j}) \equiv \epsilon_{i,j}$ and $\log(G) \equiv \alpha$, and which now can be estimated using the method of Ordinary Least Squares (OLS).

In the first stage of projecting tariffs on imports of supply chain products, one of the trade partners remains the same – the United States. This removes one dimension from the first-stage gravity equation. However, we add back two more dimensions – the 6-digit product category in the Harmonized System of product classification, and time.

Finally, we add some other covariates that are included in standard gravity models of trade[10], which include the tariff rates on different product categories with different partner countries. After these modifications, the final equation is:

$$\log(T_{j,k,t}) = \beta_1 \cdot \log(1 + Tariff_{j,k,t}) + \beta_2 \cdot \log(GDP_{j,t}) + \beta_3 \cdot \log(Dist_{j,t}) + \gamma \cdot \chi_{j,k,t} + \epsilon_{j,k,t} \quad (3)$$

where $Tariff_{j,k,t}$ are the tariff rates on country j in product category k and year t, and $\chi_{j,k,t}$ is a vector of added covariates, including population of trading partner, as well as dummy variables indicating whether the trading partner shares a border with the U.S. and whether it has prior U.S. colonial ties. $\epsilon_{j,k,t}$ is an error term.

We also estimate an alternative specification of the model, where we include trading partner-year and product-year interaction fixed effects instead of the covariates in Equation (3). This alternative equation is the following:

$$\log(T_{j,k,t}) = \beta_1 \cdot \log(1 + Tariff_{j,k,t}) + \zeta_{j,t} + \eta_{k,t} + \epsilon_{j,k,t} \quad (4)$$

where $\zeta_{j,t}$ and $\eta_{k,t}$ are partner-year and product-year fixed effects.

We estimate Equations (3) and (4) and use the average of the two estimates for the parameter β_1 as the effect of a 1% increase in tariffs on relevant electricity supply chain product categories on imports of these products, measured in percentage terms. The results of regression assessment are presented in *Table 1* below.

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[9] The physical distance between two countries can be calculated using a variety of methods. One method is to use the geodesic distance between the capitals of the two countries. Another is to use a weighted distance between the most populous cities of the two countries, where the weights represent the populations of these cities.

[10] The added covariates include tariff rates on the trading partner in a given product category, colonial links between the U.S. and the trading partner, sharing of a land border of the U.S. with the trading partner, and population of the trading partner.

Table 1

First Stage Regression Results. Two-way clustered standard errors in parentheses

Log (Imports)	Model 1[11]	Model 2
Log (1 + Tariff Rate)	-3.850* (1.855)	-5.249*** (0.961)
Log (GDP)	-	0.574*** (0.017)
Log (Distance)	-	-0.079* (0.035)
Log (Population)	-	0.059*** (0.015)
Contiguous to the U.S.	-	1.500*** (0.074)
Former U.S. Colony	-	0.594*** (0.064)
(Intercept)	-	-3.105*** (0.434)
R2	0.415	0.161
R2 Adj.	0.376	0.161
Std. Errors	by: Partner-Year & Product-Year	by: Partner-Year & Product-Year
FE: Partner-Year	X	
FE: Product-Year	X	
• p < 0.1, * p < 0.05, ** p < 0.01, *** p < 0.001		

Second-Stage Regression Approach

In the second stage of this study, we aim to estimate how a 1% change in imports of relevant electricity supply chain products is correlated with retail electricity prices. We use a linear regression model with lagged effects of the predictors to estimate this correlation. Mathematically, the linear model is the following:

$$\textbf{electricity prices}_{s,t} = \Sigma_{r=3}^{10}\beta_r \cdot \textbf{imports}_{s,t-r} + \Sigma_{r=0}^{4}\gamma_r \cdot \textbf{gas prices}_{s,t-r} + \zeta_t + \eta_s + \epsilon_{s,t} \quad (5)$$

where electricity $\text{prices}_{s,t}$ denote the monthly average retail electricity prices in state *s* and time t (time is denoted by month and year, i.e., August 2001, February 2002, etc.), $\text{imports}_{s,t-r}$ are lagged overall imports in relevant electricity supply chain categories in trading hubs located in state s at time $t-r$ (where r ranges from 3 to 10, corresponding to 3- through 10-month lagged imports), gas $\text{prices}_{s,t-r}$ corresponds to average gas prices in state s at time $t-r$ (where r ranges from 0 to 4, corresponding to 0- through 4-month lagged gas prices), ζ_t and η_s are time and state fixed effects, and $\epsilon_{s,t}$ is an error term corresponding to state s and time t. We run three separate models corresponding to three different sectors – residential, commercial and industrial, where the prices on the left correspond to residential, commercial and industrial sectors, respectively.

[11] Model 1 does not include any covariates because it includes partner-year and product-year fixed effects. These fixed effects would absorb any covariates that do not vary over products, years and trade partners.

In order to arrive at the overall correlation between imports in relevant electricity supply chain product categories and retail electricity prices, we sum the effects of all lags that exhibit statistically significant correlation with these prices. We estimate Equation (5) using fixed effects regression: we then arrive at estimates for the coefficients on lagged imports. The overall effect is then $\Sigma_{r=3}^{10}\hat{\beta}_r \cdot 1\{\hat{p}_r(\hat{\beta}_r < 0.1)\}$, which means that we sum our coefficient estimates on all those lagged imports which are statistically significant at the 1% level. *Tables 2, 3* and *4* below summarize the results of regression estimation of Equation (5) in the residential, industrial and commercial sectors, respectively.

Table 2

Second Stage Regression Results – Residential Sector. Two-way clustered standard errors in parentheses

Average Retail Residential Electricity Prices	*Coefficients*
Log (3rd Lag of Imports)[12]	0.100 (0.091)
Log (4th Lag of Imports)	-0.171*** (0.040)
Log (5th Lag of Imports)	-0.040 (0.056)
Log (6th Lag of Imports)	0.014 (0.047)
Log (7th Lag of Imports)	-0.073 (0.071)
Log (8th Lag of Imports)	0.048 (0.083)
Log (9th Lag of Imports)	0.046 (0.073)
Log (10th Lag of Imports)	-0.060 (0.100)
Num. Obs.	3801
R2	0.900
R2 Adj.	0.892
Std. Errors	by: Year-Month & State
FE: Year-Month	X
FE: State	X
• p < 0.1, * p < 0.05, ** p < 0.01, *** p < 0.001	

[12] The lags in the second stage regression are measured in months and not years. Gas prices and their first through fourth lags were also included in the regression, but are not presented in the table for the sake of brevity.

Table 3

Second Stage Regression Results – Industrial Sector. Two-way clustered standard errors in parentheses

Average Retail Industrial Electricity Prices	Coefficients
Log(3rd Lag of Imports)	0.113 (0.088)
Log(4th Lag of Imports)	-0.108 (0.060)
Log(5th Lag of Imports)	-0.046 (0.048)
Log(6th Lag of Imports)	0.023 (0.034)
Log(7th Lag of Imports)	-0.027 (0.071)
Log(8th Lag of Imports)	0.103 (0.078)
Log(9th Lag of Imports)	0.037 (0.054)
Log(10th Lag of Imports)	0.083 (0.112)
Num. Obs.	3803
R2	0.883
R2 Adj.	0.872
Std. Errors	by: Year-Month & State
FE: Year-Month	X
FE: State	X

Table 4

Second Stage Regression Results – Commercial Sector. Two-way clustered standard errors in parentheses

Average Retail Commercial Electricity Prices	Coefficients
Log(3rd Lag of Imports)	0.124 (0.070)
Log(4th Lag of Imports)	0.010 (0.047)
Log(5th Lag of Imports)	-0.040 (0.061)
Log(6th Lag of Imports)	-0.004 (0.084)
Log(7th Lag of Imports)	0.020 (0.068)
Log(8th Lag of Imports)	0.119 (0.066)
Log(9th Lag of Imports)	0.041 (0.048)

Average Retail Commercial Electricity Prices	Coefficients
Log(10th Lag of Imports)	0.039 (0.092)
Num. Obs.	3803
R2	0.896
R2 Adj.	0.887
Std. Errors	by: Year-Month & State
FE: Year-Month	X
FE: State	X

Results

In *Tables 1-4* presented in the previous section, we showed the results of the first- and second-stage regression estimation. First-stage estimates (*Table 1*) suggest that an average increase of 1% in tariffs on relevant electricity supply chain product categories is correlated with an average decrease in imports of these products between 3.85 to 5.25 percent. Taking the average of these two estimates, we arrive at an average decrease in imports of 4.55% associated with an average increase of 1% in tariffs on relevant electricity supply chain product categories. We also note that all the other covariates in the second version of our first-stage model have the expected sign. For example, distance between the U.S. and the trading partner is correlated with decreased trade, and higher GDP of the trading partner is associated with increased trade, as the standard gravity model of trade predicts.

Regarding model fit, Model 1 in *Table 1* achieves an R^2 of 0.415 and an adjusted R^2 of 0.376, reflecting that the pair of high-dimensional fixed effects absorbs much of the variation in bilateral trade. The lower R^2 in Model 2 (0.161) of *Table 1* is typical in gravity specifications when strong fixed effects are not included, and does not imply poorer identification. Both models use robust standard errors clustered at the partner-year and product-year levels, mitigating concerns about serial correlation or cross-sectional dependence along either dimension.

In the second stage, we assess how changes in imports of electricity supply chain products correlate with retail electricity prices. We only get statistically significant, robust results for the residential sector (*Table 2*). Industrial and commercial sectors enjoy lower and more stable electricity prices due to their large-scale usage of electricity and customized supplier agreements, which buffer them from abrupt or large price changes. Therefore, second-stage regression does not find statistically significant impacts of changes in imports of electricity supply chain products on retail electricity prices in commercial and industrial sectors (*Tables 3* and *4*).

For the retail electricity prices in the residential sector, lagged imports are used in order to evaluate the full impact of changes in imports of intermediary products. It is found that the strongest price response occurs with a **4-month lag** following changes in imports of tariff-affected electricity supply chain goods. This timing aligns with expected delays in utility procurement cycles, infrastructure project timelines, and cost pass-through mechanisms. Our estimates suggest that a 1% average increase in imports of the key supply chain products is correlated with a 0.171 cent per kilowatt-hour decrease in average residential retail electricity prices (*Table 2*).

The second-stage model for the residential sector exhibits excellent explanatory power, with an R^2 of 0.900 and an adjusted R^2 of 0.892. This high goodness-of-fit is typical in panel regressions with rich fixed effects, particularly in energy markets where state-specific factors and national trends account for much of the variation in retail prices. The fixed effect's structure ensures that the estimated coefficients capture within-state, over-time deviations in imports rather than cross-sectional differences.

Putting together results from the two stages, we conclude that an average increase of 1% in tariffs on relevant electricity supply chain product categories raises retail residential electricity prices by 0.78[13] cents per kWh, but does not affect retail electricity prices in the industrial and commercial sectors.

Adopting a holistic approach to estimating the pass-through of tariffs on electricity supply chain products to retail prices of electricity, we considered products in the supply chain that have a great breadth of variation. The result obtained above thus estimates the average pass-through of tariffs through a comprehensive network of electricity supply chain product categories.

Based on the estimated pass-through rate of 0.78 cents per kWh for every 1% average increase in tariffs on electricity supply chain products, we estimate that a 1% tariff increase would raise the total annual cost to U.S. residential electricity consumers by approximately **$11.78 billion U.S. dollars.**[14] In particular, a 1% increase in tariffs on electricity supply chain products is estimated to raise annual residential electricity costs in Minnesota by **$179.4 million U.S. dollars**.

Finally, we evaluate the impact of recent increases in tariffs on U.S. trade partners and how these hikes fit with the aforementioned results. The average relative increase in tariffs compared to pre-2025 levels is around 12.76%. *Table 5* below summarizes the trade deals reached with key trading partners as of August 2025, along with the agreed-upon tariffs and the relative change in tariffs as compared to pre-2025 levels. Overall, the U.S. has reached trade deals with key trading partners, including Japan, the European Union, the United Kingdom and South Korea.

Table 5

Recent U.S. Trade Agreements with Key Trading Partners and Relative Changes in Tariffs Compared to Pre-2025 Levels

Trading Partner	Agreed Tariff Rate	Relative Change from Baseline
European Union	15%	11.65%
Indonesia	19%	15.53%
Japan	15%	11.65%
Philippines	19%	15.53%
South Korea	15%	11.65%
United Kingdom	10%	6.80%
Vietnam	20%	16.5%

Source: *Cerullo & Walsh, 2025.*

[13] In the first stage, we found that a 1% average increase in tariffs is associated with a 4.55% decrease in imports of relevant supply chain products. In the second stage, we found that a 4.55% average decrease in imports of relevant supply chain products is correlated with a 0.171 cent-per-kWh increase in average residential retail electricity prices. We multiply 4.55% by 0.171 cents to arrive at the estimate of 0.78 cents per kWh associated with a 1% average increase in tariffs on relevant electricity supply chain products.

[14] We multiply the added cost of 0.78 cents per kWh as a result of a 1% increase in tariffs on supply chain products by the 2022 U.S. residential electricity consumption (1.51 trillion kWh) to get this result.

Overall, we estimate that the recent changes in tariffs, if applied to all supply chain product categories discussed in this report, and sustained for a prolonged period of time, will cost the Minnesota electricity sector about **$2.29 billion USD** annually, or an average cost of $0.035 per kWh of electricity sales in the state. As a point of reference, Minnesota's total electricity consumption in 2023 (66,215,800 megawatt-hours), evaluated at an average price of 17 cents per kWh, amounts to $11.26 billion USD. The overall cost increase due to the recent increases in tariffs thus represents about **20%** of Minnesota's annual retail sales of electricity.

For an average household that consumes 9,024 kWh per year (U.S. Energy Information Administration, 2023), this corresponds to an increase of about $316/year in electricity bills.

Conclusion

Using a two-stage regression approach, we estimate that a 1% increase in tariffs on electricity supply chain inputs is associated with an increase of 0.78 cents per kWh in residential retail electricity prices. This correlation should not be interpreted as causal, but highlights a strong historical co-movement between upstream input costs and final retail electricity prices. We do not find statistically significant and robust associations of tariff hikes with changes in retail electricity prices in the industrial and commercial sectors. Industrial and commercial sectors benefit from lower and more stable prices due to their large-scale use of electricity and often-customized agreements with their electricity suppliers, as well as greater flexibility in their electricity usage, which guarantees that prices do not change abruptly, and when they do, the changes are not as pronounced as in the residential sector.

The analysis focused on a holistic review of 440 product categories that may be directly or tangentially associated with electricity supply chains. Our estimates suggest strong pass-through of tariffs via these product categories that are eventually reflected on residential electricity bills.

Based on this analysis, we project that the recently approved U.S. trade agreements with key trading partners will cost the Minnesota electricity sector **approximately $2.29 billion USD annually**, which translates to an average cost of $0.035 per kWh of electricity sold in Minnesota and represents 20% of the annual market value of electricity sales in the state. This effect, as mentioned above, is mostly expected to affect residential consumers, and may disproportionately affect low-income households, whose electricity bill constitutes a larger proportion of their income. We estimate that these additional costs translate into an increase of $316/year in electricity bills for an average household in Minnesota. This may result in policy implications for the state to more closely monitor residential electricity rates in the upcoming months and years and make sure there are necessary programs in place to help low-income families cope with increases in residential electricity bills. This may come in the form of targeted relief or bill assistance programs if tariffs remain in place.

Utilities may benefit from enhanced monitoring of cost pass-through mechanisms to understand which products are impacting residential prices the most. Diversification of supply chains, especially in those product categories which are most closely associated with residential electricity prices, may help utilities reduce their tariff exposure and benefit from more favorable deals, which may result in reductions in additional costs related to tariffs and ultimately benefit residential consumers as well.

We find it important to mention a caveat to this analysis: our results are based on historical correlations — not causation — and could vary under different market or trade conditions. We tried to map the effects of tariffs using lags in pass-through mechanisms, but our data was limited in granularity and in time; the models were estimated using state-level trade data on a monthly or yearly basis. Furthermore, the recent tariffs imposed by the U.S. are unprecedented and thus extrapolating our results to this large and sudden policy change is inherently uncertain, as the historical relationships we observe may not hold under such extreme conditions. Studying tariff effects over a longer horizon and on a more granular spatial grid may enable future researchers to capture more precise effects of delayed pass-through of tariffs on retail electricity rates. It would also be interesting to assess other cost drivers, such as capital costs, and how these interact with tariff effects.

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