



**FACTORS AFFECTING TRANSPORTATION COSTS IN LOGISTICS:
A COMPREHENSIVE ANALYSIS OF THE DRIVERS
BEHIND FREIGHT AND SHIPPING COSTS, THEIR
QUANTITATIVE SIGNIFICANCE, AND STRATEGIC IMPLICATIONS
FOR SUPPLY CHAIN MANAGEMENT.**

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ABSTRACT

Transportation costs sit at the heart of global commerce. They determine how much businesses pay to move goods, how competitive companies can be in distant markets, and ultimately, how much consumers pay for products on the shelf. In 2023, global logistics costs surpassed 11 trillion US dollars, representing roughly 10.6 percent of the world's GDP, according to Statista. Of that enormous figure, transportation alone accounts for approximately 40 to 50 percent of total logistics expenses.

This article examines the principal factors that shape transportation costs in logistics: fuel prices, distance, cargo characteristics, mode of transport, labor, infrastructure, regulatory compliance, market demand, and geopolitical disruptions. Drawing on data from the American Transportation Research Institute (ATRI), OECD, Statista, and industry publications, the paper quantifies how each factor contributes to cost formation, highlights recent trends, and identifies strategic responses available to logistics professionals.

Keywords: transportation costs · freight rates · logistics management · fuel surcharges · supply chain · modal choice

1. INTRODUCTION

Every time a package moves from a factory to a doorstep, a container crosses an ocean, or a pallet of food travels from farm to supermarket, a complex web of costs comes into play. Transportation is not simply the act of moving things; it is a precisely calculated economic activity where dozens of variables determine the final price. Transportation costs account for nearly 58 percent of total logistics expenses, a figure that makes them arguably the single largest cost center in any supply chain.

Understanding what drives those costs matters enormously for businesses of every size. A retailer deciding whether to ship goods by ocean or air, a manufacturer comparing rail versus truck for bulk materials, or a logistics provider negotiating annual contracts with carriers all need to know which factors move prices and by how much. Without that knowledge, cost planning becomes guesswork.

The global logistics market was valued at roughly 9.4 trillion euros in 2023 and is projected to exceed 14 trillion euros by 2028, according to Statista's market outlook.¹ Within that vast





industry, road freight alone commands a 39 percent market share, making trucking the dominant mode by revenue. Yet the economics of transportation are shifting: fuel prices oscillate, driver shortages persist, geopolitical crises reroute shipping lanes, and new technologies gradually reshape cost structures.

This article organizes the landscape of transportation cost drivers into clear categories, provides quantitative data for each, and discusses how logistics professionals can respond strategically. The analysis focuses primarily on road freight, where the most granular data exists, while also comparing other major modes.

Table 1. Summary of Key Transportation Cost Factors in Logistics

Factor	Key Elements	Quantitative Impact	Source
Fuel & Energy	Diesel, electricity, aviation fuel	30–40% of total transport costs (road freight)	ATRI, 2024; Navata, 2023
Distance & Route	Mileage, terrain, tolls, congestion	Primary determinant of carrier pricing models	ATRI, 2024; Pazago, 2024
Cargo Characteristics	Weight, volume, fragility, hazardous nature	Dimensional weight pricing; special handling surcharges	Pazago Freight Guide, 2024
Mode of Transport	Road, rail, sea, air	Air up to 4× cost of sea for same container	FNC Americas, 2025; ICCT, 2025
Labor & Driver Wages	Driver pay, benefits, turnover rates	Driver wages ~\$0.80/mile in 2024 (U.S.)	ATRI, 2025
Infrastructure & Maintenance	Road quality, port congestion, vehicle upkeep	\$0.198/mile repair & maintenance in 2024 (U.S.)	ATRI, 2025
Regulations & Compliance	Hours-of-service, emissions standards, customs	Insurance premiums rose 12.5% in 2023 (trucking)	ATRI, 2024
Market Demand & Seasonality	Peak seasons, supply-demand imbalance	5–10% freight cost surges during high-demand periods	FreightRate.com, 2025
Geopolitical & External Shocks	Conflicts, pandemics, natural disasters	Red Sea disruptions doubled container rates in 2024	Cargoson, 2025; Scafom-Rux, 2024

Source: ATRI (2024, 2025); Navata (2023); Pazago Freight Guide (2024); ICCT (2025); FreightRate.com (2025); FNC Americas (2025); Cargoson (2025)

2. FUEL AND ENERGY COSTS



2.1 The Dominant Variable

No single factor influences transportation costs more directly or more immediately than fuel prices. Diesel powers the trucks, ships, and locomotives that carry the overwhelming majority of the world's freight. When diesel prices rise, the impact ripples across every mode almost instantly. Research indicates that a 10 percent increase in diesel prices typically produces a 1 to 3 percent increase in the cost of transporting goods⁴ — a relationship that sounds modest until one considers that large shippers may spend hundreds of millions of dollars annually on transportation.

In the United States, diesel prices surged from around 3.60 dollars per gallon at the end of 2021 to over 5.70 dollars per gallon by mid-2022, a 74 percent increase. That kind of movement fundamentally changed the economics of food distribution, manufacturing, and e-commerce fulfillment in a matter of months. The American Farm Bureau Federation documented this in detail, noting that the food transportation sector was particularly hard hit because of thin margins and high freight dependency.

2.2 How Carriers Respond

Carriers do not simply absorb fuel cost increases. They pass them on through fuel surcharges, which adjust the base rate by a formula tied to a published diesel price index. When oil prices spike, those surcharges can add 0.35 dollars per mile to trucking rates, and during peak periods, the cumulative impact of fuel-driven surcharges raises overall freight costs by 5 to 10 percent. In 2024, when fuel prices eased somewhat, ATRI data showed that fuel costs for trucking fell by about 7 cents per mile to 48 cents, compared to 64 cents per mile in 2022 at the peak of the surge.

Rail offers a meaningful alternative here. A single freight train can haul the equivalent of 200 or more truckloads, and trains are roughly four times more energy efficient than trucks, capable of moving a ton of freight approximately 486 miles on a single gallon of diesel. This efficiency advantage becomes decisive over long hauls, which is why intermodal shipping, combining rail and road, has grown in popularity as a hedge against trucking fuel costs.

3. DISTANCE AND ROUTE COMPLEXITY

3.1 Distance as the Baseline

Distance is perhaps the most intuitive determinant of transportation cost. Longer hauls consume more fuel, require more driver hours, and increase wear on equipment. Freight carriers build their pricing models directly around distance, charging per mile for trucking, per nautical mile for ocean shipping, and per kilometer for rail.

But raw distance is only part of the story. The complexity of a route matters just as much. A 500-mile delivery through flat, uncongested highways costs considerably less than the same distance through mountainous terrain, dense urban areas, or roads requiring multiple toll crossings. Route planning software has become a core logistics tool precisely because optimal routing can trim meaningful costs from the equation. Companies that automate route planning consistently reduce transportation spend compared to manual planning, because the software accounts for traffic, fuel stops, delivery windows, and load sequencing simultaneously.





3.2 Urban Congestion and Last-Mile Costs

The final stretch of a delivery, known in the industry as the last mile, is disproportionately expensive relative to the distance covered. Moving a shipment from a distribution center into a dense city center can represent 25 to 50 percent of total delivery costs despite covering only a small fraction of the total journey. Congestion slows trucks, increases fuel consumption, forces longer idling, and limits how many stops a driver can complete in a shift. Infrastructure quality compounds this: poorly maintained roads increase vehicle wear and raise maintenance costs over time.

4. CARGO CHARACTERISTICS

4.1 Weight, Volume, and Density

What a shipment is made of matters as much as where it is going. Carriers charge based on whichever is greater: the actual weight of the cargo or its dimensional weight, calculated from the package's volume. A large but lightweight item like foam packaging occupies significant trailer space, limiting how many other items a carrier can include in the same load. Carriers recover that opportunity cost through dimensional weight pricing, which became standard across most major freight modes.

Heavier and denser goods are generally cheaper to ship per unit of value, because they fill capacity efficiently. Bulk commodities like grain, coal, or steel pellets benefit enormously from rail and ocean freight, where loading density translates directly into low per-unit costs. Time-sensitive, low-density goods, on the other hand, often end up on expensive air freight because no other mode can justify the economics in terms of time to market.

4.2 Special Handling Requirements

Certain cargo categories carry additional cost layers. Hazardous materials require certified packaging, licensed carriers, and often specific routes that avoid tunnels or populated areas. Temperature-controlled freight, including pharmaceuticals, perishable foods, and chemicals, needs refrigerated trailers or containers, which are more expensive to operate and maintain than standard equipment. The global cold chain logistics market reached 342.8 billion dollars in 2023 and reflects these premium costs.

Fragile goods that require special bracing, high-value cargo demanding enhanced security, and oversized loads that need special permits and route clearances all add layers of cost that standard rate structures do not cover. Logistics managers who fail to account for these special handling requirements consistently underestimate total transportation spend.

5. MODE OF TRANSPORT

The choice of transport mode is one of the most consequential cost decisions in logistics. Road, rail, sea, and air each occupy a distinct economic niche, and choosing the wrong one can add substantial unnecessary cost or fail to meet service requirements. According to the ICCT, road freight's share of total freight ton-kilometers in China, the U.S., and the EU increased by 110%, 16%, and 24% respectively between 2008 and 2023⁶ — a trend that reflects both the convenience of trucking and the infrastructure investments governments have made in road networks.





Table 2. Comparative Overview of Freight Transport Modes (2025)

Mode	Relative Cost	Best Distance	Approx. Rate	Flexibility	Emissions
Road (Truck)	Medium–High	Short–Medium	~\$0.30/ton-mile	Very High	Medium–High
Rail	Low–Medium	Medium–Long	~\$0.05/ton-mile	Medium	Low
Sea	Very Low	Long (International)	~\$0.01–0.05/ton-km	Low	Very Low
Air	Very High	Any (urgent)	\$4–8+/kg	Very High	Very High

Source: FNC Americas (2025); RSI Logistics (2024); FreightAmigo (2025); Sino-Shipping (2025); ICCT (2025)

Ocean shipping remains the backbone of international trade for good reason: it is the least expensive option per unit for moving large volumes over long distances. Transporting a standard shipping container from China to the United States by sea can cost as little as 1,200 dollars, whereas the same shipment via air freight can exceed 5,000 dollars depending on weight. The tradeoff is transit time: ocean voyages take weeks, making sea freight unsuitable for time-sensitive or perishable goods.

Rail occupies the middle ground, particularly advantageous over long land distances. From a cost perspective, over-the-road trucking runs approximately 214.96 dollars per net ton for a Houston-to-Cleveland route, while rail direct comes in at about 70.27 dollars per net ton, and a combined rail-truck multimodal approach arrives at around 95.54 dollars per net ton. For shippers willing to accept slightly longer transit times, the savings are substantial. Air freight is reserved for the most time-critical shipments. Speed is its primary justification: air is roughly 30 times faster than ocean for a comparable international route. But the cost premium is extreme, and for most product categories, the economics simply do not support regular air freight except when delays would result in greater losses than the shipping premium.

6. LABOR AND DRIVER COSTS

6.1 Driver Wages: The Rising Pressure

Driver wages represent the single largest non-fuel cost in trucking. In 2024, U.S. truck drivers earned approximately 79.9 cents per mile on average, according to ATRI's 2025 update³ — a figure that has risen steadily over the past decade as driver shortages intensified competition for qualified personnel.



The United States faces a truck driver shortage of approximately 78,000 drivers in 2024, a gap projected to widen to 160,000 by 2030 without corrective intervention. This structural imbalance between supply and demand for drivers keeps wages elevated and gives carriers less flexibility to compete solely on price. The pressure is amplified by demographic trends: a large portion of the existing driver workforce is approaching retirement age, and the industry has struggled to attract younger workers despite pay increases.

6.2 Beyond Wages: Benefits, Training, and Turnover

Driver compensation extends well beyond base wages. Benefits including health insurance, retirement contributions, and paid leave added 0.197 dollars per mile to trucking costs in 2024, a 4.8 percent increase from the prior year. High turnover in the industry also generates substantial hidden costs: recruiting, screening, onboarding, and training a replacement driver typically costs carriers several thousand dollars per incident.

The relationship between driver costs and total transportation spend is therefore not simply a matter of hourly wages. It encompasses the full lifecycle cost of maintaining a qualified, stable workforce, which has become one of the more intractable challenges in modern logistics

Table 3. ATRI Trucking Cost Breakdown by Component: 2023 vs. 2024 (United States)

Cost Component	2023 (\$/mile)	2024 (\$/mile)	Change
Driver Wages	\$0.799/mile	\$0.779/mile	+2.4%
Fuel	\$0.553/mile	\$0.483/mile	−12.7%
Truck & Trailer Payments	\$0.360/mile	\$0.390/mile	+8.3%
Driver Benefits	\$0.188/mile	\$0.197/mile	+4.8%
Repair & Maintenance	\$0.202/mile	\$0.198/mile	−2.0%
Insurance Premiums	\$0.099/mile	\$0.101/mile	+2.0%
Tires	\$0.046/mile	\$0.046/mile	0.0%
Tolls	\$0.020/mile	\$0.020/mile	~0.0%
TOTAL	\$2.270/mile	\$2.260/mile	−0.4%

Source: American Transportation Research Institute (ATRI), An Analysis of the Operational Costs of Trucking — 2024 & 2025 Updates. [truckingresearch.org](https://www.truckingresearch.org)

7. INFRASTRUCTURE AND MAINTENANCE

The quality of the infrastructure a carrier uses directly affects operating costs. Poor road surfaces accelerate tire wear, increase suspension stress, and raise the frequency of unscheduled repairs. Congested ports slow container throughput, forcing vessels to wait at





anchor and adding demurrage charges. Aging bridges impose weight restrictions that force detours, adding distance and fuel consumption.

Vehicle maintenance itself is a substantial and growing cost category. ATRI reported repair and maintenance costs of 0.198 dollars per mile in 2024, representing one of the more stable cost components in recent years but still meaningfully higher than a decade ago. Trucking fleets with newer vehicles tend to have lower per-mile maintenance costs, partly because modern trucks benefit from longer warranty coverage and more reliable components. In 2024, the average age of U.S. combination trucks fell to 3.4 years, which contributed to a modest decline in repair costs.

Truck and trailer payments, which include leasing and purchase financing costs, rose 8.3 percent to 0.39 dollars per mile in 2024 — a 70 percent increase since 2015. Equipment inflation, combined with higher interest rates on financing, has made fleet expansion and replacement more expensive for carriers of all sizes, particularly smaller operators with limited capital access.

8. REGULATIONS, COMPLIANCE, AND INSURANCE

Regulatory requirements shape transportation costs in multiple ways. Hours-of-service rules limit how many consecutive hours a truck driver can operate, reducing the distance a single driver can cover per day and influencing how many drivers are needed per route. Electronic logging devices, now mandatory in the United States, enforce these rules automatically and have reduced the informal workarounds that some carriers previously used to extend driver hours.

Environmental regulations are adding cost pressure across all modes. Emissions standards for trucks have pushed manufacturers toward cleaner but more expensive engine technologies. The International Maritime Organization's sulfur emissions caps have required ocean carriers to either use low-sulfur fuel or install scrubber systems, both of which add cost. Customs and import duty requirements on international shipments create administrative expense and, in some cases, delays that translate directly into cost.

Insurance is a category that received particular attention in ATRI's 2024 report: trucking insurance premiums rose 12.5 percent to 9.9 cents per mile in 2023, the largest single-year jump in recent years. The increase reflected rising claims costs, higher vehicle replacement values, and concerns about nuclear verdicts in commercial truck accident litigation. This trend is unlikely to reverse quickly, as the underlying cost drivers in the insurance market remain elevated.

9. MARKET DEMAND, SEASONALITY, AND GEOPOLITICAL DISRUPTIONS

9.1 Demand Cycles

Transportation costs are not fixed; they move with the market. When economic activity accelerates and retailers are restocking, carrier capacity fills up quickly and rates rise. Peak seasons around major holidays consistently push freight costs 5 to 10 percent above baseline rates as the balance of power shifts toward carriers. Conversely, during freight recessions when industrial output slows, rates fall as capacity exceeds demand. The period from 2023 to





2024 exemplified this pattern: after the pandemic-era surge drove spot rates to historic highs, a prolonged freight recession pushed rates back down and squeezed carrier margins severely.

9.2 Geopolitical Shocks

Geopolitical events can dramatically disrupt transportation costs in ways that market forces alone do not anticipate. The most striking recent example came from the Red Sea crisis: disruptions to shipping lanes through the Suez Canal in 2024 forced container ships to reroute around the Cape of Good Hope, adding approximately two weeks of transit time and substantial fuel costs. Ocean freight rates more than doubled during this period⁷ as available capacity effectively shrank while demand remained constant.

The OECD's international transport and insurance costs database (ITIC) documented the broader trend: globally, CIF/FOB margins, which measure the ratio of international transport and insurance costs to the value of traded goods, increased to 4.9 percent in 2022, up from an average of 4.3 percent in the pre-pandemic period of 2015 to 2019. The Pacific region experienced the most extreme jump, with margins rising from 3.7 percent in 2019 to 6.2 percent in 2022.

Natural disasters produce similar effects on a regional scale. During Hurricane Milton in 2024, freight rates in affected areas surged as carriers faced fuel shortages, infrastructure damage, and capacity disruptions. Climate projections suggest such events will become more frequent, meaning that logistics cost models must build in increasingly larger buffers for disruption.

10. TECHNOLOGY AND ITS EFFECT ON COSTS

Technology is reshaping transportation costs, sometimes by reducing them and sometimes by creating new expense categories. Route optimization software, real-time tracking, and AI-driven load matching all improve asset utilization, reducing empty miles and improving fuel efficiency. In 2024, ATRI reported that empty miles averaged 16.7 percent for U.S. truckers — a significant waste of capacity that better matching platforms are gradually eroding. Automation in warehouses reduces handling costs at origin and destination points, contributing to the overall reduction in total logistics expense even where transportation costs remain stable. Blockchain-based documentation streamlines customs processes, reducing administrative costs and border delays. Electric vehicles, still a small fraction of the commercial fleet, promise to decouple transportation costs from diesel price volatility — though the upfront capital cost remains a barrier to rapid adoption. The global logistics automation market reached 65.25 billion dollars in 2023 and is expected to grow at 12.8 percent annually through 2033. That growth trajectory reflects the industry's recognition that technology investment is increasingly a competitive necessity rather than an optional enhancement.

11. STRATEGIC RESPONSES FOR LOGISTICS MANAGERS

Given the complexity of transportation cost drivers, no single strategy addresses all of them. Effective cost management requires a portfolio of approaches calibrated to the specific characteristics of each company's freight profile.





Consolidating shipments is one of the most universally applicable tools. A full truckload costs less per unit than a partial load because fixed costs, including driver wages, fuel for the base trip distance, and equipment, are spread across a larger volume. Companies that ship small quantities frequently can often reduce costs significantly by batching orders into less frequent, fuller loads.

Modal optimization, choosing the right transport mode for each shipment based on time requirements, distance, and cargo type rather than habit or convenience, can produce substantial savings. For land-based shipments over 500 miles with flexible timelines, intermodal rail-truck combinations frequently undercut pure trucking costs by 40 percent or more. Many shippers default to trucking simply because it is familiar, leaving real savings on the table.

Long-term carrier contracts with fixed or capped rate structures protect against spot market volatility during peak periods, at the cost of potentially paying above spot during soft markets. The appropriate balance depends on a company's risk tolerance and freight volume predictability. Carriers, for their part, increasingly offer technology partnerships, load visibility platforms, and collaborative forecasting as part of contract relationships, adding non-price value that pure spot-market relationships cannot replicate.

Network design, the placement of distribution centers and warehouses relative to customers and suppliers, is perhaps the most powerful lever of all because it affects transportation costs structurally rather than transactionally. A well-designed network minimizes average distance traveled, reduces last-mile exposure, and enables more efficient carrier routing across all shipments. The cost of designing and relocating a network is significant, but the ongoing transportation savings typically justify the investment within a few years.

12. CONCLUSION

Transportation costs in logistics are shaped by a web of interrelated factors, none of which operates in isolation. Fuel prices set the daily baseline and can shift it dramatically within weeks. Distance and route complexity determine the structural cost of any given movement. Cargo characteristics add layers of premium or penalty depending on weight, density, and special handling needs. The choice of transport mode can multiply or divide costs by a factor of four or more for the same origin-destination pair.

Labor, infrastructure, regulations, insurance, market demand, and geopolitical disruptions all add further volatility and structural pressure. The ATRI data makes clear that even in a year when fuel costs fell, total trucking costs remained near record highs in 2024 because non-fuel expenses continued to rise. This pattern underscores a critical point: businesses that focus only on fuel when modeling transportation costs will consistently underestimate their exposure.

The good news is that the factors driving transportation costs are increasingly well documented, and the tools to manage them are improving. Route optimization, intermodal shipping, network design, carrier collaboration, and technology investment each offer proven pathways to lower costs without sacrificing service levels. Companies that invest in





understanding their transportation cost drivers and responding systematically will hold a durable competitive advantage over those that treat freight as an uncontrollable overhead.

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