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International vehicle transportation: The impact of globalization on logistics and shipping

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Abstract

This article explores the impact of globalization on cross-border vehicle logistics and the key parameters influencing transportation efficiency. The relevance of the topic is underscored by the rapid expansion of international markets and the growing volume of export-import operations. The novelty of this study lies in its comprehensive examination of regulatory requirements, technical standards, and financial factors shaping the overall cost structure. The research outlines mechanisms of customs regulation, principles of safe cargo placement and securing during maritime and road transportation. The analysis draws on sources that include international codes, global trade statistics, and case studies from major markets. Particular attention is given to the examination of barriers related to environmental and certification standards, as well as the influence of technological innovations on transport processes. The methodological foundation is based on a systems approach and comparative analysis. The conclusion reveals the dynamics of cost fluctuations under economic shocks and presents practical strategies to mitigate risks. This study will be of value to logistics professionals, automotive manufacturers, and researchers of global supply chains. It provides detailed coverage of customs requirements in leading import markets, including the United States and the European Union, and references the CTU Code and VCSF Guidelines standards. Additionally, it considers the prospects for the digitalization of global logistics and offers forward-looking projections.

Keywords: Globalization; International logistics; Automotive industry; Customs regulation; Technical standards; CTU Code; VCSF Guidelines; Transport safety; Cost; Export

1. Introduction

The volume of international car trade continues to grow steadily. In 2023, the total value of exported passenger vehicles worldwide reached approximately USD 958.7 billion, representing a 25.1% increase compared to five years earlier (USD 766.3 billion in 2019). This growth reflects heightened global demand and deeper integration of international automotive supply chains. Automobiles have secured the fourth position among the most exported product categories—following crude oil, refined petroleum products, and integrated circuits—and account for approximately 4.1% of the total value of global merchandise exports . Global logistics networks have become crucial for the automotive sector: vehicle manufacturing is increasingly distributed across countries, necessitating a reliable system for transporting finished vehicles to consumers around the world.

However, large-scale international vehicle transportation involves numerous requirements and complexities. Compliance with international transportation standards is essential to ensure cargo integrity, human safety, and environmental protection. Countries impose their own customs regulations and technical requirements on imported vehicles, ranging from taxes and duties to environmental and safety standards. Global developments such as trade liberalization, the emergence of major new exporters (e.g., China's growing share), and technological trends (electric vehicles, logistics digitalization) have a direct impact on the structure and cost of vehicle transportation. Furthermore,

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the international logistics of vehicles is highly sensitive to external factors—economic cycles, pandemics, geopolitics (sanctions, trade wars)—all of which can disrupt supply chains and alter cost structures.

The relevance of this study stems from the fact that understanding these aspects enables market participants—including automakers, logistics companies, and regulators—to optimize supply chains, ensure regulatory compliance, and reduce costs. As the share of export-import operations involving vehicles continues to rise (for instance, in 2023, car exports accounted for over 51.9% of the market for the top five exporting countries), a comprehensive analysis of logistics is becoming increasingly necessary .

The aim of this article is to examine how globalization affects the logistics and transportation of vehicles in international contexts. To achieve this, the following research objectives are addressed:

- To examine international standards and regulations governing vehicle transportation between countries;
- To identify the influence of global trends (market expansion, shifts in production geography, new technologies) on transport organization;
- To analyze the characteristics of customs regulation in vehicle import/export operations and associated barriers;
- To evaluate the cost structure of vehicle logistics and the factors influencing global expenses;
- To outline safety requirements and risks in international vehicle transport, as well as mitigation measures

2. Material and methods

This study is based on an analysis of contemporary international regulatory documents, industry reports, and statistical data reflecting the current state of vehicle transportation. The materials include international standards and agreements governing cargo transportation, such as the 2014 Code of Practice for Packing of Cargo Transport Units (CTU Code) developed by the International Maritime Organization (IMO) in collaboration with the International Labour Organization (ILO) and the UNECE, as well as the 2024 Vehicle Carrier Safety Guidance—new industry guidelines on safe vehicle transport . Data from the World Trade Organization and trade statistics databases (UN Comtrade, Tendata) were also examined, along with reports from international logistics associations (e.g., the International Chamber of Shipping, International Road Transport Union) , and scholarly publications and expert reviews on global automotive supply chains.

Methodologically, this research takes the form of a descriptive-analytical review. Comparative analysis was employed to contrast requirements across countries (e.g., U.S. vs. EU customs regulations), and a systems approach was used to examine the entire logistics chain from manufacturer to end importer. Statistical series of vehicle export/import by country and the dynamics of transportation costs were analyzed. A case study element was also incorporated, focusing on the specifics of vehicle imports into the United States as one of the world's largest markets, including safety requirements, duties, and related factors.

3. Results and discussion

3.1. Global Trends in Car Trade and Transportation

The analysis indicates that the global car market is becoming increasingly international. The volume of international vehicle transport has grown in parallel with rising exports from manufacturing to consumer countries. While traditionally, the leading exporters of automobiles were industrialized nations such as Germany, Japan, and the United States, the past decade has witnessed a notable shift with the emergence of powerful new exporters. China, in particular, has experienced a dramatic rise—from playing virtually no role in the early 2000s to becoming a global leader. In 2022, China exported 3.2 million vehicles, surpassing Germany (2.6 million) . By 2023, China had become the world's largest vehicle exporter by volume, shipping 4.4 million vehicles abroad—a 58% increase from the previous year—overtaking Japan (3.99 million) . Figure 1 shows the top five countries by car export value in 2023, with China ranking third after Germany and Japan.

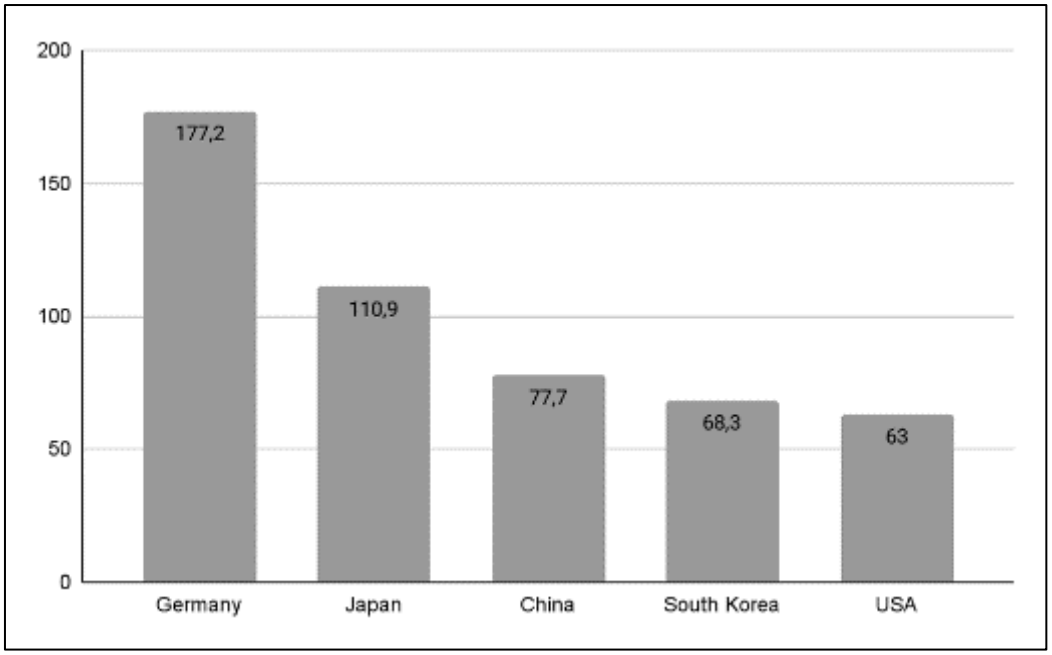

Figure 1 Export Value of Passenger Vehicles by Leading Countries in 2023, USD billion (Source: calculated from Tendata)

Globalization has led to regional specialization. For instance, the mass production of affordable vehicles has shifted to countries with lower labor costs—such as China, Mexico, and Thailand—while premium brands are still manufactured in Europe, Japan, and the United States. However, even premium vehicles are increasingly assembled in overseas plants for subsequent re-export.

3.2. International Standards and Agreements for Car Transportation

To ensure safe and efficient vehicle logistics, universal standards have been developed and adopted worldwide. A central document in this context is the Code of Practice for Packing of Cargo Transport Units (CTU Code), last updated in 2014 by the IMO, ILO, and UNECE. This code provides comprehensive guidelines for the proper loading and securing of cargo—including vehicles—in containers and trailers across all modes of transport. The application of the CTU Code significantly reduces the risk of vehicle damage during transportation and enhances overall safety. Studies have shown that companies implementing the CTU Code have achieved notable cost reductions, with annual incident-related expenses dropping from €670,000 to €13,000 following adoption . In this regard, standardization of packing and securing processes delivers clear economic benefits.

Another key document is the newly issued Vehicle Carrier Safety Guidelines (2024), developed by the Vehicle Carrier Safety Forum (VCSF) with support from the International Group of Pand I Clubs and the International Chamber of Shipping . These guidelines consolidate best practices for preparing vehicles for maritime transport and securing them on roll-on/roll-off (ro-ro) vessels. They are particularly relevant in light of new challenges: the increasing share of electric and large hybrid vehicles in shipping volumes has shifted the risk profile. The guidelines emphasize that the greater weight of electric vehicles must be accounted for during vessel load planning and that fire safety measures must be revised due to the combustion risk posed by lithium-ion batteries. The proactive adoption of these guidelines by shipping companies demonstrates the industry's commitment to self-regulation and improving operational safety.

Beyond maritime transport, several international agreements facilitate vehicle transport by road. The TIR Convention simplifies customs transit for international car transport on car carriers, while the CMR Convention standardizes transport documentation across much of Europe (see Table 1).

Table 1 Main International Regulations in Car Transportation (Source: compiled by the author based on original research)

Regulation / Convention	Focus Area	Effective Regions
CTU Code (2014)	Correct cargo loading and securing	Global
TIR Convention	Simplified customs transit	77 contracting parties
CMR Convention	Standardized transport documents	Most European countries
VCSF Guidelines (2024)	Safety in transporting vehicles	Maritime sector

All these instruments aim to harmonize requirements across countries, thereby facilitating global logistics operations.

3.3. Customs Regulation and Requirements for Imported Vehicles

When crossing international borders, vehicles are treated as commercial goods and are therefore subject to customs regulations, which vary significantly from country to country. One of the strictest examples is the United States—the world's largest car importer—which imposes stringent safety and environmental requirements on imported vehicles. According to the U.S. National Highway Traffic Safety Administration (NHTSA), vehicles less than 25 years old may not be permanently imported unless they meet all applicable Federal Motor Vehicle Safety Standards (FMVSS). This so-called "25-year rule" effectively prohibits the importation of modern models not originally manufactured for the U.S. market, except through a costly modification process conducted by a certified importer. For example, popular Japanese sports cars can only be legally imported into the U.S. once they reach 25 years of age, which has given rise to a niche "vintage import" market. In addition, U.S. regulations require specific engine markings confirming compliance with Environmental Protection Agency (EPA) emission standards, reinforced bumpers, and anti-theft systems for vehicles manufactured after 1987 .

In addition to technical requirements, customs duties and taxes are levied on imported vehicles. In the U.S., the base tariff on passenger cars is 2.5% of the value, while pickups and trucks are subject to a 25% duty—the so-called "chicken tax." In the European Union, the common external tariff on passenger cars from non-EU countries has traditionally been 10%, although these rates are gradually reduced or eliminated under free trade agreements (FTAs), such as the EU-Japan agreement. Variations in tariff rates and regulatory standards encourage automakers to localize production in major markets—for example, building factories in the U.S. to avoid the 25% tariff on pickups—or to exploit loopholes in rules of origin provisions in trade agreements (see Table 2).

Table 2 Tariff Rates and Technical Requirements in Selected Markets

Country/Region	Base Tariff on Passenger Cars	Technical Requirements
USA	2.5%	Must comply with FMVSS, 25-year rule
EU	10% (gradual reductions in FTAs)	Requires EU type-approval
Japan	0%	Conformity with safety standards
Australia	5% (some exemptions)	Strict biosecurity inspections

Another critical aspect involves vehicle cleanliness and safety at the point of import. Many countries enforce strict quarantine regulations. For instance, the U.S. requires that the underside of vehicles be cleaned of soil and organic matter prior to shipment in order to prevent the introduction of harmful pests and plant species. Australia and New Zealand maintain even stricter biosecurity protocols: imported vehicles undergo thorough inspections for insects—especially the brown marmorated stink bug—and, if necessary, are subjected to fumigation. Moreover, to prevent smuggling, customs authorities generally prohibit placing personal belongings inside vehicles during maritime transport. Otherwise, the vehicle may be classified as a container shipment, complicating customs procedures.

Therefore, logistics companies must manage not only the transportation itself but also the vehicle's preparation for import, including washing, cleaning, and documentation (such as transit plates and certificates of environmental compliance). Failure to comply may result in border delays, fines, or even denial of entry for the shipment.

3.4. Logistics Costs and the Impact of Global Processes on Expenses

Globalization has generally contributed to reducing the unit cost of vehicle transportation by enabling economies of scale and advancing infrastructure development. Nonetheless, logistics costs remain highly sensitive to global market conditions and external shocks. Structurally, the cost of international vehicle transport includes freight charges (by sea, rail, or car carrier), port fees, insurance, customs duties and taxes, documentation and brokerage costs, as well as domestic logistics within the countries of origin and destination.

Recent years have seen sharp fluctuations in transportation expenses. During and immediately after the COVID-19 pandemic (2020–2022), global supply chains experienced an unprecedented spike in maritime shipping costs. Freight rates for car carriers (ro-ro vessels) and container ships soared due to capacity shortages and scheduling disruptions. Reports noted that, at the height of the pandemic, daily earnings for car carriers reached $80,000—the highest level since 2000. Shipping rates rose four to five times above pre-pandemic levels. For instance, in 2022, the cost of transporting a single passenger vehicle by sea averaged around $3,700, compared to approximately $740 before the pandemic . This surge in logistics costs had a negative impact on automakers: major companies such as GM and Ford reported that expensive transportation became a significant new factor influencing vehicle pricing and delivery timelines.

Global disruptions and crises also affect cost dynamics. A notable example is the blockage of the Suez Canal in March 2021, which delayed hundreds of vessels, leading to a temporary shortage of car carriers in other regions and a spike in freight rates. Rising fuel prices—for example, the jump in marine fuel costs following the introduction of the IMO 2020 low-sulfur regulations—were passed on to customers through Bunker Adjustment Factors (BAF) . Trade wars and tariff hikes, such as the reciprocal U.S.-China tariffs on automobiles in 2018–2019, also drove up costs for importers or forced them to seek alternative supply routes.

At the same time, globalization has enabled cost optimization through the development of specialized transportation systems. New-generation ro-ro vessels can carry up to 8,000 vehicles per voyage, achieving cost efficiency through scale. Specialized port terminals automate the handling of vehicle cargo, reducing dwell times. Information systems and tracking technologies (trackers, electronic navigation maps) support efficient delivery planning, minimizing storage and transshipment needs. Major automakers have established regional distribution centers and hubs—for example, European parts consolidation centers in France that supply assembly plants in Africa —enhancing the predictability of finished vehicle logistics.

Cost analysis shows that under normal conditions, transporting a car by sea from Japan to Europe typically costs around $1,000–$1,500, including inland transportation to and from ports. Air freight, in contrast, is many times more expensive and is used only for high-value vehicles or urgent deliveries . Global competition compels logistics providers to reduce expenses by seeking optimal routes—such as shipping to Europe via the port of Bremerhaven, with subsequent redistribution to individual countries via smaller vessels—or by consolidating shipments, where multiple manufacturers jointly charter a vessel to transport batches of their vehicles. At the same time, seasonal fluctuations and speculative market effects can influence pricing. For instance, automotive exports tend to increase in the fall (driven by new model releases and the holiday season in the U.S.), which can temporarily raise rates due to heightened demand. All these factors make logistics costs highly dynamic, requiring constant monitoring and strategic planning.

3.5. Safety and Security Requirements in International Vehicle Transportation

The transportation of vehicles involves multiple risks, including cargo damage, accidents, and—in the case of maritime shipping—potential environmental threats such as fuel leakage from damaged vehicles. As a result, strict safety measures are applied throughout the entire logistics chain. Maritime transport using roll-on/roll-off (Ro-Ro) vessels requires careful securing of vehicles on deck: each vehicle is fastened with straps or chains to designated anchoring points, preventing movement due to vessel rolling. International regulations, including the aforementioned CTU Code and the SOLAS Convention (International Convention for the Safety of Life at Sea), define methods for securing cargo and establish limits for weight and load distribution.

The new VCSF 2024 guidelines pay special attention to electric vehicles. They recommend increasing the spacing between EVs during stowage to prevent fire spread in the event of battery ignition, and crew members are trained in battery fire response. Transporters also minimize fuel levels in vehicle tanks (typically below one-quarter full) and disconnect batteries to reduce the risk of leaks and electrical short circuits .

On road car carriers and rail platforms, safety is ensured through a combination of structured loading—vehicles are stacked in multiple tiers using specialized racks or trailers—and wheel securing with chocks. EU and U.S. standards

regulate the strength of such restraints under conditions of acceleration and braking. Furthermore, unloading protocols require that only professional drivers or trained logistics personnel handle vehicle loading and unloading to prevent accidents at terminals. Insurance requirements are also in place: under the CMR Convention, the liability of road carriers is limited to around €10 per kilogram, prompting shippers to obtain additional insurance coverage for high-value vehicles to cover their full value.

Another critical aspect is personnel safety and damage prevention. On port terminals, vehicles are moved at minimal speeds, and a strict loading/unloading sequence by deck and row is enforced to avoid collisions. Modern technologies aid in control and monitoring: some shipping companies attach RFID tags to vehicles during loading, allowing real-time tracking of their location on board and logging of any movement. Video surveillance systems and sensors are also being deployed in cargo holds to detect issues such as smoke early. Environmental conditions during transit are taken into account as well: moisture-absorbing materials are used in containers to prevent condensation, and Ro-Ro vessels are equipped with ventilation systems in cargo decks to disperse fuel vapors.

Finally, the issue of theft and fraud protection is also critical. There have been instances of attempts to steal high-end models or swap components during international transportation. To counteract this, shipping containers are sealed and locked, valuable vehicles are equipped with GPS trackers, and inspection procedures upon arrival are enforced, including VIN number verification and photographic documentation before and after shipment. International agreements, such as the Carnet de Passages system (used for temporary vehicle imports for rallies or travel), include built-in guarantees to ensure that transported vehicles are either returned or properly cleared through customs.

Taken together, these findings show that globalization has led to a sharp increase in international vehicle transportation while simultaneously driving the development of a comprehensive system of standards, requirements, and best practices to support and secure this complex logistics process

4. Conclusion

The findings of this study confirm that globalization has had a profound impact on the development of international vehicle transportation, accelerating the scale of operations while adding complexity to logistics processes. The analysis of international transport standards and customs regulations revealed substantial differences in requirements, particularly between major markets such as the United States and the European Union. A high degree of procedural standardization—through instruments like the CTU Code and VCSF Guidelines—has contributed to cost reduction and improved cargo safety. However, the increasing volume of electric vehicle shipments has necessitated additional risk mitigation measures related to batteries and fire hazards, as reflected in the updated 2024 guidelines.

It was found that the structure of logistics costs is highly responsive to external economic shocks: the COVID-19 pandemic and the Suez Canal blockage triggered sharp fluctuations in freight rates. Despite advancements in technology and infrastructure, international vehicle logistics remains a costly sector that is sensitive to market conditions. Nevertheless, companies are leveraging digital tools, regional hubs, and specialized car carriers to optimize expenditures.

The practical value of this study lies in the systematization of factors that determine the efficiency of international vehicle transportation. The conclusions drawn may serve as actionable recommendations for automakers and logistics providers in planning export-import operations and ensuring the safe transport of vehicles amid global uncertainty.

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