

The Determinants of Bulk Truck Rates

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Abstract

This study examines U.S. agricultural trucking activities and the factors driving bulk truck rates using historical transaction data. We identify key trends and regional variations, analyzing trucking activities and rates for various origin-destination pairs, commodities, and trailer types. Average rates per ton and per mile for all commodity types show increasing trends over time, though rates for some commodities fluctuate more than others. The Midwest emerges as a central hub for agricultural trucking, with generally lower per-ton and per-mile rates compared to other U.S. regions. Within-state trips are among the most frequent truck routes, with the median average rate per ton at \$24.26 and the median average rate per mile at \$6.05. Additionally, past truck rates are positively related to current truck rates, indicating that higher rates in previous period are associated with higher rates in the present. Fuel prices are also a determinant of truck rates, with fuel prices and truck rates moving in the same directions.

1 Executive Summary

Many bulk agricultural products have a low value relative to their volume, making transportation cost the largest component in their supply chain. Understanding the determinants of bulk truck rates, as well as where and when to transport, can help improve efficiency in the agricultural trucking industry. This study examines the trucking activities of agricultural commodities across the U.S. and analyzes the factors impacting agricultural truck rates.

Truck rate data provide historical information on weekly bulk load shipment transactions from January 2017 through December 2023. The data include trailer type, commodity type, truck rate per mile, and truck rate per ton for origin-destination city pairs throughout the U.S.

Most trucking activities within this data originate from and are headed to the Midwest region. The top three origin states are Iowa, Missouri, and Kansas, while the top three destination states are Texas, Missouri, and Iowa. Notably, within state trips are among the most frequent truck routes. For example, the most frequent trips to Alabama also originate from Alabama, and the same observation applies to Arkansas, California, and Texas. States in the New England region, such as Maine, New Hampshire, and Rhode Island, have the least agricultural trucking activities. Hoppers are the most popular trailer type in the data, almost twice as popular as end dumps — the next most frequent trailer type. In comparison, belt, tanker, and walking floor trailers represent only a small fraction of uses by trailer type within the data.

The analysis separated bulk truck rates into two categories: by tonnage and mileage. The average rate per ton has an increasing trend over time for all commodity types, although rates for some commodities fluctuate more than others. Similarly, the average rate per mile also shows an increasing trend over time for most commodity types. The median average rate per ton for within-state trips (origin and destination reside in the same state) is \$24.26, with seventy-five percent of these rates being less than or equal to \$28.75 per ton. Connecticut has the highest average rate per ton at \$196.68 for within-state trips (i.e., origin and destination within Connecticut), followed by Maryland at \$78.39 per ton. Connecticut also has the highest average rate per mile at \$67.11, followed by Delaware at \$17.31. The median average rate per mile for within-state trips is \$6.05, with seventy-five percent of these rates being less than or equal to \$7.22 per mile.

On a regional level, bulk trucking activities originating and ending in the Gulf Coast region have the highest average rate per ton at \$54.66/ton, while the Midwest has the lowest at \$41.64/ton. The New England region has the highest average rate per mile at \$13.98, whereas the Rocky Mountain region has the lowest average rate per mile at \$3.89. The West Coast excluding California and Midwest also have low average rates per mile at \$4.20 and \$4.60, respectively. Compared to the other regions, trucking activities in the Midwest and Rocky Mountain regions generally have lower per ton and per mile rates.

Investigation into the determinants of truck rates shows that truck rates are persistent: higher (lower) truck rates in the current period are associated with higher (lower) truck rates in the previous period. Fuel prices are also an important determinant of truck rates, with higher fuel prices being associated with higher truck rates and lower fuel prices being

related to lower truck rates. Other factors including wages, unemployment, and GDP are not found to be statistically significant predictors of bulk truck rates.

This work makes two important contributions. The first is a detailed characterization of bulk truck rates. Bulk truck services are a critical input to agricultural supply chains, and information on truck rates is important in making operating decisions including truck ownership decisions, mode choice tradeoffs, and rate negotiations. Bulk truck rates are also integral components to agricultural supply chain research, including commodity flow modeling, transport network impact estimation, and transport mode competitive analysis. The second contribution of this work is an evaluation of the determinants of agricultural truck rates. These results show that the primary determinant of bulk truck rates are fuel prices; a dollar increase in fuel prices/gallon is estimated to increase per-mile truck rates by \$0.42. This result is helpful in evaluating the impacts of increased fuel prices, perhaps from increased fuel taxes or supply/demand shocks. Findings also show that driver wages are an insignificant determinant of bulk truck rates, perhaps dampened through the substitution between for-hire trucking and farm-operated agricultural transport.

2 Introduction

Agricultural producers depend upon efficient transportation to access domestic and international markets. As those agricultural products leave the farm, truck transportation is the primary avenue for accessing grain elevators, processing plants, intermodal terminals and other mode options (e.g., barge and rail loaders) (81% of domestic grain products, and 64% of all grain products (including foreign-bound grain products) move by truck) (Henderson et al., 2024). Given that many bulk agricultural products possess low value relative to their volume, the cost to transport those products to market represents the largest component of post-farm costs.¹

Agricultural producers in some areas own and operate their own trucks and in other regions rely more on designated commercial bulk truck providers to move products to market, particularly during harvest season when peak shipping demands may exceed their own trucking capacity. Producers also contract out their trucks during non-harvest periods to maximize equipment utilization and improve farm income. In both aspects, agricultural producers are increasingly competing in the truck transportation market with other commercial transportation providers and having access to timely, accurate, and dependable information on truck rates (within their geographical market) is critical to making marketing decisions.

The determinants of bulk truck rates are influenced by a complex interplay of factors. Market dynamics—including supply and demand, competition among carriers, and

¹Post-farm costs for exported unprocessed grain primarily include storage, handling, and transportation to final market. Estimated storage, handling, and transportation costs are as follows (2023 USD): storage: ~\$0.03/bu/month (University of Minnesota Extension Farm Resource Guide 2024 (survey)); handling: ~\$0.10/bu (University of Minnesota Extension Farm Resource Guide 2024 (survey)), transportation (from Minnesota to Shanghai): truck to barge: \$0.40/bu, barge to port: \$1.02/bu, port to export country: \$1.36/bu, total transportation: \$2.79/bu (Grain Transportation Report (December 14, 2023), USDA Agricultural Marketing Service), transportation (from North Dakota to Shanghai): truck to rail: \$0.40/bu, rail to port: \$1.77/bu, port to export country: \$0.73/bu, total transportation: \$2.90/bu (Grain Transportation Report (December 14, 2023), USDA Agricultural Marketing Service). Transportation costs represent the largest share of post-farm unprocessed grain exports.

economic conditions—shape pricing. For example, following the COVID-19 pandemic, the shortage of transportation services could be attributed to increased demand due to fiscal and monetary programs, pandemic-induced staffing shortages, and bottlenecks in the physical movement of goods. Driver wages and labor availability also play a role, with industry-wide driver availability issues leading to higher rates. The COVID-19 pandemic resulted in a 38% increase in for-hire trucker wages and a nearly 50% rise in average truck rates (Richards et al., 2024).

Regulatory factors, such as safety and environmental standards and hours-of-service regulations, also influence rates as they affect operational efficiency and costs. During the COVID-19 pandemic, protocols for the delivery of farm inputs, farm produce, or intermediate or final processed goods to grocery distribution centers were modified to allow truckers to remain in the safe confines of their trucks (Gray, 2020). Efforts were also made to limit the use of multiple drivers per truck, and COVID-19 related delays made it more difficult to serve some routes in a timely manner. To protect drivers while keeping products moving, Transport Canada and several provincial governments increased the maximum hours of service for drivers (Tabak, 2020).

Additionally, truck-specific characteristics such as weight, volume, distance, and commodity type are also critical in determining rates, as these factors impact loading, unloading, and transportation efficiency. Heavier trucks and those carrying larger volumes tend to incur higher operating costs due to increased fuel consumption and wear and tear on the vehicle. Longer distances add to these costs, not only through additional fuel expenses but also increased labor costs. Fruits or frozen goods require refrigerated trucks and faster transit times to maintain quality, thus increasing costs. On the other hand, non-perishable items such as grains or raw materials may be less expensive to transport but might require specialized handling or adherence to specific safety protocols, which can also influence rates.

3 Literature

There are two important strands of literature pertaining to truck rates. The first is measurement of trucking costs, usually via carrier surveys, to identify the component parts of trucking costs which ultimately affect rates.

Trego (2008) conducted a survey to study trucking operating costs, specifically the average aggregate carrier cost per mile or cost per hour for 2008. The survey findings reveal that the average marginal cost per mile is \$1.73 (\$2.53 in 2024 USD) and the average cost per hour is \$83.68 (\$122.27 in 2024 USD) with diesel/oil, driver's wages, and truck/trailer rentals or purchases being the highest costs.

The American Transportation Research Institute (ATRI) in their annual, *Operational Costs of Trucking Report: 2024 Update*, reports trucking costs based on a survey of drivers and carriers (2023 USD). ATRI reports fuel costs to be \$0.55/mile (\$22.23/hour), truck/trailer lease/purchase payments to be \$0.36/mile (\$14.46/hour), repair and maintenance costs to be \$0.20/mile (\$8.13/hour), insurance costs to be \$0.10/mile (\$3.99/hour), and other truck costs (permits, licenses, tires, tolls) to be \$0.09/mile (\$3.56/hour). ATRI reports driver wages to be \$0.78/mile (\$31.32/hour) and driver benefits to be \$0.19/mile (\$7.58/hour). ATRI reports total trucking costs of \$2.27/mile (\$91.27/hour).

The second important strand of literature focuses on understanding the impacts of changes in trucking costs and market dynamics (supply, demand, competition) on trucking operations and truck rates.

Fuel costs are an important factor in truck rates, as fluctuations in fuel prices affect operational expenses. De Borger and Mulalic (2012) find higher fuel prices induce firms to invest in higher capacity (lowering cost per ton-mile) and more fuel-efficient trucks. Winebrake et al. (2015) estimated fuel price elasticities of trucking operations in the United States between 1970 and 2012, finding that fuel price elasticities have shifted from an elastic environment in the 1970s (increased fuel prices yield a relatively large decrease in demand for truck services) to an inelastic environment in 2012 (increased fuel prices yield a relatively small decrease in demand for truck services).

Intermodal competition plays an important role in influencing agricultural transportation rates. Because of the difference in cost structures across transportation modes, which are primarily a function of transportation distance, some shipping lanes have intermodal competition which can drive down rates, while others are either truck- or rail-dominated which can result in the exertion of market power and increased rates (Jessup et al., 2022). Short haul lanes (on average 183 miles) are typically truck-dominated, while long-haul lanes (on average 1,658 miles) are rail-dominated. These mode-dominated lanes do not face intermodal competition that would otherwise put downward pressure on transportation rates. Medium-haul lanes (on average 657 miles) are competitive between truck and rail, benefiting shippers with the choice between modes and competitive downward pressure on transportation rates (Jessup et al., 2022).

This study conducts an analysis of the determinants of bulk truck rates. As the truck industry deals with national labor shortages, higher fuel costs and other post-pandemic supply chain challenges, agricultural producers can benefit from increased transparency and information related to bulk truck rates. Understanding the determinants of bulk truck rates can be helpful in forecasting rates and understanding relevant policy implications (e.g., the impact of increased fuel taxes).

4 Data

Data on truck rates are collected from Bulkloads.com, an online truck service load board specializing in bulk freight shipments. Bulkloads.com on their load board brings together shippers who can request truck services, and carriers who can fulfill those services. Bulkloads.com publishes average weekly rates per mile and per ton by lane and load type (trailer and commodity) derived from fulfilled loads from their load board. This data has been collected from Bulkloads.com yielding historical information on weekly average rates from bulk load shipment transactions for week-origin-destination-trailer-commodity pairs from January 2017 through December 2023. The data include trailer type, commodity type, truck rate per mile, and truck rate per ton for origin-destination pairs throughout the U.S. While Bulkloads.com publishes data on origin-destination city-level pairs, we use origin-destination state-level pairs throughout the data description and analysis.

Trailer types observed in the data include walking floor, end dump, hopper, and tanker.² Hoppers are the most popular trailer observed in the data, with 72,905 lane-week-commodity rate data points, followed by end dump at 38,471 lane-week-commodity rate data points. Walking floor and tanker trailers only appear rarely in the data representing 130 and 27 lane-week-commodity data points respectively.

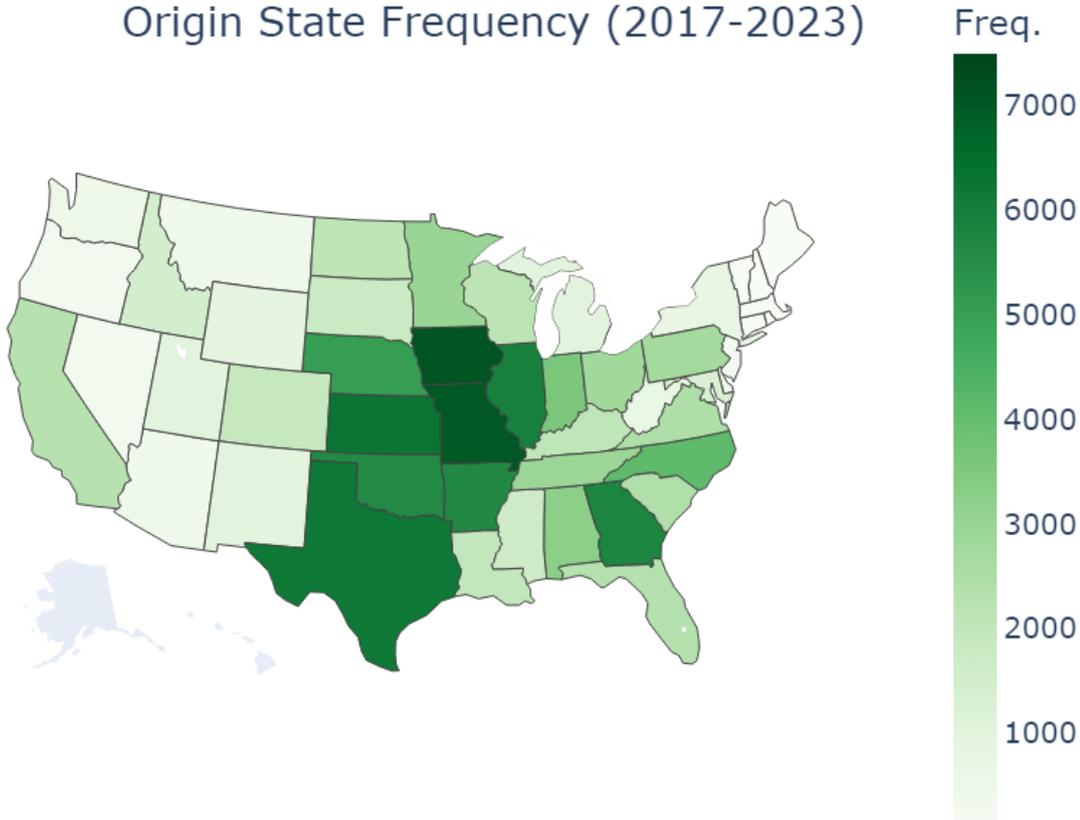
Bulk commodities in the data include feed ingredients, fertilizer, grain, industrial, aggregates, metal/recycling, liquid, and other. Feed ingredients are observed most often with 38,530 lane-week-trailer rate data points, followed by fertilizer with 26,030 lane-week-trailer rate data points, followed by grain with 21,360 lane-week-trailer rate data points, and industrial with 13,256 lane-week-trailer rate data points. Aggregates and metals/recycling are observed with 7,300 and 4,900 lane-week-trailer data points respectively. Other and liquid commodities are uncommon, with 130 and 27 lane-week-trailer data points respectively.

Figures 1 and 2 show the number of unique week-origin-destination-trailer-commodity pairs originating from each state (1) and destined to each state (2). The darker color indicates a greater frequency of week-origin-destination-trailer-commodity pairs with at least one load fulfilled. The largest concentration of Bulkloads.com load board activity is in the Midwest region. The top three origin states based on frequencies are Iowa, Missouri, and Kansas (Figure 1), and the top three destinations are Texas, Missouri, and Iowa (Figure 2). Outside of the Midwest region, the top states include Texas, Georgia, and North Carolina—all states with large livestock and poultry industries. States in the New England region, such as Maine, New Hampshire, and Rhode Island have the least observed trucking activities.

Figure 1: Origin State Frequency Count

² End dump and hopper trailers are typically open-top, loading bulk products from above. End dumps use a lift to raise the trailer and dump loads out the rear. Hoppers have chutes below the bed of the trailer that open to dump product below. Walking floor trailers carry bulk and non-bulk loads. Walking floor trailers have a 'walking' floor that operates by incrementally moving floor slats to move the load to the rear of the trailer, and for bulk products ultimately onto the ground. Tanker trailers carry bulk liquid products and are loaded from above but can be discharged from below or above using a pump.

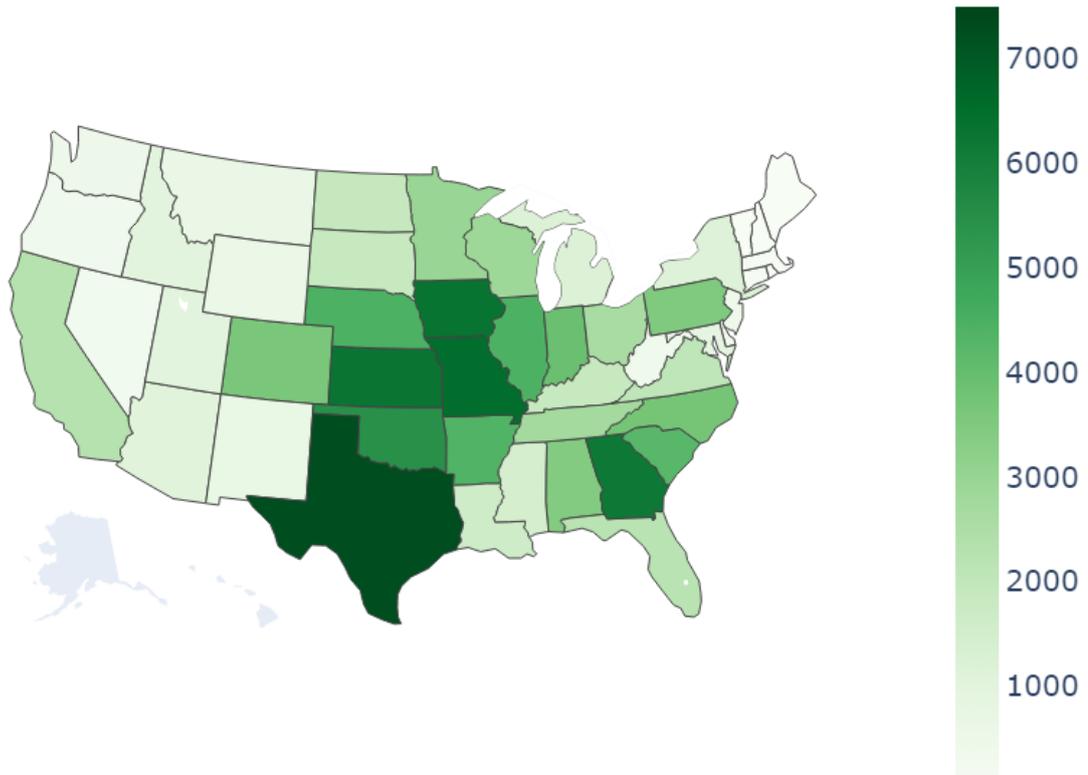
Origin State Frequency (2017-2023)



Note: Count of lane-week-trailer-commodity pairs across all trailers, all commodities. Source: Bulkloads.com

Figure 2: Destination State Frequency Count

Destination State Frequency (2017-2023) Freq.



Note: Count of lane-week-trailer-commodity pairs across all trailers, all commodities. Source: Bulkloads.com

Data represent fulfilled loads across 1,566 unique origin-destination-state pairs (including within state movements). For most states, within-state trips are the most frequent trip type. For example, the most frequent trips to a destination in Alabama *originated* in Alabama. The most frequently observed origin-destination pairs are loads that originate from and are destined for Texas, representing 1,764 lane-week-commodity-trailer rate data pairs. The most frequently observed inter-state origin-destination pair is Missouri to Oklahoma, representing 912 lane-week-commodity-trailer rate data pairs (see Appendix for details).

Figures 4 and 5 show the average rate per ton and per mile, respectively, for shipments within each state across all commodities and trailer types (i.e., origin and destination in the same state). Connecticut has the highest average rate per ton at \$196.68, followed by Maryland at \$78.39 per ton (fig. 4). The median average rate per ton for within-state trips is \$24.26 and seventy-five percent of the rate is less than or equal to \$28.75. This rate distribution indicates that the average rate per ton in Washington is far higher than most states. Connecticut also has the highest average rate per mile at \$67.11, followed by Delaware at \$17.31 (fig. 5). The median average rate per mile for within-state trips is \$6.05, and seventy-five percent of these rates is less than or equal to \$7.22 per mile. Besides Connecticut and Delaware, Louisiana, Michigan, Indiana, and Washington also have a higher average rate per mile than the other states. The average rates per mile for Louisiana, Michigan, Indiana, and Washington are \$18.10, \$15.16, \$12.09, and \$12.07, respectively.

Figure 4: Within-State Average Rate per Ton

Tables 1 and 2 show the spatial variation in within-region and across-region rates (average rate per ton and per mile, respectively) at the regional level based on Petroleum Administration for Defense Districts (PADDs).³ The seven regions are the West Coast, Rocky Mountain, Gulf Coast, Midwest, Lower Atlantic, Central Atlantic, and New England. Within-region rates are averaged across all lanes with an origin and destination within the same region for all trailers and commodities (within-region rates are located along the diagonal of the table in bold). Across-region rates are averaged across all lanes by origin region and destination region pair for all trailers and commodities. The highest average within-region rate per ton is in the Gulf Coast region, with an average rate of \$54.66/ton. This cost represents the average rate of trucking activities that have origin and destination within the Gulf Coast. The lowest average within-region rate per ton is in the Midwest at \$41.64. New England has the highest average rate per mile at \$13.98, and the Rocky Mountain region has the lowest average rate per mile at \$3.89. The West Coast excluding California and Midwest also have low average rates per mile at \$4.20 and \$4.60, respectively. Compared to the other regions, trucking activities in the Midwest and Rocky Mountain regions generally have lower per ton and per mile rates.

Table 1: Rate per Ton Within and Across Regions (2017-2023)

Destination Region	California	Central Atlantic	Gulf Coast	Lower Atlantic	Midwest	New England	Rocky Mountains	West Coast exc California
Origin Region								
California	22.84	172.33	140.88	109.85	190.69	-	121.78	69.2
Central Atlantic	201.48	42.28	141.76	67.72	84.77	94.27	156.51	328.46
Gulf Coast	207.99	184.37	54.66	60.05	88.38	387.49	112.91	91.83
Lower Atlantic	180.79	87.09	55.48	51.14	73.7	206.6	224.09	287.19
Midwest	203.45	97.54	81.84	70.46	41.64	158.01	77.05	158.32
New England	510.1	57.57	89.04	79.69	89.48	51.53	-	80
Rocky Mountains	115.48	186.13	88.71	163.31	76.58	-	47.1	76.51
West Coast exc California	74.42	257	125.39	258.12	139.65	258.33	133.12	51.78

³ More information on PADDs is available on <https://www.eia.gov/todayinenergy/detail.php?id=4890>.

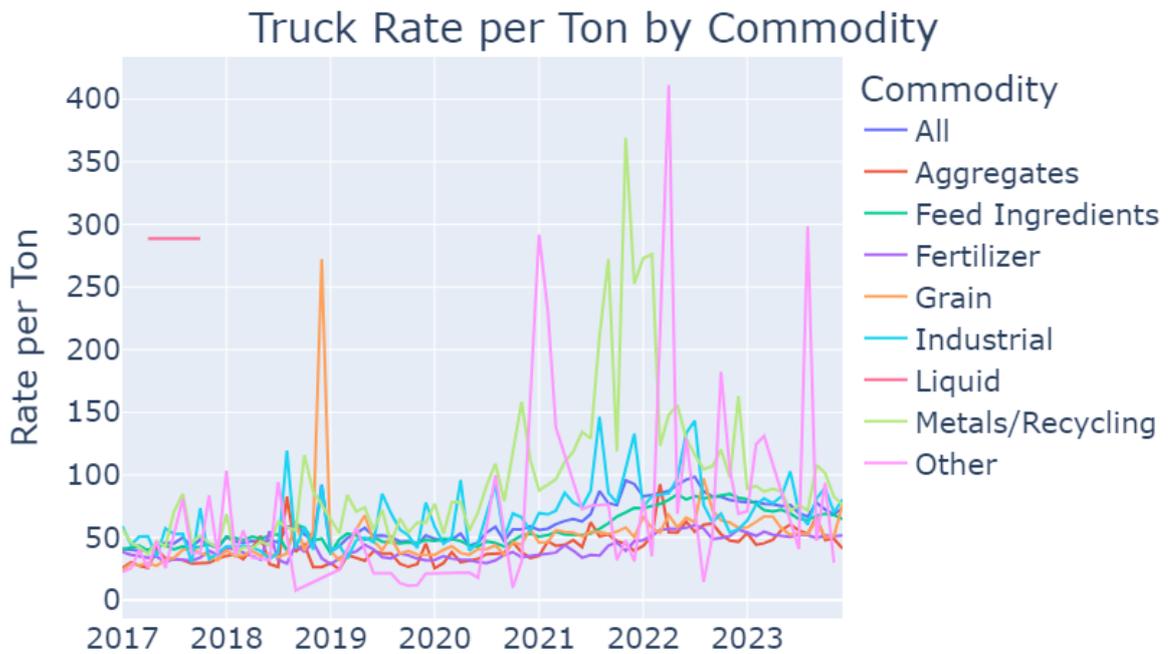
Table 2: Rate per Mile Within and Across Regions (2017-2023)

Destination Region	California	Central Atlantic	Gulf Coast	Lower Atlantic	Midwest	New England	Rocky Mountains	West Coast exc California
Origin Region								
California	5.31	1.68	2.34	1.17	1.90	-	2.84	3.13
Central Atlantic	1.40	5.33	2.82	3.15	3.01	4.12	2.08	3.26
Gulf Coast	2.69	2.90	5.28	3.23	2.85	3.26	2.49	2.85
Lower Atlantic	2.61	3.63	3.50	4.51	3.16	3.28	2.60	2.59
Midwest	2.80	3.47	2.90	3.26	4.20	3.22	2.81	2.95
New England	2.96	3.54	1.34	2.31	2.50	13.98	-	0.77
Rocky Mountains	3.05	2.28	2.46	2.71	2.55	-	3.89	2.86
West Coast exc California	2.89	2.41	3.02	2.29	2.35	1.99	3.12	4.60

The average rate per ton has increased over time for all commodity types (fig. 6, not inflation adjusted⁴). However, the rates for some commodities fluctuate more than others. For example, the average rate per ton for *Metals recycling* increased and decreased substantially during 2021-Q1 to 2022-Q3. As one might suspect, the COVID-19 pandemic resulted in higher trucking costs: *all* commodity types saw rates increase starting in the second quarter of 2020.

⁴ On average, per ton bulk truck rates have outpaced inflation. From 2017-2023, per ton bulk truck rates have increased by 71% while aggregate prices as measured by the producer price index have increased by 32%.

Figure 6: Average Monthly Truck Rate per Ton by Commodity

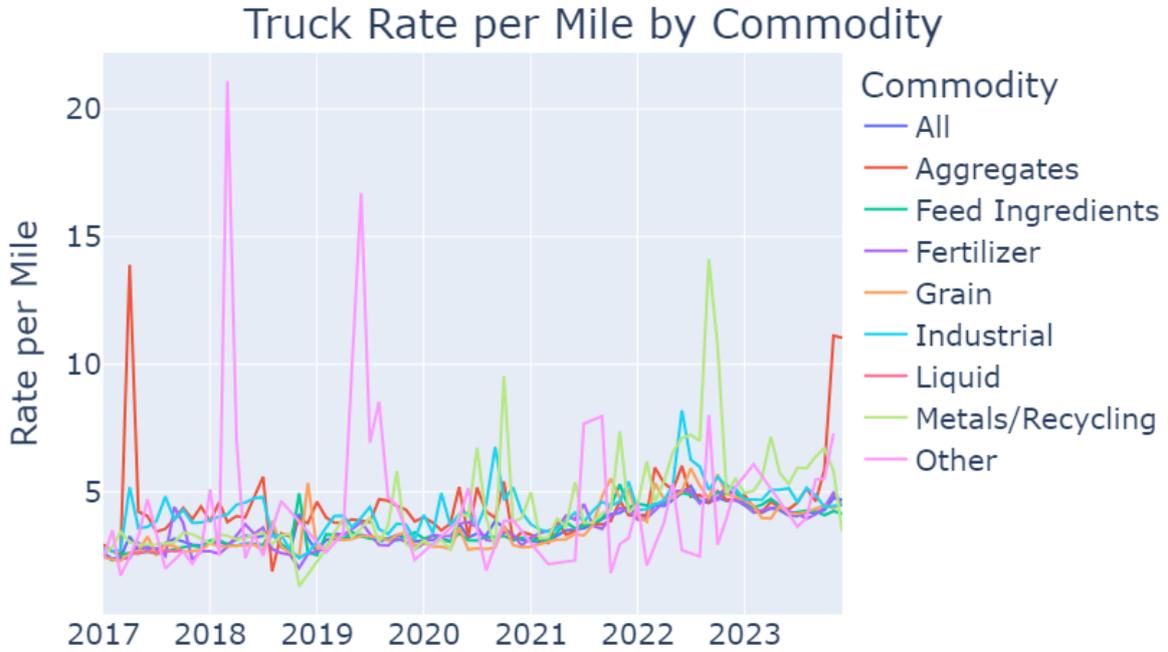


Note: Average monthly rate by commodity across all lanes and trailers. Source: Bulkloads.com

Figure 7 shows that average rates per mile have increased for most commodity types over time (not inflation adjusted⁵). The *other* commodity category fluctuates the most over time. Putting the *other* commodity aside, there are clear increasing trends in rate per mile for all other commodity types starting in 2021-Q1, and they generally move in the same direction. The *feed ingredients* category has the most stable rates over time, particularly before 2021.

⁵ On average, per mile bulk truck rates have outpaced inflation. From 2017-2023, per mile bulk truck rates have increased by 52% while aggregate prices as measured by the producer price index have increased by 32%.

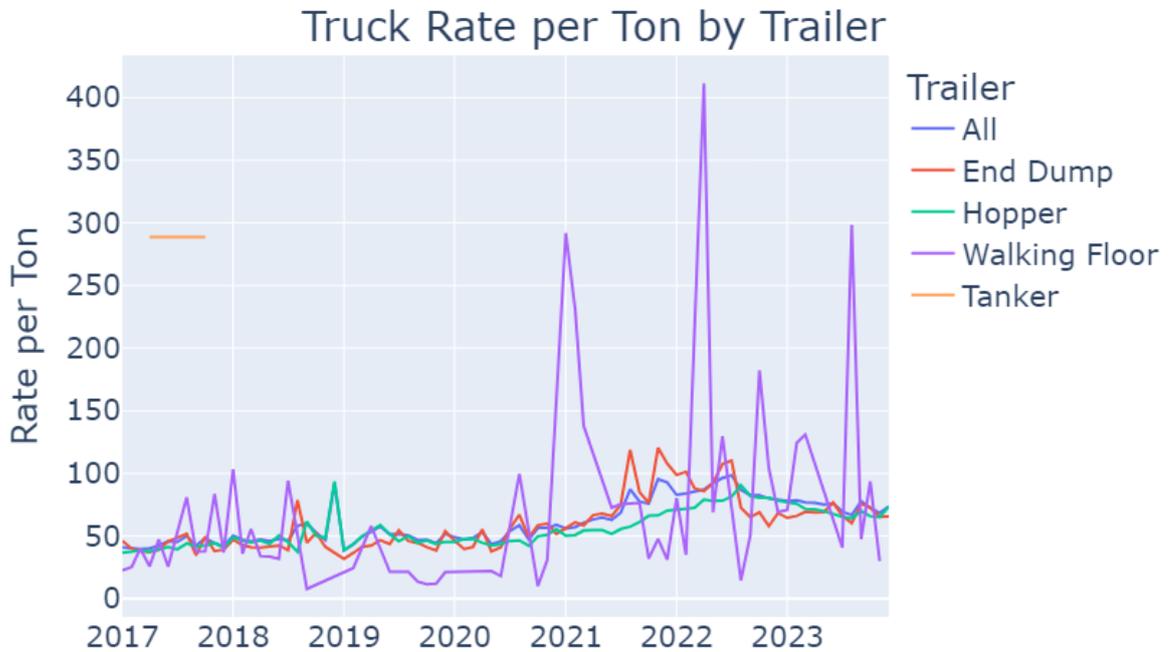
Figure 7: Average Rate per Mile by Commodity Over Time



Note: Average monthly rate by commodity across all lanes and trailers. Source: Bulkloads.com

Figure 8 shows average rates per ton by commodity type. The greatest variance in rates occurs for *walking floor* trailer types. Hopper, the most popular trailer mode, are the most stable from 2017 to 2023.

Figure 8: Average Rate per Ton by Trailer Over Time

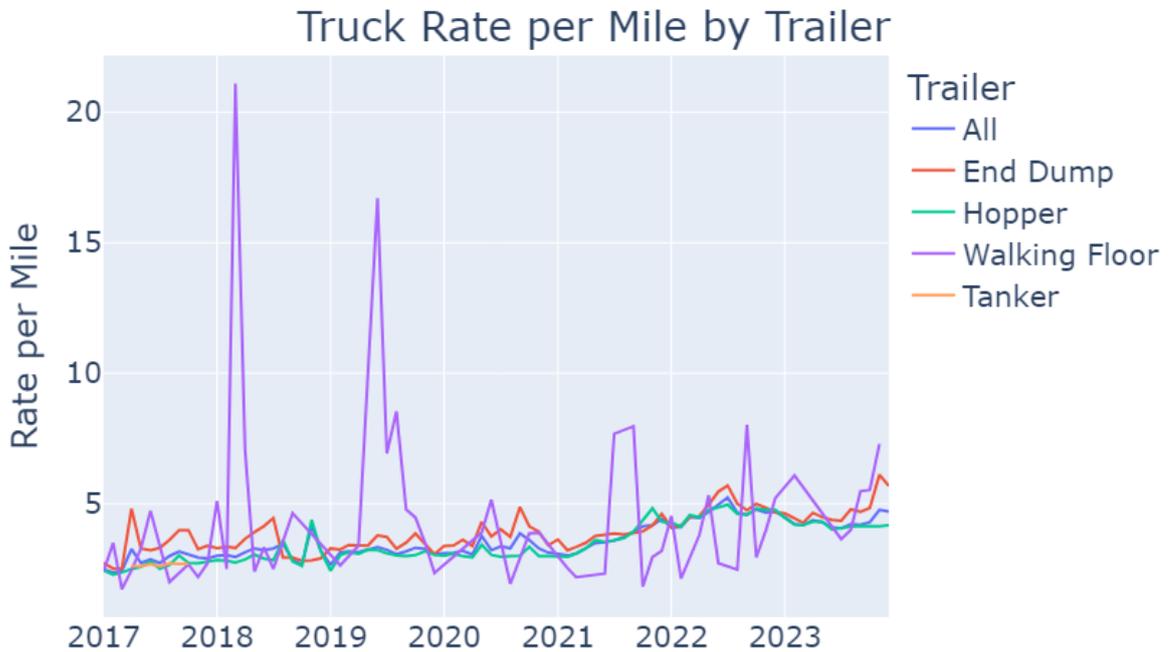


Note: Average monthly rate by trailer across all lanes and commodities. Source: Bulkloads.com

Figure 9 shows the average rate per mile over time by trailer type. The per mile rate for *walking floor* fluctuates the most over time, with multiple steep rate increases and

decreases. Other than *walking floor*, the per mile rates by trailer type have been steady, and they move in the same direction with increasing trends over time. The increases in rates across all trailer types are more clearly visible after 2021.

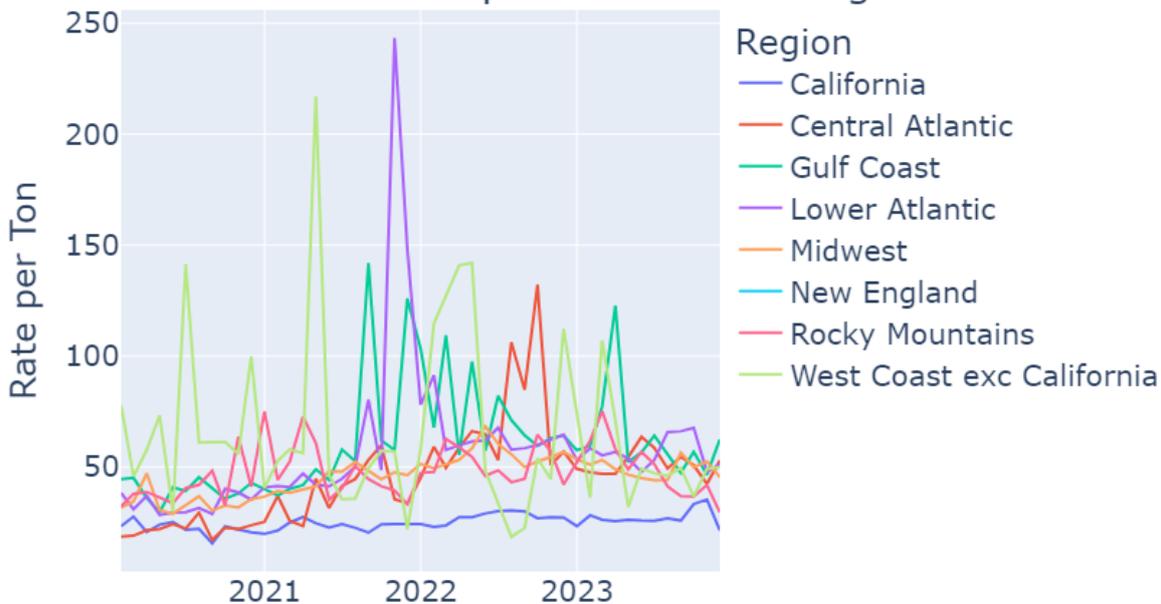
Figure 9: Average Rate per Mile by Trailer Over Time



Note: Average monthly rate by trailer across all lanes and commodities. Source: Bulkloads.com

Figure 10 shows rates per ton over time by region. The average rate rose significantly in the Lower Atlantic and Gulf Coast regions between the second and third quarters of 2021, perhaps in response to shifts in volumes to Gulf and Atlantic Coast export gateways caused by West Coast port congestion. Variation in per ton truck rates is largest in the Lower Atlantic, Gulf Coast, and West Coast excluding California regions. Variation in per ton truck rates in these regions may be caused by the diversity in commodities produced in these regions, evidenced in part by the relative stability of per mile truck rates (fig. 11).

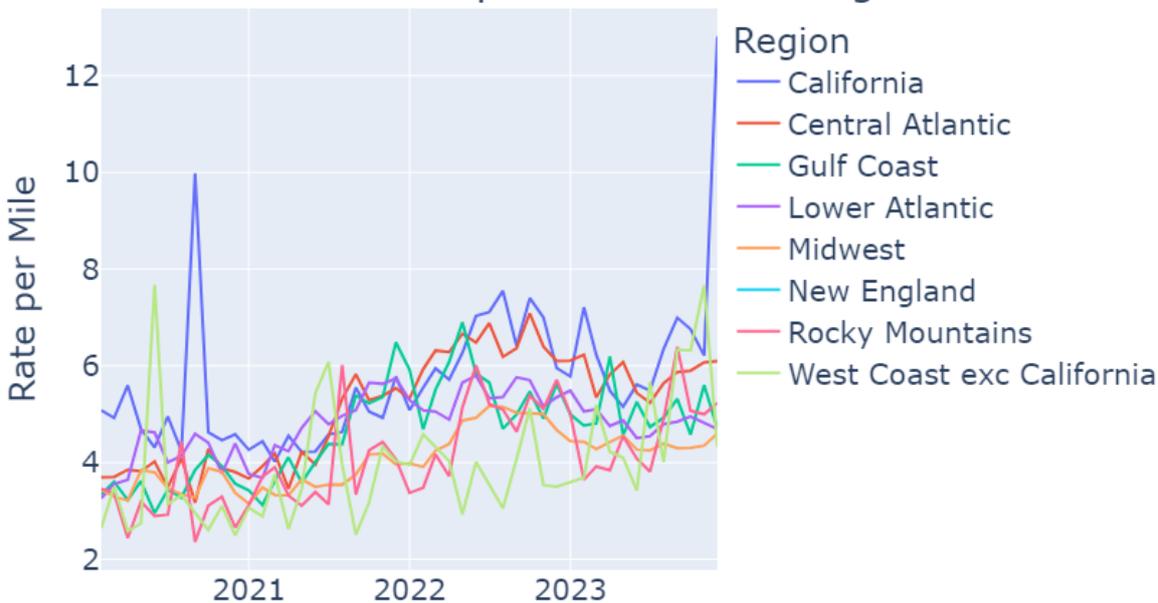
Figure 10: Average Rate per Ton by Region Over Time
Truck Rate per Ton Within-Region



Note: Monthly average of within-region lane rates for all trailers and commodities. Source: Bulkloads.com

Figure 11 presents the average rate per mile over time by region. Within-region per mile rates are less volatile. Per mile rates in all regions peaked in 2022, and stabilized in 2023.

Figure 11: Average Rate per Mile by Region Over Time
Truck Rate per Mile Within-Region



Note: Monthly average of within-region lane rates for all trailers and commodities. Source: Bulkloads.com

For analysis, rates per mile are used as they more accurately represent marginal costs of trucking services, that are otherwise unobserved in a rate per ton (not accounting for

distance traveled). Additional data is included in analysis to measure the impacts of changing costs (fuel prices and wages) and macroeconomic indicators of supply and demand (unemployment rate and state-level GDP) on bulk truck rates. Fuel prices are collected from EIA, which provide monthly prices by PADD region. PADD region prices are mapped to the state level. Fuel prices are converted from a per-gallon rate, to a per-mile rate, assuming average fuel efficiency of 7 miles/gallon (American Transportation Research Institute, 2024). Wages for heavy and tractor-trailer truck drivers by month-state are reported by the U.S. Bureau of Labor Statistics from their Occupational Employment and Wage Statistics program. Unemployment rate by month-state is reported by the U.S. Bureau of Labor Statistics from their Current Employment Statistics program. Gross Domestic Product (GDP) by month-state is reported by the U.S. Bureau of Economic Analysis.

The unit of observation for analysis are average monthly truck rates from an origin-state to a destination state pair. To mitigate multicollinearity in state-level variables induced within state shipments (i.e., the origin-state and destination-state are the same), fuel prices, wages, unemployment rate, and GDP are included for each observation by taking the average of the origin-state and destination-state variables.⁶ A log-log specification is used to address the skewed and non-negative distribution of variables used in analysis. Table 3 provides the descriptive statistics for the key variables used in analysis.

Table 3: Descriptive Statistics

	mean	obs	sd	min	max
Log Rate per Mile	1.09	26,636	0.46	-2.66	5.48
Avg. Log Fuel Prices	-0.74	26,636	0.26	-1.18	-0.018
Avg. Log Wages	3.21	26,636	0.074	2.98	3.46
Avg. Unemployment Rate	0.042	26,636	0.019	0.018	0.23
Avg. Log GDP	12.75	26,636	0.68	10.46	14.99

5 Methods

The determinants of bulk truck rates are identified using a set of panel data models. Each model is estimated on the full set of Bulkloads.com bulk truck rate data from 2017-2023

⁶ The model specification could include separate regressors for origin-state variables and destination-state variables (e.g., origin-state wage, destination-state wage). However, for within-state shipments (most common in the data), the origin-state variable is equal to the destination-state variable. This induces perfect multicollinearity for the subset of within-state moves. To resolve this issue, rather than including origin-state and destination-state variables as separate regressors, we take the average of the two. For example, the wage for a within-state shipment is simply the state's wage; the wage for an inter-state shipment is the average wage between the origin and destination states.

for all lane-month-trailer-commodity pairs.⁷ Truck rates from origin (state) i to destination (state) j in time period t are written as a function of fuel prices, wages, unemployment, and GDP, in addition to month, year, and origin-destination pair fixed effects. The persistence of past conditions (truck rates, wages, etc.) on current rates are controlled for using lagged variables.

$$\begin{aligned} \log(Y_{ijt}) = & \alpha + \gamma_1 \log(Y_{ij,t-1}) + \beta_1 \log(FP_{ijt}) + \beta_2 \log(W_{ij,t-1}) \\ & + \mathbf{f}'\mathbf{X}_{ij,t-1} + \sum_{k=1}^{12} \delta_k \text{MONTH}_k + \sum_{m=1}^T \lambda_m \text{YEAR}_m \\ & + \mu_{ij} + \epsilon_{ijt} \end{aligned}$$

The dependent variable, $\log(Y_{ijt})$, is the natural log of truck rates from origin i to destination j in month t . To capture the influence of past rates on current rates, $\log(Y_{ij,t-1})$ represents the natural log of truck rates lagged one month from origin i to destination j (month $t - 1$). The variable $\log(FP_{ijt})$ represents the natural log of average fuel prices in the origin-state and destination-state⁸ in month t , and $\log(W_{ij,t-1})$ denotes the natural log of truck drivers' average wages in the origin-state and destination-state month $t - 1$. Vector $\mathbf{X}_{ij,t-1}$ includes control variables, such as the natural log of the average GDP and the average unemployment rate in origin and destination in month $t - 1$. Variable (MONTH_k) contains a monthly indicator to account for seasonal effects, and (YEAR_m) captures year-specific effects. In the notation, μ_{ij} represents the unobserved individual effect, and ϵ_{ijt} is an error term.

The model is estimated using several estimators: Ordinary Least Squares (OLS), Fixed Effects (FE), First Difference Generalized Method of Moments (Diff-GMM), and System Generalized Method of Moments (System GMM). Diff-GMM and System GMM are commonly used for dynamic panel data estimation, but Diff-GMM often shows poor finite sample properties, such as bias and imprecision. Nonetheless, Diff-GMM estimation is included for comparison. System GMM considers the large number of entities (n) and fewer time periods (T) (Blundell and Bond, 1998). Additionally, System GMM accounts for the endogeneity issues that arise from the model by using internal instruments from the model's data and combining equations in differences and levels to improve efficiency and reduce bias. This approach is particularly suited for unbalanced panel data. An example of endogeneity is the lagged dependent variable $Y_{ij(t-1)}$ correlates with the past error terms. Furthermore, drivers' wages ($Wages_{ijt}$) and fuel prices (FP_{ijt}) are treated as endogenous (that is they are determined by other variables in the model). Wages are influenced by the supply of drivers, which is unobserved in the estimation. Fuel prices are also endogenous to truck rates, such as geopolitical events that can influence fuel prices. Unobserved factors that include regional policies or economic conditions can also influence both the explanatory variables and truck rates, and lead to biased estimates if not properly

⁷ A separate model restricted to grain shipments is included in the Appendix (Tables A2 and A3). Results are similar, in part due to the grain shipments representing a large share of the overall data.

⁸ Fuel prices are only observed and the PADD region level. PADD region prices are mapped to the state level; there is no within-region variation in 'state-level' fuel prices.

addressed (Arellano and Bond, 1991; Blundell and Bond, 1998; Nickell, 1981; Baum et al., 2003).

6 Results

Results are estimated on the full set of Bulkloads.com bulk truck rate data from 2017-2023 for all lane-month-trailer-commodity pairs. A separate model restricted to grain shipments is included in the Appendix (Tables A2 and A3).⁹ Across all specifications, truck rates per mile from the previous time period (*lagged log rate per mile*) are positively related to the current truck rates (Table 4). This suggests that higher (lower) truck rates in the current period are associated with higher (lower) truck rates in the previous time period (i.e., truck rates are persistent). The System GMM model offers the most reliable estimates, balancing the need to control for endogeneity while preserving the dynamic nature of truck rates (see appendix for details). The discussion of results is restricted to estimates from the System GMM model (column 4).

The lagged truck rate per mile coefficient suggests a 1% increase in last period's truck rate corresponds to a 0.24% increase in this period's truck rate. At the mean truck rate, this indicates a \$0.0297 increase in truck rates last period, causes a \$0.007 increase in today's truck rate. All models report a statistically significant effect of lagged truck rates at the 1% level.

Table 4: Regression Results

	(1) OLS b/se	(2) FE b/se	(3) Diff-GMM b/se	(4) Sys-GMM (Forward) b/se
Lagged Log Rate per Mile	0.670*** (0.006)	0.260*** (0.019)	0.151*** (0.009)	0.238*** (0.025)
Avg. Log Fuel Prices	0.143*** (0.029)	0.254*** (0.058)	0.322*** (0.057)	0.485*** (0.135)
Lagged Avg. Log Fuel Prices		0.026 (0.049)	0.077 (0.053)	-0.126 (0.109)
Avg. Log Wages	0.055 (0.067)	0.226 (0.512)	-0.298 (1.258)	-0.142 (2.610)
Lagged Avg. Log Wages		-0.323 (0.531)	2.836** (0.973)	1.964 (2.446)
Real GDP	-0.001 (0.004)	-0.383 (0.209)	-0.298 (0.180)	-0.157 (0.200)
Lagged Real GDP		0.354 (0.198)	0.087 (0.151)	0.155 (0.201)
Avg. Unemployment Rate	-0.192 (0.185)	-0.823** (0.269)	-0.508* (0.198)	0.300 (0.351)
Lagged Avg. Unemployment Rate		0.512 (0.274)	0.695*** (0.191)	
Observations	15262	15086	11655	15086
R2	0.521	0.330		
AR(1) p-value			0.000	0.000
AR(2) p-value			0.456	0.077
Hansen p-value			0.661	0.220

⁹Results are similar, in part due to the grain shipments representing a large share of the overall data.

Fuel prices (*Avg. Log Fuel Prices*) are another important determinant of truck rates. All models report a positive and statistically significant effect, indicating that higher fuel prices are associated with higher truck rates. The System GMM result suggests that a 1% increase in fuel prices causes a 0.49% increase in per mile truck rates. At the mean truck rate and fuel price, this indicates that a \$0.005 increase in per-mile fuel prices causes a \$0.014 increase in truck rates. That is, for every \$0.10 increase in per-mile fuel prices (\$0.70 per gallon), per-mile truck rates are expected to increase by approximately \$0.30. Or, for every \$0.10 increase in per-gallon fuel prices, per-mile truck rates are expected to increase by approximately \$0.042.

There is no evidence that drivers' wages (*Avg. Log Wages*) and their wages from the previous time period (*Lagged Avg. Log Wages*) have statistically significant impact on truck rates per mile. Real GDP (*Real GDP*) are the real GDP from the previous time period (*Lagged Real GDP*) are also not found to be statistically significant predictors of bulk truck rates. The FE and Diff-GMM models provide some evidence that the unemployment rate is negatively associated with truck rates (i.e., higher unemployment rates yield lower truck rates), however, this is not consistent across all models.

In summary, the findings reveal that truck rates exhibit strong persistence, indicating that past rates are a determinant of current rates. This persistence underscores the importance of historical data in understanding current market truck rates. Additionally, fuel prices are positively related to truck rates. This highlights the critical role of fuel costs in the trucking industry. Policy interventions targeting fuel prices can affect transportation costs.

7 Conclusions

This study highlights the heterogeneity of U.S. bulk trucking activities across locations, commodities, and trailer types, using data from Bulkloads.com. The data reveal that the Midwest is a central hub for bulk load trucking, and is a region characterized by lower rates compared to other U.S. regions. Hoppers are the most popular trailer type among bulk shipments within the Bulkloads.com dataset. Increasing trends in rates per ton and per mile underscore the dynamic nature of this industry, with a higher degree of fluctuations on certain commodity types.

Bulk truck rates are analyzed to understand the impacts of fuel prices, wages, unemployment, and GDP on rates. Results show that past truck rates are important predictors of the current rates (persistence), and fuel prices are an important driver (and multiplier) of bulk truck rates. Wages, unemployment, and GDP are not found to be statistically significant drivers of bulk truck rates.

Data is at the state-level, as presented in this paper abstracts from city-level variation in rates that may provide valuable insight. Other more granular information on fuel prices, trucking supply, and trucking demand would also help to paint a fuller picture of the drivers of truck rates. Additional work is needed to provide more granular and predictive forecasts of bulk truck rates, which would be useful both for policy evaluation and for decision support for shippers evaluating trucking and freight logistics decisions.

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Appendix

Table A1: Top 3 Destination States by Origin State, Frequency Count of Week-Lane-Trailer-Commodity Pairs (2017-2023)

Origin	Destination	Frequency
AL	AL	597
AL	GA	443
AR	TX	530
AR	AR	685
AZ	TX	128
AZ	CA	124
CA	AZ	297
CA	CA	1271
CO	CO	390
CO	TX	207
CT	NJ	12
CT	NC	17
DE	VA	90
DE	PA	55
FL	GA	874
FL	FL	380
GA	GA	1438
GA	SC	733
IA	MO	636
IA	IA	1018
ID	ND	283
ID	MT	182
IL	IA	752
IL	IL	1073
IN	IN	845
IN	IL	346
KS	KS	1058
KS	OK	674
KY	GA	236
KY	IN	212
LA	GA	251
LA	TX	610
MA	PA	9
MA	NY	9
MD	MD	194
MD	PA	339
ME	MI	1
ME	NY	1
ME	VA	1

ME	LA	1
MI	IL	163
MI	OH	138
MN	MN	752
MN	IA	469
MO	MO	1154
MO	OK	912
MS	TX	260
MS	AR	135
MT	ID	63
MT	ND	70
NC	NC	671
NC	GA	648
ND	ND	501
ND	CO	221
NE	KS	721
NE	NE	913
NH	OH	4
NJ	NC	82
NJ	PA	49
NM	AZ	105
NM	TX	276
NV	CA	159
NV	OR	40
NY	NC	133
NY	PA	258
OH	IN	409
OH	OH	269
OK	TX	841
OK	OK	1083
OR	ID	72
OR	WA	60
PA	NY	264
PA	PA	648
RI	PA	1
SC	GA	510
SC	SC	835
SD	IA	221
SD	SD	231
TN	TN	504
TN	GA	418
TX	TX	1764
TX	OK	731
UT	CO	433

UT	ID	71
VA	NC	504
VA	VA	521
VT	OH	12
VT	NJ	12
WA	VA	61
WA	CA	61
WA	MI	98
WI	MN	284
WI	WI	519
WV	WV	139
WV	OH	103
WY	NE	146
WY	WY	146
WY	CO	224

Methodology and Model Choice

The Fixed Effects (FE) model is a popular method for controlling time-invariant characteristics within units by using dummy variables for each unit. However, it falls short in addressing endogeneity, which occurs when the lagged dependent variable is correlated with the error term. This limitation makes FE unsuitable for dynamic panels, where the inclusion of a lagged dependent variable can lead to biased estimates. Similarly, Ordinary Least Squares (OLS) with a lagged dependent variable is plagued by issues of endogeneity and bias. The correlation between the lagged dependent variable and the error term results in biased and inconsistent estimates, rendering OLS unreliable in dynamic panel data contexts.

Although, Difference GMM, an earlier version of the Generalized Method of Moments (GMM), attempts to address fixed effects by differencing the model and using lagged levels as instruments, this approach often suffers from weak instruments, particularly when the time series is persistent, leading to inefficient and biased estimates. Additionally, differencing the model results in a loss of valuable information about the levels of the variables, further weakening the robustness of the results.

Two-Stage Least Squares (2SLS) is another alternative that seeks to address endogeneity by using external instruments. However, 2SLS faces significant challenges in finding valid instruments that are both correlated with the endogenous regressors and uncorrelated with the error term. Furthermore, 2SLS may lack efficiency in panel data settings, especially when dealing with multiple endogenous variables and potential autocorrelation.

In contrast, System GMM emerges as a superior method for our analysis. It effectively handles endogeneity by using lagged levels and differences as instruments, addressing the dynamic panel bias and overcoming the weak instrument problem associated with

Difference GMM. System GMM also internally generates instruments, eliminating the challenge of finding external instruments that 2SLS requires. Moreover, System GMM is well-suited for unbalanced panel data, making it a more robust and reliable choice for our dataset. This method provides more consistent and efficient estimates, making it the preferred approach over other alternatives in our analysis.

The System GMM model offers the most reliable estimates, balancing the need to control for endogeneity while preserving the dynamic nature of truck rates (see appendix for details)

In Column 1 (Table 4), the OLS model yields a lagged rate per mile coefficient estimate of 0.670, and it decreases in Column 2, to 0.260, after controlling for the unobserved heterogeneity across states. This reduction in the coefficient estimate on lagged truck rate per mile caused by the inclusion of state-fixed effects, suggests that unobserved characteristics are relevant determinants of truck rates. These state specific unobservables impacting truck rates could include, for example permitting and licensing costs or insurance costs that vary by state. The Diff-GMM model in Column 3 reports a lagged rate per mile coefficient estimate of 0.151, which is lower than both OLS (Column 1) and FE (Column 2). This reduction in the lagged rate per mile coefficient suggests potential attenuation bias in the difference estimator when instruments are weak. The System GMM model in Column 4 reports a lagged rate per mile coefficient estimate of 0.238, which is closer to the OLS estimate (upper bound) of 0.670. This suggests that System GMM is better at retaining the dynamic structure of the model while addressing endogeneity.

The System GMM model effectively addresses endogeneity by using internal instruments derived from the model's data. The combination of equations in differences and levels improves efficiency and reduces bias from omitted variables. This approach is also particularly suited for unbalanced panel data, as the method minimizes data loss and handles data imbalance effectively¹⁰.

To ensure the validity of the instruments used in the System GMM estimation, we conducted the Hansen J test and the Arellano-Bond test for autocorrelation. The Hansen J test for over-identifying restrictions resulted in a p-value of 0.220 for the System GMM model, indicating that the instruments used are valid. Additionally, the Arellano-Bond test for AR(1) in first differences showed a p-value of 0.000, confirming the presence of first-order autocorrelation. The Arellano-Bond test for AR(2) in first differences yielded a p-value of 0.077, suggesting no significant second-order autocorrelation, which is crucial for validating of the instruments.

Estimation of Grain Shipments

Table A2: Monthly Grain Regression Results

	(1)	(2)	(3)	(4)
	OLS	FE	Diff-GMM	Sys-GMM (Forward)
	b/se	b/se	b/se	b/se
L. Log Rate per Mile	0.493*** (0.023)	0.150*** (0.045)	-0.105*** (0.005)	0.152*** (0.044)
Avg.Log Fuel Prices	0.259* (0.106)	-0.019 (0.255)	0.094*** (0.027)	-0.035 (0.434)
L.Avg Log Fuel Prices		0.319 (0.211)	0.553*** (0.031)	0.134 (0.333)
Avg Log Wages	0.340 (0.231)	-0.150 (2.388)	-2.490*** (0.482)	-7.415 (5.430)
L. Avg Log Wages		-1.424 (2.301)	3.193*** (0.363)	-6.172 (4.217)
Avg Log GDP	-0.037** (0.013)	0.429 (0.757)	-0.304 (0.179)	-0.670 (0.612)
L. Avg Log GDP		0.187 (0.858)	0.087 (0.154)	0.625 (0.616)
Avg Unemployment	1.591** (0.605)	1.050 (0.839)	0.281 (0.203)	1.568 (0.917)
L.Avg Unemployment		0.770 (0.930)	0.910*** (0.164)	2.649 (1.415)
Observations	15262	15086	11655	15086
R2	0.382	0.256		
AR(1)			0.000	0.000
AR(2)			0.434	0.358
Hansen Test			0.523	0.401

* p<0.05, ** p<0.01, *** p<0.001

Table A3: Quarterly Grain Regression Results (including Use and Availability Indices)

	(1)	(2)	(3)	(4)
	OLS	FE	Diff-GMM	Sys-GMM (Forward)
	b/se	b/se	b/se	b/se
L. Log Rate per Mile	0.200** (0.073)	-0.033 (0.055)	0.115 (0.171)	0.024 (0.236)
Avg.Log Fuel Prices	-0.901 (0.925)	-1.492 (0.734)	-6.613 (3.319)	0.217 (3.371)
L.Avg Log Fuel Prices	1.275* (0.722)	1.355* (0.552)	2.107 (2.193)	1.023 (0.889)
Avg Log Wages	-2.866 (6.01)	1.983 (8.051)	-5.370 (80.603)	-0.047 (1.139)
L. Avg Log Wages	2.268 (5.590)	0.961 (2.809)	-3.586 (16.980)	0.000 (.)
Avg Log GDP	0.227 (0.164)	0.314* (0.124)	0.462 (0.493)	1.484 (0.759)
L. Avg Log GDP	-0.185 (0.151)	-0.199 (0.103)	-0.287 (0.260)	-1.127 (0.702)
Avg Unemployment	-3.803 (2.967)	-5.448 (3.346)	-21.499** (7.573)	10.048 (4.960)
L.Avg Unemployment	0.0231 (3.034)	-1.155 (2.545)	-1.888 (4.393)	-9.814 (5.569)
Avg Use	0.012 (0.113)	-0.008 (0.087)	0.213 (0.123)	-0.186 (0.152)
Avg Availability	-0.074 (0.084)	-0.061 (0.121)	0.018 (0.099)	-0.914 (0.470)
N	194.000	194.000	142.000	194.000
R2	0.249	0.234		
AR(1)			0.011	0.017
AR(2)			0.274	0.00
Hansen Test			0.394	1

* p_i0.05, ** p_i0.01, *** p_i0.001