

**COMPARATIVE ANALYSIS AND ADAPTATION FRAMEWORK FOR INTERNATIONAL WARRANTY STANDARDS TO U.S. COMMERCIAL REQUIREMENTS: MITIGATING FINANCIAL RISKS IN THE SUPPLY OF HEAVY-DUTY COMPONENTS**

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**Abstract.** This study integrates a comparative legal analysis of EU and US statutes with supply chain gap analysis to identify critical bottlenecks in cross-border warranty processing, regarding reverse logistics, labor cost inflation and defect verification latency. The analysis reveals that traditional parts-only reimbursement models are commercially unviable within the US market. To address this, the article proposes a hybrid alignment strategy - a methodological framework that harmonizes European operational prudence with American commercial demands. Key components include the implementation of capped labor reimbursement models based on standard repair times, the adoption of scrap-in-field protocols for low-value components and the deployment of a centralized digital ecosystem for evidence-based adjudication. The implementation of these standardized protocols transforms warranty management from an unpredictable cost center into a strategic instrument for financial hedging. By automating claim triage and enforcing objective verification standards, suppliers can optimize working capital, mitigate fraud risks and secure a competitive advantage in the transatlantic supply chain.

**Key words:** hybrid alignment strategy, transatlantic supply chain, warranty, logistics, aftermarket.

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### Introduction:

In the automotive industry, expansion into the North American market represents a critical strategic imperative for European independent aftermarket (IAM) manufacturers. However, this cross-border integration exposes suppliers to significant commercial risks that extend beyond logistics and engineering. A European supplier entering the US commercial sector encounters a market, where warranty is a comprehensive financial instrument expected to indemnify the client against operational downtime and ancillary losses.

This divergence creates a fundamental compliance gap. European manufacturers, traditionally operating under limited liability directives (such as Directive (EU) 2019/771), often struggle to adapt to the litigious and service-intensive demands of US fleet operators. Therefore, the absence of a harmonized warranty strategy results in significant margin erosion driven by unverified claims, inflated labor costs and inefficient reverse logistics.

Despite the financial magnitude of this issue, existing literature often treats warranty management as a purely legal or engineering concern, overlooking its key role in supply chain finance and operational efficiency. The proposed hybrid alignment strategy is a methodological framework designed to bridge European operational prudence with American commercial expectations. By analyzing regulatory disparities between the EU and the US, identifying key friction points in transatlantic logistics, and outlining a digital ecosystem for evidence-based adjudication, this study demonstrates how standardized warranty protocols can be transformed from a cost center into a strategic asset for financial risk mitigation and competitive advantage.

The relevance of this study is underscored by the critical strategic imperative for IAM manufacturers to expand their footprint within the North American market amidst the increasing globalization of supply chains. This research addresses the acute compliance gap between the European model of limited warranty liability and the American commercial practice of full indemnification, which includes coverage for asset downtime. The significance of this work is further amplified as it shifts the analytical focus from the traditional view of warranty as a purely legal or engineering concern to the domain of financial risk management and operational efficiency.

In an environment where the absence of a harmonized strategy results in margin erosion and logistical inefficiencies, the proposed framework for standard adaptation emerges as a key instrument for maintaining the competitiveness and financial resilience of suppliers engaged in transatlantic trade.

The limitations of this study are inherent to its qualitative design and specific geographic and sectoral scope. The analysis is exclusively focused on the transatlantic vector (EU exports to the US) and the specificities of the commercial segment (B2B/fleets) within the heavy-duty component market, which may constrain the generalizability of the findings to other regions or the B2C segment. The methodology is predicated on theoretical modeling and the utilization of secondary data sources, including legislative statutes and industry standards such as Mitchell 1 and MOTOR. Consequently, the proposed strategy represents a theoretical framework whose efficacy is analytically substantiated. The study does not present longitudinal empirical data validating the quantitative outcomes of implementing this model within specific enterprises over an extended period.

### Materials and methods:

This study employs a qualitative, multi-stage research design combining comparative legal analysis with supply chain process re-engineering. The primary objective is to identify structural inefficiencies in cross-border warranty management and to develop a unified operational framework [1].

The research methodology is structured into three distinct phases: regulatory and commercial benchmarking, operational gap analysis and strategic model formulation. The

comparative analysis is anchored in the primary legislative texts regulating warranty obligations within the target geographies. In the European context, the study examines Directive (EU) 2019/771 [2]. For the United States context, the analysis focuses on the Uniform Commercial Code (UCC), specifically Article 2, and the Magnuson-Moss Warranty Act [3].

Secondary data sources include industry-standard labor time norms, Mitchell 1 and MOTOR, which serve as the baseline for the proposed capped labor reimbursement model [4]. Need to say, that the standard OEM warranty policies were analyzed to establish the gold standard regarding the commercial expectations of fleet operators [5].

A systematic gap analysis was conducted to juxtapose the limited liability model, prevalent in the European independent aftermarket (IAM), against the indemnification model required by the US commercial sector [6]. The analysis mapped the entire warranty lifecycle to identify critical friction points - from claim initiation to financial settlement [7]. Key variables assessed included: liability scope, reverse logistics protocols and verification methodologies.

Based on the identified discrepancies, a hybrid alignment strategy was synthesized. This theoretical model integrates principles of financial risk management with digital transformation. The architecture of the proposed ecosystem was designed utilizing Business Process Model and Notation (BPMN) principles to ensure interoperability between supplier ERP systems and external databases [8].

Benchmarking warranty policies: a comparative study of EU, US and international OEM approaches:

Within the context of transatlantic supply chains, warranty obligations evolve beyond simple legal compliance, transforming into a sophisticated instrument for financial risk management and competitive positioning [9]. To develop a unified warranty system, it is imperative to deconstruct the fundamental divergences in the regulatory frameworks and commercial expectations of three nodal clusters: the European Union, the United States and global OEM standards.

The discrepancies between European and American approaches originate at the legislative level, shaping distinct expectations for both end-consumers and B2B partners. The European model is characterized by its strict regulatory nature, predicated on consumer protection directives such as Directive (EU) 2019/771. The cornerstone of this framework is the concept of conformity of goods, meaning supplier liability is often confined to remedial actions intended to restore conformity, typically limited to the repair or replacement of the physical component [10]. Accordingly, in the independent aftermarket (IAM) B2B segment, European suppliers traditionally adhere to a conservative parts-only reimbursement model that frequently excludes coverage for ancillary costs [11].

On the other hand, the US ecosystem is defined by a highly litigious environment and aggressive enforcement of contractual obligations under the Uniform Commercial Code (UCC) and the Magnuson-Moss Warranty Act [12]. Here, the dominant legal concept is the "Implied warranty of merchantability" [13]. A critical distinction lies in market expectations, as the commercial segment, specifically fleet operations, views warranty as an insurance policy against asset downtime. This exerts substantial pressure on suppliers to cover the replacement part and also consequential damages, including towing services and labor costs [14].

Amidst these regional differences, international OEM establish the industry benchmark - a standard that the aftermarket strives for, but rarely attains. OEM warranties are holistic, covering 100% of the component's landed cost, dealer labor expenses based on standardized labor time guides and often administrative overheads [15]. OEM employ centralized systems

with rigorous defect codification, allowing manufacturers to leverage warranty claim data to drive continuous product improvement [16].

Ultimately, a critical misalignment exists between the limited liability models of European IAM suppliers and the expansive expectations of American commercial consumers, who are acclimated to OEM standards. Without the strategic harmonization of these approaches, with particular emphasis on the implementation of labor cost reimbursement mechanisms and claims automation, European products face elevated commercial exposure when entering the US market.

Criterion	EU independent aftermarket (IAM)	US commercial market (fleets/B2B)	Global OEM standard
Regulatory basis	Consumer protection directives (EU 2019/771)	UCC and Magnuson-Moss Act	Internal corporate policy and engineering standards
Primary philosophy	Remedial: restoration of conformity (repair/replace)	Indemnification - compensation for downtime and loss	Lifecycle management: brand protection and QA feedback loop
Liability scope	Limited to the physical component (parts only)	Broad coverage including consequential damages (towing, fines)	Comprehensive (“Bumper-to-Bumper”) + including admin fees
Reimbursement model	Unit replacement or credit for the part cost	Part cost + labor + ancillary operational costs	100% landed cost + standardized labor time guides
Data utilization	Minimal and focused on financial settlement	Focused on litigation defense and contract compliance	High - focused on engineering analysis and continuous improvement

Table 1. Comparative matrix of warranty frameworks across key geographies and sectors

Challenges and discrepancies in warranty coverage within transatlantic supply chains:

The conceptual mismatch between European and American warranty philosophies, as outlined previously, precipitates tangible operational friction when applied to real-world transatlantic logistics. This friction is most acute in three specific domains that directly impact the financial liquidity and operational efficiency of suppliers: the management of core charges, the reimbursement of labor costs and the liability associated with part failure verification [17].

The primary bottleneck involves the administration of “core charges” for remanufactured components notably calipers, starters and steering racks, which constitute a significant proportion of US aftermarket inventory. Within domestic US supply chains, the exchange of the old unit (or core) represents a rapid, low-cost cycle. However, for a European supplier exporting to the US, the core charge mechanism creates a complex liquidity constraint [18]. The prohibitive cost of reverse logistics often renders the physical repatriation of cores to Europe financially unviable, yet the failure to return them results in the forfeiture of the deposit. This dynamic engenders a latent cost structure wherein the

supplier is compelled to either absorb the loss of the core value or establish expensive local consolidation hubs in the US, thereby eroding profit margins [19].

Compounding this financial strain is the contention surrounding labor cost reimbursement. While European IAM warranties typically exclude labor coverage, the US commercial sector operates on the expectation that a warranty claim must make the fleet whole, indemnifying them for both the replacement component and the mechanic's time. The discrepancy here is methodological: unlike OEM networks that operate on fixed labor time guides (LTG), the independent sector often lacks a unified standard for repair times [20]. Hence, European suppliers are frequently exposed to inflated labor claims based on arbitrary hourly rates and excessive repair durations, without a verifiable mechanism to remotely challenge these costs.

Finally, the geographic latency inherent in transatlantic trade severely compromises the efficacy of technical liability verification. The traditional warranty process necessitates the physical return of a defective part for root cause analysis (RCA) to ascertain whether the failure resulted from a manufacturing defect or improper installation [21]. In a cross-border context, shipping a single defective unit back to the EU for analysis introduces significant delays, often exceeding 60 days. This logistical lag forces suppliers to issue goodwill credits without verification to maintain customer relations, resulting in artificially elevated "no trouble found" (NTF) rates and significant revenue leakage on invalid claims [22]. Thus, the inability to execute rapid, evidence-based adjudication constitutes a systemic vulnerability within the supply chain.

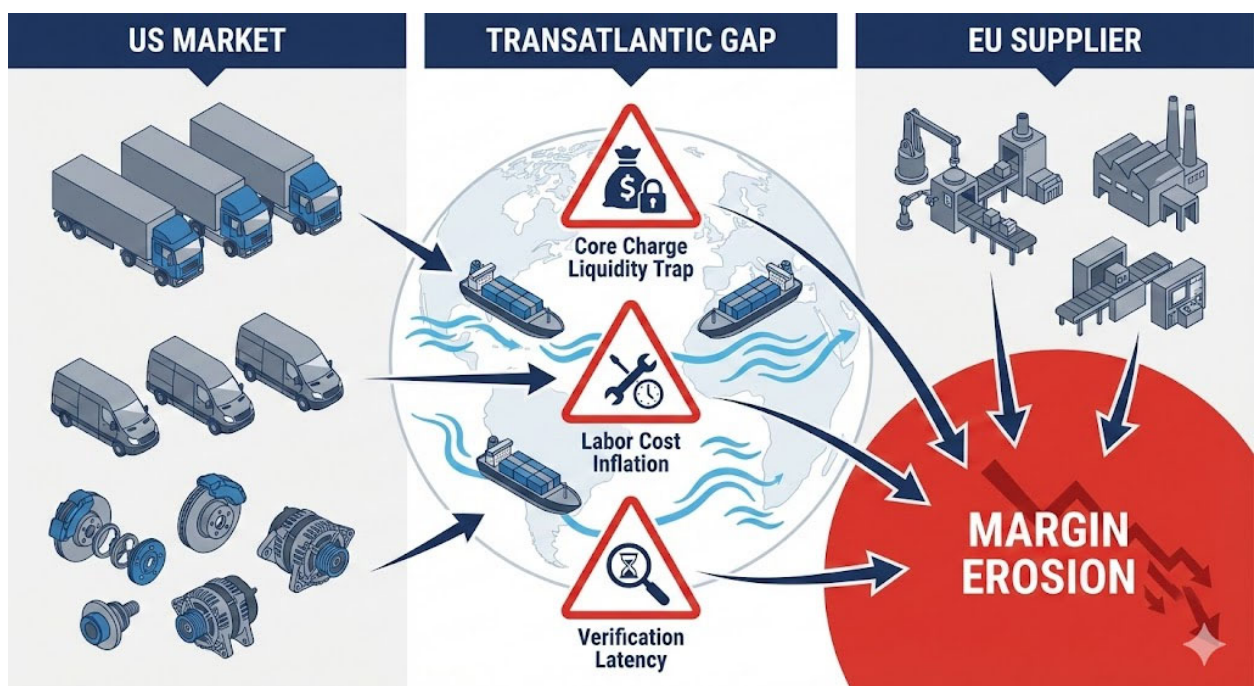


Figure 1. Transatlantic warranty friction points: visualizing the liquidity traps and verification latency in cross-border supply chains. Generative artificial intelligence and prompt were used to create the image.

Methodology for aligning warranty terms with the requirements of the US commercial sector:

To effectively bridge the gap between European operational prudence and the comprehensive coverage mandated by the US market, suppliers must execute a hybrid alignment strategy. This methodology establishes a controlled risk environment that satisfies commercial demands while safeguarding margins.

The foundational step involves the legal restructuring of the warranty offer through the implementation of a capped labor reimbursement model. Rather than adhering to a rigid parts-only policy, which is commercially unviable in the US, suppliers should agree to cover labor costs subject to strict, pre-defined ceilings. This typically involves setting a maximum hourly rate (benchmarked against regional averages) and explicitly excluding premium dealer surcharges. This approach signals to fleet customers that their operational risks are mitigated, while simultaneously insulating the supplier from open-ended financial exposure.

Parallel to rate capping, the methodology requires the standardization of repair duration through the integration of third-party labor time guides, utilizing independent industry standards such as Mitchell 1 or MOTOR. The warranty contract must explicitly stipulate that reimbursement is calculated solely based on the published standard repair time for the specific operation, rather than the actual time logged by the technician. This clause eliminates subjectivity regarding mechanic proficiency and provides an objective, data-driven baseline for claims adjudication.

Finally, to address the logistical inefficiencies identified previously, suppliers must adopt a scrap-in-field protocol for high-volume, low-value components. Under this system, the requirement for physical return is waived in favor of digital evidence of destruction (geotagged imagery of the serialized unit). The costly return merchandise authorization process is thus reserved exclusively for high-value or complex assemblies where root cause analysis is technically essential. This segmentation significantly reduces reverse logistics costs and accelerates claim settlement times [23].

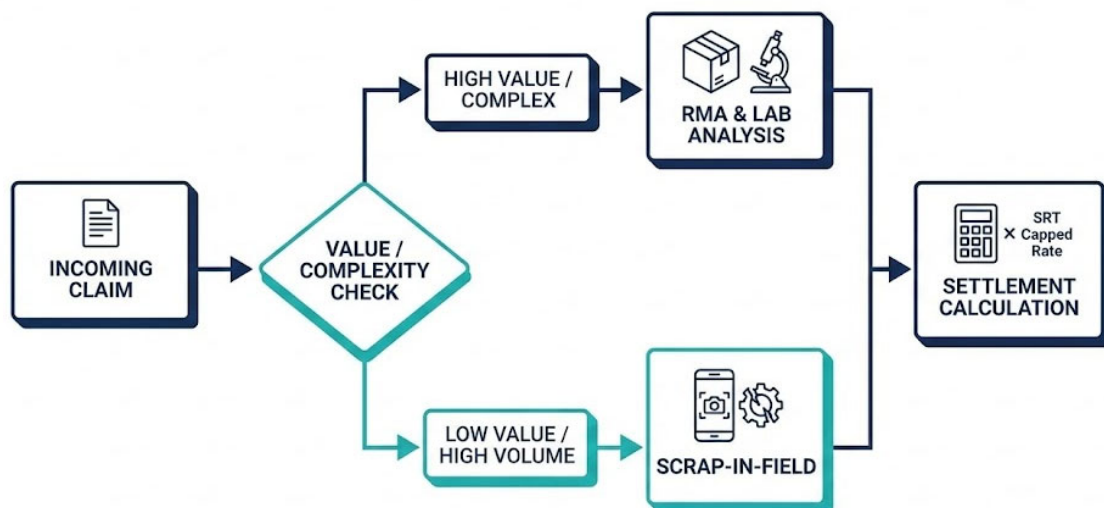


Figure 3. Warranty claim sorting protocol, which shows how the system automatically decides whether to dispose of the part on site (SIF) or return it (RMA), and how the payment is calculated

Beyond the immediate legal and operational restructuring, the efficacy of this hybrid alignment methodology is contingent upon a supporting infrastructure of digital enforcement. The deployment of centralized interfaces serves as the primary control mechanism for ensuring strict adherence to the established labor rate caps and standardized repair durations. This framework must incorporate continuous auditing loops that monitor partner compliance in real-time, facilitating the early detection of policy deviations and enabling immediate corrective intervention.

The standardization of these protocols streamlines knowledge transfer, allowing for targeted training programs that minimize variability in service execution and enhance consistency across the disparate nodes of the supply chain. Crucially, this structured

methodological approach provides a blueprint for strategic scalability, permitting the rapid extension of warranty operations into new territories or product verticals without diluting financial control or compromising service quality.

Finally, the integration of embedded analytics transforms raw claim data into actionable intelligence, offering visibility into labor cost anomalies and process bottlenecks, thereby empowering evidence-based decision-making and the continuous optimization of the management lifecycle.

Development of a transparent digital ecosystem for warranty claims management:

The practical execution of the aforementioned hybrid alignment strategy necessitates the abandonment of legacy, email-based communication in favor of a centralized, cloud-native warranty ecosystem. This digital transformation is a fundamental shift towards evidence-based adjudication [24].

The architecture of such a system must prioritize verification at the source, leveraging mobile technology to capture high-fidelity data at the precise moment of failure. By mandating claim submission through a dedicated portal or mobile interface, suppliers can enforce standardized data entry protocols, requiring claimants to upload geotagged video or photographic evidence of the defect, the Vehicle Identification Number (VIN) and odometer readings. This integration of rich media, embedded with unalterable metadata, serves as a primary layer of fraud detection, allowing the system to validate the physical presence of the vehicle and the temporal accuracy of the claim without the need for physical inspection.

Beyond this, the scalability of this ecosystem is contingent upon the implementation of automated algorithmic triage. The system should be engineered to instantly process incoming claims against a set of pre-configured logic gates derived from the warranty policy limitations established in the previous section. In this regard, the platform can utilize optical character recognition to parse labor invoices and automatically cross-reference requested hours against an integrated labor time guide API. Should the claimed hours exceed the standard repair time or the hourly rate surpass the agreed cap, the system can automatically adjust the payout offer or flag the claim for manual review. This capability enables straight-through processing for routine, low-value claims, while reserving human capital for complex, high-value disputes.

At an aggregate level, the objective of this digital infrastructure is to establish comprehensive transparency between the European supplier and the US client. By providing a real-time dashboard that displays the status of every claim, the supplier eliminates the communication void that typically breeds mistrust.

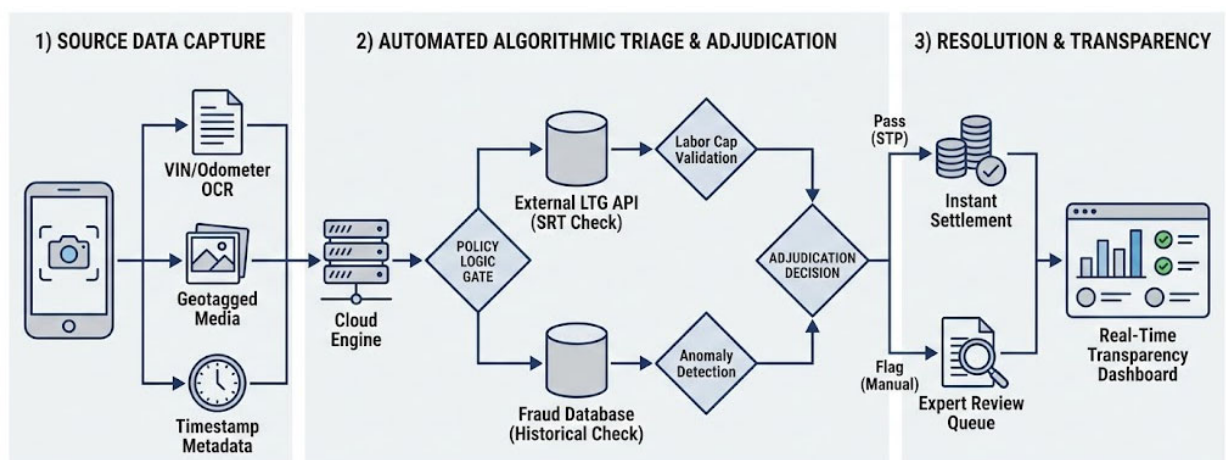


Figure 4. architecture of the digital warranty ecosystem: automated triage and evidence-based adjudication flow. Generative artificial intelligence and prompt were used to create the image.

The ecosystem's resilience is further fortified through API driven interoperability with supplier ERP environments, dealer networks and third-party logistics databases. This connectivity ensures the real-time synchronization of inventory levels, repair schedules and warranty obligations across disparate platforms. Beyond immediate operational efficiency, the aggregation of structured claim data acts as a foundation for predictive analytics, enabling the proactive identification of failure patterns and the optimization of spare parts logistics.

Integral to this design is a robust governance framework: comprehensive digital audit trails ensure adherence to trans-regional data privacy mandates, including GDPR and CCPA, while maintaining alignment with internal quality assurance protocols [25]. From a user experience perspective, the portal's interface is engineered to minimize data ingress friction, thereby accelerating submission velocity and fostering trust through workflow clarity. Also the deployment of machine learning algorithms facilitates a continuous feedback loop. By analyzing adjudication data, the platform progressively refines its automated triage logic and fraud detection heuristics, optimizing the allocation of human expertise for high-value anomalies.

Ultimately, measurable KPI, such as straight-through processing rates and settlement latency, quantify the ecosystem's ability to deliver tangible strategic value to both European suppliers and US clients. This visibility, combined with the velocity of automated settlement, transforms the warranty process from a point of friction into a value-added service, demonstrating to the US market that the supplier possesses the technological maturity to support commercial fleet operations.

Mitigating financial risks through the standardization of warranty protocols:

The culmination of this hybrid alignment strategy and digital ecosystem implementation lies in the substantial mitigation of fiscal exposure for all stakeholders within the transatlantic supply chain. By transitioning from ad-hoc, reactive claim handling to a standardized, data-driven protocol, suppliers effectively eliminate the ambiguity of arbitrage that has historically plagued cross-border transactions [26].

In the absence of standardized protocols, ambiguity regarding labor rates and defect verification inevitably favored the claimant, resulting in margin erosion through inflated payouts. However, the enforcement of capped labor rates and objective labor time guides establishes a predictable cost structure, allowing suppliers to model warranty expenses with actuarial precision rather than relying on worst-case estimates. This enhanced predictability directly improves the accuracy of warranty accrual estimation on the balance sheet, thereby preventing the unnecessary freezing of liquidity in exaggerated reserve funds and optimizing overall working capital.

Additionally, it is crucial to note that the standardization of processes significantly reduces the administrative overhead associated with dispute resolution. For B2B marketplaces and distributors, the integration of automated SIF logic minimizes the holding costs of defective inventory and accelerates the credit issuance cycle. This velocity is critical for maintaining healthy cash flow within the distribution network. Simultaneously, for US-based fleet operators, the transparency provided by the digital ecosystem functions as a risk mitigation tool against operational downtime. Knowing that warranty claims will be adjudicated fairly and rapidly based on clear, pre-agreed standards reduces the friction of switching to European suppliers, effectively removing the foreign risk premium often attached to imported components.

Complementing these operational efficiencies, the standardization of protocols acts as a robust firewall against financial malfeasance. Secure, centralized digital workflows significantly reduce the surface area for unauthorized claim manipulation and data breaches, thereby curbing unanticipated liabilities. The granularity of historical claim data facilitates

sophisticated, scenario-based financial modeling. This analytical capability allows suppliers to stress-test their liquidity positions under varying demand and failure conditions, enabling the proactive adjustment of warranty reserves.

This heightened transparency and predictability bolster the supplier’s standing with financial institutions and insurers, potentially yielding favorable credit terms and reduced insurance premiums. These harmonized procedures engender strategic flexibility, permitting rapid scalability into new transatlantic markets while maintaining a strictly controlled risk profile. Integrated financial dashboards offer real-time visibility into reserve utilization and claim velocity, empowering stakeholders to identify fiscal anomalies and execute informed, evidence-based interventions.

Ultimately, the standardization of warranty protocols transcends mere operational compliance - it serves as a strategic financial hedge. It transforms the warranty function from an unpredictable cost center into a controlled, value-generating asset that fosters trust. By harmonizing European engineering rigour with American commercial service expectations, suppliers can secure sustainable long-term partnerships, ensuring that financial risks are systematically identified, quantified and eliminated from the supply chain.

Metric	Traditional approach (reactive)	Standardized protocol (proactive)	Financial outcome
Claim cycle time	30-60 days (shipping and manual review)	<48 hours (automated/scrap-in-field)	Accelerated cash flow
Labor payouts	Variable/inflated (retail rates)	Predictable (capped rate x SRT)	Cost reduction (~15-20%)
Reverse logistics	High cost (transatlantic shipping)	Near zero (digital verification)	Margin protection
Accruals accuracy	Low (based on "worst case")	High (actuarial precision)	Working capital optimization
Inventory liquidity	Blocked by "phantom cores"	Freed (instant core crediting)	Reduced holding costs

Table 2. Financial impact of warranty standardization on supply chain stakeholders

Conclusion. The comprehensive analysis of transatlantic warranty frameworks reveals a fundamental structural misalignment between the regulatory ethos of the European Union and the commercial imperatives of the US market - the European IAM model is predicated on a remedial approach focused on restoring conformity, the US commercial sector operates on a logic of indemnification, demanding comprehensive coverage for labor costs and asset downtime.

Without strategic harmonization, this dissonance precipitates critical friction points within the supply chain: liquidity constraints in core charge management, uncontrolled labor cost inflation and verification latency due to cross-border logistics. To overcome these barriers, this study validates the necessity of a hybrid alignment strategy. This methodology compels European suppliers to evolve beyond rigid parts-only policies by adopting controlled labor reimbursement structures based on capped rates and standardized labor time guides. Also the implementation of scrap-in-field protocols for high-volume components effectively eliminates logistical latency and reduces reverse logistics costs to near zero.

A critical condition for the success of this strategy is digital transformation. The deployment of a centralized ecosystem, grounded in evidence-based adjudication (geotags, immutable metadata, API integration), allows for the replacement of subjective decision-making with automated algorithmic triage. This infrastructure minimizes fraud risks and establishes the comprehensive transparency required to build trust with US fleet operators.

As a result, the standardization of warranty processes transforms the warranty function from an unpredictable cost center into a strategic instrument for financial hedging. The transition from reactive management to proactive risk modeling enables suppliers to optimize working capital, enhance the precision of accrual estimation and eliminate the foreign risk premium. Thus, the harmonization of warranty obligations emerges as a decisive factor in securing the competitiveness of European manufacturers within the US market.

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