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From Compliance to Competitiveness; A Case Study of Tariff Classification as a Strategic Capability for Cost Optimization and Risk Mitigation at ARGO-HYTOS US

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Abstract

While accurate classification for tariffs is often viewed as just a compliance requirement for international commerce, it constitutes a fundamental element of the cost structure of the supply chain as well as the exposure to risk. This research develops an applied model for establishing the classification of tariffs as a competitive advantage through costs/resource optimization, and mitigation of risk, based on ARGO-HYTOS US (AHUS) as a case study in the hydraulic systems business. The literature relating to trade compliance, management of supply chain costs, and regulatory regimes (HTSUS, WTO, BIS EAR) sheds light on the challenges that exist when classifying complex hydraulic components under multiple tariff classifications between different tariff chapters, as well as the importance of having a strategy in place to ensure the correct classification of water hydraulic components. A four-tiered decision framework for classifying products will be presented that creates a link between accuracy of classification, improved landed cost estimates, reduced risk of penalties and compliance, and more resilient operations due to smoother border clearance times and higher quality data. This research is a single case study based on document analysis and structured evaluation of representative product families in SAP S/4HANA master data and public regulatory databases. Examples will also be presented to show how misclassification affects the amount of duty associated with products and increases the risk of penalties, while proper classification enables cost control transparency and proactive management of risk.

Keywords

Tariff Classification, International Trade Compliance, Cost Optimization, Risk Mitigation, Strategic Trade Management.

1. Introduction

Due to globalization supply chains are ever more exposed to geopolitical shifts (alliance, conflicts, sanctions etc.), cross-border trade conflicts, evolving regulatory frameworks and different economic factors. A proper tariff classification that is the process of assigning Harmonized Tariff Schedule (HTS) and Export Control Classification Numbers (ECCNs) to products for cross-border trade has often been taken to be as an administrative task which is administered for customs clearance. It is also administered to be compliant with existing law and avoid penalties. Misclassification of tariffs leads to significant operational and financial consequences, including higher tariff payments, non-compliance penalties and substantial shipment delay (Grainger, 2024). In the era of global village businesses engage in complex trans frontier commodity and service flows. Accurate tariff classification is therefore a strategic determinant of supply chain efficiency and resilience that leads to profitability and keeping up with the ever changing business environment gives the firms tactical advantages. Primarily proper tariff classification helps with a. over-or under-payment of duties; b. penalties in huge sum and regulatory investigations if underpayment is detected; c. compliance terms. A small coding error cascades into tangible and intangible properties of an organization. If applied and harmonized well, strategic advantages can be leveraged in sourcing and logistics as tariff regimes directly influence these. Higher tariff encourages firms restructure sourcing pathways that evidently shapes global value chain (Zhang et al., 2025). The excess duty imposition is often geopolitical and directed to discourage trade with certain regions. Yet it has substantial influence in the business strategies. Tariff burdens alter coordination across suppliers, manufacturers and third-party logistics providers (Hu et al., 2022). As major business functions are influenced by tariff classifications, it has the prospects to be used as a strategic tool to impact broader supply chain strategy rather than just an administrative task. This paper situates Argo-Hytos US (AHUS) as a case context. The case will illustrate the strategic implications of accurate classification in sourcing, cost saving as well as overall business performance. As AHUS sources raw materials/parts/semi-finished products from its international networks and distributes semi-finished and finished products to its global hubs, the applicable local HTS comes into effect. Being harmonized with the regulations and updated classifications thus is not just a procedural undertaking. Firm's financial performance is predominantly depended on this. For instance, the recent increase in tariffs imposed by the United States on steel and steel products of certain countries is affecting AHUS' ability to implement seamless administration, thereby necessitating that AHUS re-examine its sourcing strategies and explore additional opportunities for domestic supply sources.

AHUS manufactures and assembles hydraulic components – filtration equipment, hydraulic valves, hydraulic flow control contrivance for commercial and agricultural purposes, for which it sources bars of aluminum, steel, copper and different alloys, plastic, seal, o-rings, gaskets and different derivative components of profuse metal and non-metal compositions. These often spans multiple HTS US import chapters – chapter 39, 40, 73, 74, 84 etc. HTS classification is based on 3 factors / product attributes. i. material composition (steel, rubber, plastic, glass fiber); ii. Function

(filtration vs. sealing); iii. End-use (commercial/industrial, agriculture, automotive hydraulics, avionics, defense). AHUS products are solely for commercial and agricultural impetus. Product attributes complicate tariff determination. Such complexity cast back comprehensive industry challenges. Classification outcomes significantly affect cost structures and compliance obligations (Chae et al., 2019). At AHUS, even 2-3% divergence in duty rates for misclassification may result in substantial shifts in landed cost calculations. Such issues raise questions on operational functionality, financial strategy and impacts competitiveness in export market.

1.1. Research Objectives

The purpose of this research is to develop and show how to create a framework for understanding how tariff classification relates to global supply chain management as an organization's strategic capability. The objectives of this study are to:

a. Determine the impact of proper tariff classification on duty payments, landed costs, and total cost optimization for international trade transactions.
b. Establish how proper tariff classification can help reduce risks associated with compliance and operations such as penalties, delays, and possible violations of export control laws.
c. Provide an example of the ARGO-HYTOS US (AHUS) as a case study of how a company with multiple hydraulic product portfolios (filters, valves, seals, housings) can implement a discipline for classifying products accurately in practice.
d. Reframe tariff classification as not just a compliance obligation but rather a strategic capability that can also use digital tools for international trade compliance (for example, AI-based automated tools in combination with SAP).

The questions this paper answers are as follows-
Research Question 1: In what way does accurate tariff classification impact the customs duty payment and landed costs for a specific set of AHUS products?
Research Question 2: What is the extent to which correct tariff classification lowers an AHUS product's potential penalty exposure as compared to its associated savings from tariff duties?
Research Question 3: Using a four-tier decision framework, how does AHUS construct tariff classification as an operational skill within its supply chain?

2. Literature Review

Before actually go for the elaborate classification of the products and components of the organization, a number of previous literature were observed for reliability and references. To make sure of the impact and importance tariff classification has and identify strategic implications in operations, the literature explored few aspects with more specific manner. WCO-World Customs Organization administers the classification system and makes sure there is uniformity in the duty rates in goods and services traded internationally. More than 200 countries comply with the WCO duty classification systems. WCO introduced the baseline for a standardized Harmonized System across the globe, popularly known as HS-Harmonized System. According to this WCO-HS, global export-import follow a structured legal way of trade as it is the foundation for the duty rate imposition. WCO serves as a mean of harmonization of duty collection, trade statistics and regulatory enforcement (Grainger et al., 2018). Accurate HTS-Harmonized Tariff Schedule classification is important for –

- Duty rate determination during global trade;
- Customs regulation compliance regarding associated regions or countries;
- Tax calculations and ascertain taxes owed (organizationally);
- International trade documentation;
- Trade eligibility determination (for instance- US doesn’t trade with Syria, not even in case of humanitarian aid, US has specific rules implied for trading with China and India, again some regions are under FTA-Free Trade Agreement);

These are more applicable in global markets. Country specific and organization wise the importance are intense. Almost 20 percent goods imported in North-America are partially or fully misclassified; and the reasons behind is either complicated material description or internal organizational uncoordinated product specification (Grainger, 2024). A specified process is developed; a flow chart to keep the process in check and upgrading the chart every time

at the end step The accuracy of hydraulic (HTS) classifications has major implications for a company including: reducing shipping or border processing time, improving the business's ability to prepare for an audit (both externally and internally). It helps in avoiding tax penalties, preventing the over- or under-payment of duties; and avoiding customs penalties. Accurate classification can also assist in cost control; maintaining the reputation of one of the longest variable hydraulic manufacturers in North America since 1835; improving the overall quality of documentation provided to freight forwarders and intermediaries; supporting sourcing and production decisions; helping with landed-cost calculations; and providing steady and predictable timelines for OEM customers such as Caterpillar Inc., and John Deere. Overall, accuracy in HTS classification supports AHUS-US in cost control, compliance and thus provides with better visibility. This helps the management draw strategic path better and more efficiently. An organizational order of conducting operations becomes less complicated and manageable as tools required come handy through the following of process. Such implications strengthen strategies and positively impacts overall operational performance. A tabular presentation of literature on misclassification risks are as follows in Table 1:

Table 1. Risks of tariff misclassification

Risks	Brief Explanation	Reference
Financial Risks	Cost implications like penalty, duty overpayment, cost due to customs delay etc.	(Morini et al., 2024), (Marra De Artiñano et al., 2023a), (Grainger, 2024)
Operational Efficiency	Operational efficiency lackages caused due to wrong HTS and lack of regulatory compliance i.e. SCM interruption, strategic blind spots, data insufficiency.	(Wicaksana et al., 2025), (Małgorzata & Małgorzata, 2024), (Grainger, 2024)
Audit & Duty Assessment	Wrong HTS codes imbalance the financial strategy and leads to external and internal audit and duty reassessment; often seem as major violations involved and risky end-user trading involvement.	(Grainger, 2024), (Karklina-Admine et al., 2024), (Habib et al., 2022), (Sardana, 2024)
Resource Intensive Investigation	External audit on internal inconsistency that employs extensive resource (employees, work hours, different departments' involvement, customs brokers interventions, legal representation, goods held).	(Grainger, 2024), (Marra De Artiñano et al., 2023b), (Sardana, 2024)
Retrospective Corrections	Correcting Previous Errors like- redoing and resubmitting documents, processing refunds for overpayments, system update as future preventive measures, retroactive interest payments etc.	(Grainger, 2024), (Strati, 2018), (D'Angelo et al., 2023)
Reputational Damage	When penalties are paid, customs audits are initiated, it causes reputational damage of an organization like AHUS that has been in business for 190 years among stakeholders.	Our contribution to the study.

Tariff classification risk implications are more than just financial, it affects organizational strategies and internal discipline. Organizations trading with FTA approved countries might not avail it until the customs documentations are not in place and Country Of Origin-COO declarations match the HTS classification. So the procedure goes beyond cost and strategy repercussions; affects and questions firms' credibility in trade that is existential factor. Organizations now prioritizing trade compliance and formalizing internal process once left to customs brokers at very high charges. From above literature it is visible that, misclassification leads to costly corrective measures and expensive investigation (either internal or external). If proper and accurate justification of classification is not documented and presented to the customs during import firms lose the opportunity of duty reduction or exemption.

Classifying 'Hydraulic Components and Composite Material products' are technical in nature. As our research is US import focused, we explored the rules regarding this. Hydraulic assembly requires valves, filters, seals & gaskets, different kinds and multi material-composite fasteners & washers, manifolds, solenoids, and packaging & quality testing products. These materials are pure and composite materials employing metals like- steel, aluminum, copper, iron; non-metals like- rubber, silicon, plastic. Pure materials and composite materials employ different classification chapter in HTSUS. Again 'function' and 'use' impacts the codes (Figure 1).

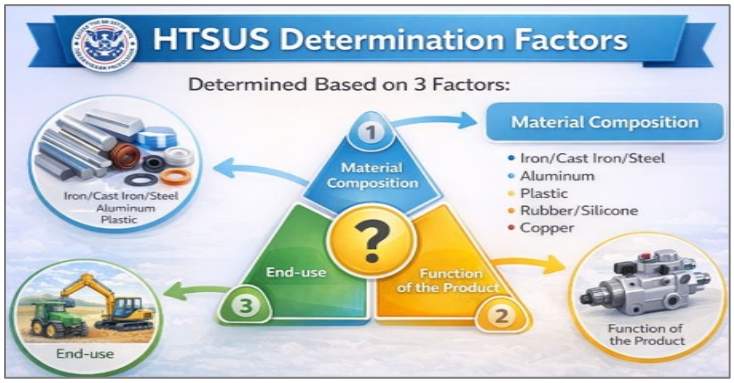

Figure 1. HTSUS determination factors (Source: HTSUS)

According to GRI (General Rule of Interpretation) – 1 by HTSUS, metals always follow chapter headings. It means if it is a metal or metal composite it must follow the specific chapter's description while classifying. For instance – if a fastener is made of iron/steel/steel composites, used in hydraulic assembly, for commercial end-use like agricultural equipment manufacturing, the fastener must be classified under chapter-73 of HTSUS. As it is going to be used in hydraulics assembly chapter 84 could apply, yet for most metals 'the chapter heading overrides function'. But if it is of non metal like – plastic or rubber and being used in hydraulics, we can't classify this under chapter- 39 or 40 which are regarding plastics and rubber, we must follow the 'function overrides material composite' rule and include that component under chapter – 84 that describes most products with hydraulic attributes. Again, if that plastic/rubber component is of mechanical nature that means 50% composite of metal like iron/steel, the chapter heading rule applies.

To navigate the challenges of tariff classification, organizations must ensure they accurately classify their products, starting with determining the materials used in the product through the engineering team. Following validation, the classification must also reference the actual function and intended use of the product. For example, Ford Motor Company imported several Transit Connect vehicles manufactured in Turkey that were classified incorrectly by using a lower duty rate for passenger vehicles instead of the higher rate applicable to cargo van imports. This misclassification resulted in the assessment of large post-import duty assessments and penalties. This example emphasizes that minor differences in HTS interpretations can lead to significant compliance and financial consequences for organizations importing potentially dual-use products. Ultimately, end-use documentation and appropriate application of HTSUS rules are key for importers. For complexities like frequently updated HTSUS codes, incurred cost and risks associated with SKU volume, different legal notes that may apply and interpretation difficulty regarding functionality, tariff classification is sensitive and technical (Grainger, 2024). HTSUS shows core 'connection formulae' dilemma of classification by material, by function, by use, and pull the classification in different directions specially for hydraulic components between chapter headings and function/heading 8481; even experts suffer the ambiguity very often (Wagner, 2023). In certain shipments, composite materials face post-clearance duty adjustments, usually CBP- Customs and Border Protection is in charge of such rulings, declaration needs correction as current HTSUS might not specify certain product (D'Angelo et al., 2023). (Islam et al., 2024) expressed the complication of correct classification of hybrid lay-ups as determining a dominant material identification is complicated. AHUS assembles hydraulic products that employ parts and semi-finished parts such as – valves, filters, manifolds, couplings, seals, fasteners, gaskets, washers etc. Complexities occur due to function and composition of an item as they can be used in different speculations. As we know HTS codes follow –

- Function such as sealing component, filtering equipment;
- Material composition such as metal, rubber, composites;
- Overall apparatus such as assembly parts/components or finished-goods;

These factors overlap among themselves and make it intricate to decide on the exact HTS code rather the best fit is chosen often.

2.2 Decision-making and Rule Based Conceptual Structure, Tech-integration in HTS Code Determination

To eliminate the complexities of HTS coding system accuracy, researchers suggested developing decision tree logic utilization and conceptual layout development. Some researchers emphasize tech-advancement like AI- Artificial Intelligence, ML-Machine Learning, NLP-Natural Language Processing, employment in tariff code assessment. A tabular presentation from different literature is given below in Table 2.

Table 2. Literature based tariff classification and process calibration approach

Suggested Process Calibration	Literature
Generalized decision making hierarchical model that will analyze and determine right HTS for a certain product based on thorough assessment of its function, material and use; proper interpretation of HTSUS chapter headings, GRI & CBP legal notes.	(Grainger, 2024)
Explore and utilize best conceptual practices from US-CBP and TARIC database in the EU.	(Wicaksana et al., 2025)
Decision tree framework capacitates manufacturers with reproducible deliverables and curb subjective interpretation interdependence. AI integration in extant ERP- Enterprise Resource Planning systems like SAP and ONESOURCE for classification consistency at scale.	(Sardana, 2024)
Domain specific drawbacks must be eliminated otherwise generic dataset trained AI will incorrectly classify industrial items such as hydraulic components.	(Marra De Artiñano et al., 2023b)
A hybrid model by combining rule-based logic and AI technology trained in the loop capabilities is suggested to ameliorate the accuracy of HS codes.	(Spichakova & Haav, 2020)
A number of convolutional neural networks that are trained with image datasets to determine and ensure accuracy of HS codes for consumer and industrial products were developed to reduce complexity by the authors.	(Cuaya-Simbro et al., 2022)
Sentence BERT models were appointed to extract meaning from product narratives and turn them into intent focused cognitive grasp specific HS codes. The authors emphasized NLP adoption in the task.	(Anggoro et al., 2024)

From above literature study, it can be synthesized that, HTS coding complications are well researched about for its financial impacts and strategic significance. A slight mistake may result the firm in big amount of monetary, operational, strategic and reputational loss. Tariff classification that looks like a straightforward yet complex task that involves cost implication thus a paramount strategic consideration for a firm. In addition to meeting obligations set by law, proper tariff classification can also be considered a source of organizational strength or capability contributing to supply chain strategies due to increasing the quality of data available and reducing uncertainty around regulation. Consistent with Resource Based (RB) and Dynamic Capabilities perspectives, the AHUS Framework is a micro routine enabling firms to successfully navigate the changing regulatory landscape, modify sourcing and logistics, enhance resilience and improve cost performance globally within their supply chain.

3. Methodology of Study

3.1 Research Design

This research utilizes a singular exploratory case study design of ARGO-HYTOS US (AHUS). The author follows the recommended guidelines on case study research in operations and management (Eisenhardt, 1989) (Yin, 2018). The qualitative aspect examines the analysis of internal documents, descriptions of processes and experts to analyze the organizational practices of tariff classifications. The quantitative portion of the study constructs an illustrative numerical example that simulates how much duty savings or exposure to penalties could occur under multiple classification case scenarios. The numerical data presented due to confidentiality constraints do not reflect actual transactional data but representative data utilized to show mechanisms rather than provide reader(s) with statistically generalizable estimates. The single-case design is suitable for this study because AHUS is an example of a manufacturing organization with a rich information base where an internal compliance function has been established and there is a structured decision framework in place for tariff classification. The single-case design will allow for a detailed examination of the classification processes, decision criteria and cross-functional co-ordination, which would be difficult to measure using a large sample survey. The study seeks analytical generalization to concepts and/or

frameworks, and not statistical generalization to a larger population of firms. Based on our problem statement, it was broken down into following criteria (Figure 2). –

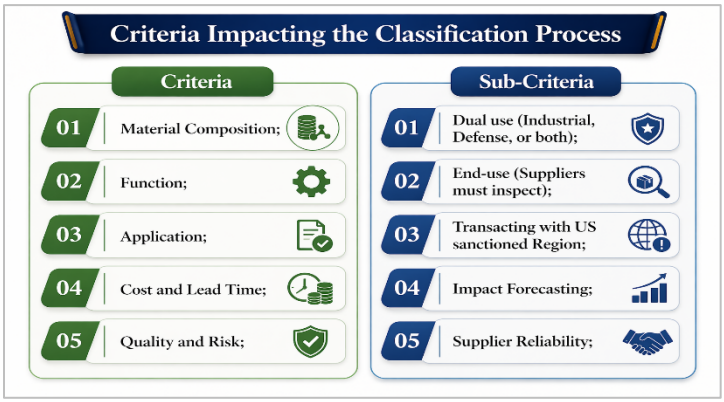

Figure 2. Impacting criteria of the classification process (Source: HTSUS)

Four Tier Tariff Classification Decision Making Framework for AHUS products

AHUS's is one of the pioneers to have separate compliance department that deals with international trade issues. Here the practice is being standardized instead of only SKU-based shipment clearance and 'work on it after red-flagged by the authority'. The compliance department's structure is cross-functional yet simple in nature for keeping the goal specific and outcomes predictable; so that strategy formulations become less uncertain and critical.

3.2 Rationale of 4 Tier Tariff Codes Assignment Structure from Industry Perspective

TR-Thomson Reuters is a reliable industry white paper that brings together government declared customs rules, GRIs, important factors and industry standard methods to map consistent HTS codes aligned with global practices. TR Trade Compliance Guide, 2023, outlined best practices and recommended following aspects must be ruled out –

- Item/ product and its material/ composition identification;
- Appropriate function/ use determination;
- Applicable HTS chapters, headings and sub-headings review;
- GRI - General Rules of Interpretation application;
- Assisted legal notes, interim rulings and pertinent precedence validation.

TR recommended these steps must be considered while assigning HTS code of a product. For reliability and relevance these consolidated practical guidance by TR is accepted and adopted by global firms and practiced by compliance professionals worldwide.

3.3 Rationale of 4 Tier Tariff Codes Assignment Structure from Authoritative Standpoint

The legal foundation of tariff classification is provided by USITC - U.S. International Trade Commission. The Commission is the official HTS governing body and provides the following - GRIs (General Rules of Interpretation), HTS Rules, Sections, Chapter Descriptions and Special Rules, HTS Search Tools, Interim Rulings and References. USITC serves the legal structure of the classification. We leveraged the TR steps into structured decision making stratums aligned with USITC that is compliant and consistent to address AHUS product line. TR's recommended steps were grouped into four relevant stages to assign and cross check the accuracy of it. Neither TR nor USITC offers a formal tiered framework for tariff related decisions. We leveraged their guidelines to develop one that best suits the need and serves the purpose best. The framework we followed is structured in a way that ensures transparency, compliance and accuracy.

4. Data Collection

Data collection involves SAP4/HANA, AHUS Windchill Database, purchasing invoices. For this study unit prices, quantities, HTS codes, country of origin and supplier data are required and the sources served purpose. The master data csv file that contains material description and type, SKU information, existing tariff codes was drawn from SAP. HTSUS- Harmonized Tariff Schedule of the United States, database of products from USITC- United States

International Trade Commission, was leveraged as regulatory and legal reference for US import classification. CBP- Customs and Border Protection has interpretive rulings and associated legal bindings for hydraulic and industrial products. CROSS- Customs Rulings Online Search System was utilized to look for any such authoritative aspect regarding AHUS products. ECCN- Export Control Classification Number and CCL- Commerce Control List were verified from BIS- Bureau of Industry and Security. Engineering teams inputs regarding technical issues were discussed to verify product composition, ambiguous functions regarding various composite filter and manifold assembly with several kits with multiple parts in Table 3.

Table 3. Research design

Research Design	Case Study	Description
Data Collection	Primary Data	Extracted from AHUS SAP, Windchill and publicly available data from website, HTSUS Legal Notes, BIS, EAR and CCL.
Tools Utilized	R, Excel, SAP S/4HANA, Windchill	'R' for Data visualization, SAP/HANA and Windchill of AHUS for Data selection.
Classification Framework	A Four-tier Decision Tree Model was Developed	As the process is multi criteria decision making point, a decision tree was required to process the best fit HTS for a particular component.

5. Results and Discussion

5.1 Numerical Results

Due to confidentiality constraints, the results shown are partial. This is a partial presentation of final outcomes that are going to be uploaded in the system (SAP4/HANA and AHUS Windchill). This allows duty rates to be determined in advance for forecast demand. It will facilitate strategic decision making. Due to confidentiality clauses, the paper is presenting a representative dataset yet closest in nature for numerical illustration. The data that are presented here are not exactly that of AHUS but it is similar and represents the case as it should in Table 4.

Table 4. Representative data and impact analysis

SAP No.	Product Group	Import Value ($)	Incorrect Duty Rate	Correct Duty Rate	Incorrect Duty ($)	Correct Duty ($)	Savings ($)	Penalty Rate	Potential Penalty Risk ($)
00001	Carbon Steel Fixings	18,000	6.5%	3.8%	1,170.00	684.00	486.00	20%	3,600
00005	Aluminum Hydraulic Components	22,000	5.9%	2.5%	1,298.00	550.00	748.00	20%	4,400
00007	Aluminum Machining Component	26,500	5.8%	3.0%	1,537.00	795.00	742.00	20%	5,300
00010	Stainless Steel Components	13,400	6.4%	2.9%	857.60	388.60	469.00	20%	2,680
00013	Vulcanized Sealing Components	11,300	8.1%	4.5%	915.30	508.50	406.80	20%	2,260

Several example products in Table 4: Total duties assessed on the five examples reduced from 5,777.90 to 2,926.10 or about 2,851.80 (49.36% of original duties, 3.13% of total import value). This provides an example to illustrate the potential benefits but does not provide statistically generalizable results. In addition, in practical application, accurate classification may also increase duties when the correct duty rate is higher than the originally applied rate. The primary value of accuracy is that you comply with customs regulations and reduce penalty exposure. Using 20% of the value of the goods as the approximated potential penalty, the potential penalty would be 18,240. This greatly exceeds the duty savings in this example. The 20% penalty rate is a conservative illustrative estimate. This is aligned with U.S. Customs guidelines. In the guidelines it is stated that negligence penalties can be up to 20% of a shipment's value.

5.2 Graphical Results

Figure 3 illustrates the relationship between savings on duties and potential penalties for misclassification of certain types of AHUS products. When the correct classification is executed, an average savings of $407 to $748 can be expected per product; however, potential penalties exceed these amounts considerably with penalties ranging from $2,260 - $5,300 each. With total savings estimated at $2,852 and total risks estimated at $18,240, the risk exceeds the savings approximately 6.4 times. This example shows that the main financial value of proper product classification and import HTS code assignment comes from reducing penalty risk rather than from duty savings alone. Thus accurate tariff classification serves as an important strategic area within supply chain management.

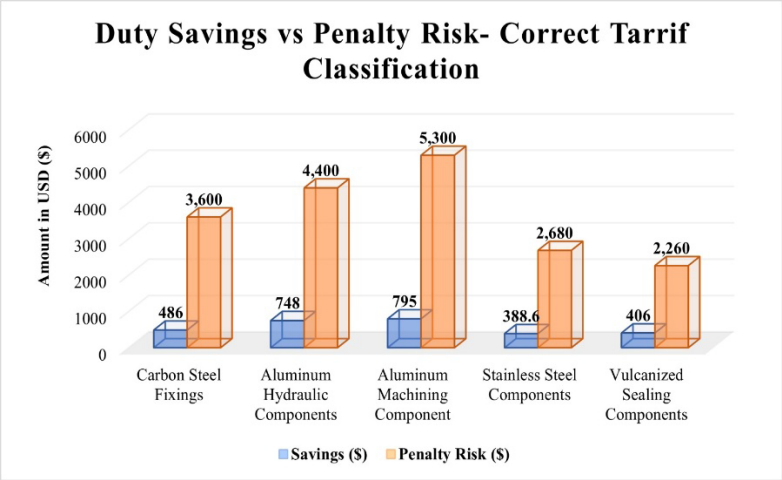

Figure 3. Savings on duties vs potential penalty exposure for the five illustrative product categories.

5.3 Proposed Improvements

Tier 1: Product Identification: Unique SAP numbers were assigned and we collected the data sheet that has information on components that need classification upgrade as HTS rules change to cope up with ever changing global trade (Table 5). The collected data has SAP numbers, material description and material composite to state what the materials are made of- steel, plastic or aluminum. It looks like the following Table 5.

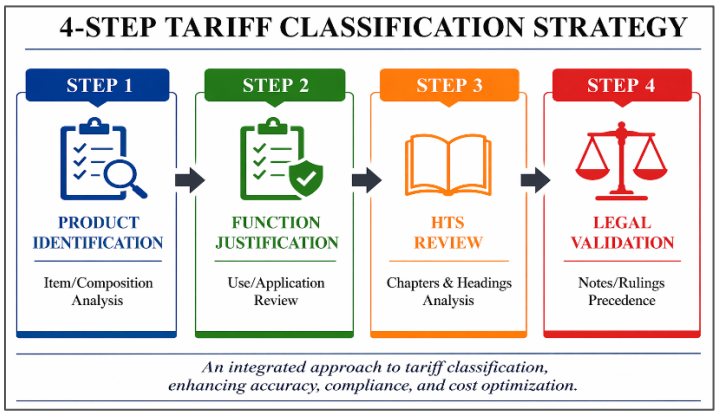

Figure 4. Tier Decision tree framework for tariff classification (Source: Developed by the authors)

Table 5. AHUS product based on basic material composition and relevant AHUS products

AHUS product based on basic material composition			Relevant HTSUS chapters and their descriptions for AHUS products	
Unique SAP No	Material Description	Basic Material	HTS Chapter	Description
00001	Adapter	WN2012-F260	39	Plastics and plastic articles (resins, pipes, fittings, molded parts).
00002	Screen	PA6 Ultramid B3S	40	Rubber and rubber products (seals, gaskets, hoses, O-rings).
00003	Rod	PA6 GF30 laser transparent;	73	Iron or steel articles (fasteners, pipes, fittings, hardware).
00004	Bag	PVC	74	Copper and copper alloy items (tubes, wire, brass parts).
00005	Bowl D 044.0101	EN AW-Al Si1MgMn	76	Aluminum articles (plates, profiles, castings, housings).
00006	Bowl E 094.0903	WN2021-1-3-2; leitf	84	Machinery and mechanical parts (pumps, valves, filters).
00007	Pipe 40.0;1.00;347	EN AW-6082 (Al Si1MgMn)T4	90	Measuring and precision instruments (sensors, gauges, devices).
00008	Stirrup E 198.0910	DC04		
00009	Pipe 46; 1.00;1000	EN AW-6060 (Al MgSi)T6		
00010	Bolt E 498.0702	A2F+Dickschichtpass +Versie		

Different reliable sources such as - Werkstoffdaten.de, DIN EN 10027 (Steel designation system), EN 10084, Thyssenkrupp datasheet, EN 10269, EN 573 (Aluminum alloys), EN 755, MatWeb, Supplier datasheets (DuPont / Chemours), ISO 1629 (Rubber classification), BASF Ultramid datasheet, ASTM D4894 (PTFE standard), DIN 50961 (Electroplated coatings standard), U.S. Military Specification MIL-A-8625, were leveraged to describe the material composite extracted from 'Basic Material' column. The description was required for better understanding of the components for the purchasing team and this is also a criteria based on which accurate HTS is assigned. This description will be added to an extended window in SAP once the tariff code is assigned. From this process we found out the basic materials we are dealing with, these are - Iron/Cast Iron/Steel, Aluminum, Plastic, Rubber/Silicone, Copper. Major criteria of classification including HTSUS and its GRI rulings, AHUS products mostly fall under above mentioned HTSUS defined chapters and tariff codes are to be extracted accordingly.
SAP4/HANA is being incorporated in daily task and thus data presentation is being changed. Thus generic products were given a common group name that defines the entire generic product line.

Tier 2: Function and Application Justification: The products, parts and components of AHUS Product line that were primarily selected for the project are given below in Table 6-

Table 6. AHUS product specification for more appropriate code assignment

AHUS Products	**Generic Name**
Adapter, Connection, Connection piece, Hydraulic connector, Hose/pipe adapter, Quick-connect fitting (QC type), Locking device, DN32 connector, Verschlusskappe (German for 'closure cap')	Adapters & Fittings or Hydraulic Connector Components
Screen, Screen element, Filter screen, Strainer element, Mesh screen, Magnetic drain plug screen	Screens & Filtration Elements
Rod, Filter rod, Support rod	Rods / Support Bars
Screw (different types), Cylinder head screw M6, Bolt	Screws & Fasteners
Cover, Cover complete, Filter cover, End cover, Closure cap, Tank cap / Fuel cap	Covers & Caps

Bowl, Bowl complete, Filter bowl, Housing lower body	Filter Bowls / Lower Housing
Filter head, Mounting head, Filter mounting adapter, Housing body	Filter Heads / Upper Housing Assemblies
Hydraulic pipe, Steel pipe, Tube section, Pipe complete, Connection pipe	Pipes & Tubes
Diffusor	Flow Diffuser / Flow Element
Ring complete, Retaining ring, Sealing ring, Metal ring	Rings & Circular Components
O-ring, NBR O-ring, Metric O-ring, Rubber seal, Elastomeric sealing ring	O-Rings & Elastomer Seals
Plug, Drain plug, Magnetic plug M18×1.5, Blank plug	Plugs / Service Plugs
Stirrup, Mounting bracket, Clamping bracket	Clamps & Mounting Brackets
Locking device, Retaining latch, Locking clip, Safety lock	Locking Devices
Bag, Disc, Housing, Trade show element	Miscellaneous Components (Packaging bag, Metal disc/shim, Line adapter, Housing, Demo screen element)

From above table the functional aspect can be simply put as – **'Hydraulics Solution'**. In his step further specification regarding AHUS products' application was determined to find the accurate tariff code. Facts such as – Filtration Product, Flow Control Valves & Components, Unbuilt Manifolds, Mobile EquipmentThese aspects are very important to evaluate to assign the accurate HTS code for a component.

Tier 3: HTS Placement: Based on the above analysis HTS codes were assigned at this phase. Product specification and intended use was verified against each code decided upon. As we assigned unique group names so it can be identified in the SAP when stakeholders are using it, we made sure to assign either exact or best fit HTS for each component.

Tier 4: Regulatory Cross-Validation: After assigning the tariff codes a thorough validation process was conducted. This tier ensured all possible regulatory avenues are accounted for while assigning tariff codes, delved into appropriately and properly documented for internal compliance. For validation against assigned Tariff Codes, following steps were taken –

- Performed cross-checking against USITC Ruling to ensure material properties match;
- Eliminated ambiguity of alternative applicable HTS codes (based on material composite different HTSUS chapters apply);
- Reviewed functional description of a product with HTS chapter intent;
- Reviewed EAR and CCL rulings for potential dual-use controls;
- Checked associated compliance sensitive documentations and licensing;
- Confirmed with engineering teams input on technical descriptions;
- Verified master data inputs from findings by workflow approval;

5.4 Validation

A proposed four-tier tariff classification framework was validated by applying it to key AHUS product categories using concrete criteria relating to the materials, function, and application of each product. This four-tier tariff classification framework incorporates the best industry practices along with the applicable legal standards (HTSUS, GRI, and USITC rulings) while ensuring regulatory compliance for all of the AHUS products included in this sample population through application of this validation process. Validation occurred by matching the assigned HTS codes against various official databases (USITC, CROSS) and verifying technical specification for each product through engineering verification. The classifications were consistent, accurate, and reproducible across all three product groups. Quantitatively, the validated classifications indicated a reduced exposure to duty liability and a minimized risk of penalties associated with tariffs which confirms the validity of the first tier classification as a legitimate and effective tool for tariff classification purposes.

6. Conclusion

Accurate classification of tariffs will yield both short- and long-term benefits to AHUS; it will continue to provide both internal and external compliance, reduce the likelihood of audit risk, mitigate regulatory impacts, and facilitate

smooth flow of goods across borders by avoiding delays, reroutings, and/or holds. Enhanced alignment among stakeholders; duty rate forecasting; and enabling of landing cost modeling for new products. In addition, it will enable leveraging of trade programs (FTAs, duty exemptions, drawback claims) as well as support to generate long-term strategic value via master data structures, automation of duty calculations, and harmonization across all AHUS facilities. Accurate classification of tariffs will also aid in financial planning through cost-benefit calculations. Limitations include focus on imports only; lack of end-use validation; not assessing variation at the port level; absence of quantified financial impact due to data limitations; and need for periodic verification. Future research topics may include cost-benefit analysis, artificial intelligence-based classification systems, and duty impact models.

Compliant, consistent and accurate tariff codes contribute to extended business tactics like sourcing decisions, location & storage selections, modifying product designs to lower tariff rate, supply chain visibility, manufacturing & reshoring decision impact modelling, data consistency among key actors & facilities and so on. A well-outlined tariff system prompted reposition of several firms during US-China trade war and facilitated inventory policies & supplier shift based on evolving tariff rate structure (Zhang et al., 2025). HTS classification thus often referred to as tariff engineering and classification excellence because it is not just for duty savings and compliance. This can be used as an advantage for short & long range strategic flexibility, organizational resilience and a powerful decision-making tool.

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Reference

Anggoro, A. W., Corcoran, P., De Widt, D., and Li, Y., Harmonized system code classification using supervised contrastive learning with sentence BERT and multiple negative ranking loss, *Data Technologies and Applications*, vol. 59, no. 2, pp. 276–301, 2024. https://doi.org/10.1108/DTA-01-2024-0052

Chae, S., Mena, C., Polyviou, M., Rogers, Z. S., and Wiedmer, R., The effects of tariff increases on supply base complexity: A conceptual framework, *Journal of Purchasing and Supply Management*, vol. 25, no. 4, p. 100556, 2019. https://doi.org/10.1016/j.pursup.2019.100556

Cuaya-Simbro, G., Hernandez-Vera, I., Ruiz, E., and Gutierrez-Fragoso, K., Automatic Tariff Classification System using Deep Learning, *International Journal of Advanced Computer Science and Applications*, vol. 13, no. 7, 2022. https://doi.org/10.14569/IJACSA.2022.01307105

D'Angelo, G., Tarini, F., De Wit, W., Schippers, M., Ibáñez Marsilla, S., Milla Ibañez, J. J., Wolffgang, H.-M., and Wemmer, B., Interplay Between Customs Valuation and Transfer Pricing in the European Union: General Observations and Administrative Practices in Four Countries After the Hamamatsu Case, *World Customs Journal*, vol. 17, no. 1, 2023. https://doi.org/10.55596/001c.73300

Eisenhardt, K. M., Building Theories from Case Study Research, *The Academy of Management Review*, vol. 14, no. 4, p. 532, 1989. https://doi.org/10.2307/258557

Grainger, A., Customs Tariff Classification and the Use of Assistive Technologies, *World Customs Journal*, vol. 18, no. 1, 2024. https://doi.org/10.55596/001c.116525

Grainger, A., Huiden, R., Rukanova, B., and Tan, Y.-H., What Is the Cost of Customs and Borders Across the Supply Chain?…and How to Mitigate the Cost Through Better Coordination and Data Sharing, *World Customs Journal*, vol. 12, no. 2, 2018. https://doi.org/10.55596/001c.115725

Habib, N., Nurlaela Wati, L., and Wardini, A. K., Determinants Of Customs Regulations Compliance In Directorate General Of Customs And Excise Audit Result, *Jurnal Reviu Akuntansi Dan Keuangan*, vol. 12, no. 1, pp. 88–105, 2022. https://doi.org/10.22219/jrak.v12i1.17655

Hu, X., Fu, K., Chen, Z., and Du, Z., Decision-Making of Transnational Supply Chain Considering Tariff and Third-Party Logistics Service, *Mathematics*, vol. 10, no. 5, p. 770, 2022. https://doi.org/10.3390/math10050770

Islam, T., Chaion, M. H., Jalil, M. A., Rafi, A. S., Mushtari, F., Dhar, A. K., and Hossain, S., Advancements and challenges in natural fiber-reinforced hybrid composites: A comprehensive review, *SPE Polymers*, vol. 5, no. 4, pp. 481–506, 2024. https://doi.org/10.1002/pls2.10145

Karklina-Admine, S., Cevers, A., Kovalenko, A., and Auzins, A., Challenges for Customs Risk Management Today: A Literature Review, *Journal of Risk and Financial Management*, vol. 17, no. 8, p. 321, 2024. https://doi.org/10.3390/jrfm17080321

Małgorzata, O. and Małgorzata, C., Logistics and customs handling – new technologies and operational efficiency and compliance with international regulations, *Scientific Papers of Silesian University of Technology Organization and Management Series*, vol. 2024, no. 211, 2024. https://doi.org/10.29119/1641-3466.2024.211.30

Marra De Artiñano, I., Riottini Depetris, F., and Volpe Martincus, C., Automatic Product Classification in International Trade: Machine Learning and Large Language Models, *Inter-American Development Bank*, 2023a. https://doi.org/10.18235/0005012

Marra De Artiñano, I., Riottini Depetris, F., and Volpe Martincus, C., Automatic Product Classification in International Trade: Machine Learning and Large Language Models, *Inter-American Development Bank*, 2023b. https://doi.org/10.18235/0005012

Morini, C., Pieri Leonardo, F., Chaudhary, V., and Hintsa, J., A Paradigm Shift in Cross-Border E-Commerce Regulatory Compliance: Evidence From Brazil, *World Customs Journal*, vol. 18, no. 2, 2024. https://doi.org/10.55596/001c.123504

Sardana, J., Automating Global Trade Compliance through Product Classification Systems, *The American Journal of Management and Economics Innovations*, vol. 6, no. 8, pp. 134–156, 2024.

Spichakova, M. and Haav, H.-M., Application of Machine Learning for Assessment of HS Code Correctness, *Baltic Journal of Modern Computing*, vol. 8, no. 4, 2020. https://doi.org/10.22364/bjmc.2020.8.4.13

Strati, H., Post-clearance Amendment of Customs Declarations and Repayment of Customs Duties and VAT in the Context of EU Law, *World Customs Journal*, vol. 12, no. 1, 2018. https://doi.org/10.55596/001c.115715

Wagner, O., The Connection Formula in Classifying Goods Under the Harmonized System (HS) Convention, *World Customs Journal*, vol. 17, no. 2, 2023. https://doi.org/10.55596/001c.88843

Wicaksana, A., Ho, W., Samson, D., and Lam, H. K. S., Tariff barriers and operational efficiency: The mitigative role of top management team supply chain management experience and potential domestic supply base, *Transportation Research Part E: Logistics and Transportation Review*, vol. 200, p. 104204, 2025. https://doi.org/10.1016/j.tre.2025.104204

Yin, R. K., Case Study Research and Applications: Design and Methods (6th ed.), *Sage Publications*, 2018.

Zhang, D. J., Dabadghao, S. S., and Udenio, M., Global sourcing under tariffs: A perspective of time series analysis, *International Journal of Production Economics*, vol. 280, p. 109473, 2025. https://doi.org/10.1016/j.ijpe.2024.109473

Thomson Reuters, Global Trade Compliance Best Practices Guide, *Thomson Reuters*, 2023

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