

CHAPTER 1 – INTRODUCTION

1.1. Background

In today's interconnected economy, governments frequently adjust trade policies to protect domestic industries and manage economic risks. A striking example of these policy shifts in Indonesia is captured by a recent headline from *Kompas* (17 May 2024) “*Imbas Aturan Pembatasan Impor, 26.000 Kontainer Barang Tertahan di Pelabuhan*” (translated: “Impact of Import Restrictions: 26,000 Containers Stuck at the Port”). This large-scale backlog illustrates how sudden changes in import regulations be they stricter enforcement, newly introduced tariffs, or protective measures can halt thousands of shipments, creating costly delays and operational bottlenecks for businesses.

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Imbas Aturan Pembatasan Impor, 26.000 Kontainer Barang Tertahan di Pelabuhan

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Rully R. Ramli, Yoga Sukmana
Tim Redaksi



Ilustrasi kontainer. (Dok. UNSPLASH/CHUTTERSNAPI)

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Baca berita tanpa iklan. Gabung Kompas

Figure 1.1 Stacks of containers at the Indonesia port affected by the import restrictions under Ministry of Trade Regulation No. 36 of 2023, leaving thousands of containers on hold awaiting licensing.

In the past few years, global trade has been shaped by a series of escalating tariff measures, most prominently between the United States and China. Each side has imposed new tariffs on a wide range of goods from agricultural products to high-tech components triggering ripple effects throughout global supply chains. As countries rapidly revise tariff structures and tighten import regulations, misclassification of goods can result in higher duties, shipment delays, and punitive measures. Consequently, businesses must stay vigilant continuously monitoring policy shifts and ensuring that their HS Code assignments align with both domestic and international regulatory requirements.

Reliance on Tacit Knowledge for Ambiguous Products

Developed and maintained by the World Customs Organization (WCO), the HS Code is an internationally standardized nomenclature for classifying traded products. Each product is assigned a numerical code ranging from broad product categories to very specific items enabling customs authorities worldwide to identify goods accurately.

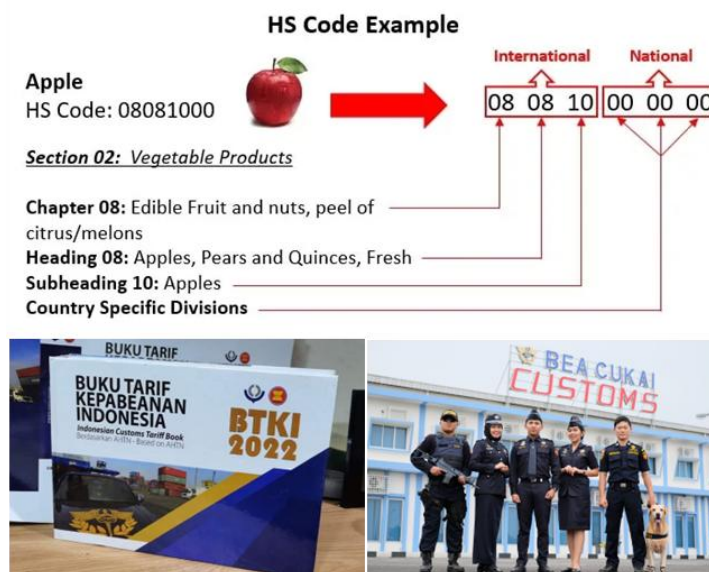


Figure 1.1 Harmonized System (HS) code structure showing the division of the first 6 digits standardized globally and the 7th and 8th digits customized for Indonesia

Harmonized System Code Structure.

As shown in Figure 1.1, the *Buku Tariff Kepabeanan Indonesia* (BTKI) structure consists of:

1. First six-digits: Standardized globally under the WCO, representing uniform product categories across all member countries.
2. Seventh and eighth digits: Specific to Indonesia, these provide additional sub-classifications for tariff rates, regulatory requirements, and statistical purposes.

Despite the structured nature of the HS Code, classification can become complex particularly when products are made from multiple materials, have multifunctional designs, or fall into “gray areas.” Even with detailed guidance from tariff books and regulatory bodies, some products remain difficult to classify as shown in Figure 1.2 a gold knife case shown a good example. A folding knife with a gold handle may be classified as cutlery under the heading for knives, yet the presence of a precious metal (gold) can lead to confusion over whether it falls under codes for jewelry or precious metal items.



Figure 1.2 A folding knife with a gold handle, illustrating an ambiguous product that relies on tacit knowledge for classification.

In many customs environments, classification officers and freight forwarders rely on personal expertise or historical precedent referred to as tacit knowledge to resolve ambiguous cases. As in case of gold knife, custom officer will set the gold knife as

precious metal, and likely go with higher tariff or certain regulation to stop any illegal material entrance. While experience is valuable, over-reliance on subjective judgment can increase the likelihood of errors. For instance, an importer might pay excessive duties if the item is mistakenly categorized under a more heavily taxed code. Conversely, if a lower-duty code is used in error, authorities could later impose fines or seize the goods for non-compliance.

In Indonesia, these rules are adapted as KUM HS (*Ketentuan Umum Menginterpretasi Harmonized System*) and integrated into the BTKI. KUM HS provides a step-by-step framework for determining the correct HS code for any product, starting with general principles, and moving to specific guidelines when ambiguities arise. Numerous studies have sought more efficient, automated methods to ease the complexity of HS code classification. For instance, rule-based systems leverage predefined logical structures and decision trees mapped to KUM HS to systematically narrow down codes by matching product attributes with explicit classification rules. Meanwhile, machine learning techniques, particularly in natural language processing and text classification, have unlocked more sophisticated solutions. By tapping into large datasets of product descriptions and their assigned HS codes, algorithms like support vector machines, random forests, or deep neural networks can learn classification patterns.

However, despite these gains in speed and accuracy, automated approaches also confront traceability and explainability challenges. Traditional methods allow classification experts to document each decision step, referencing specific notes from KUM HS and thereby providing a clear audit trail. In contrast, rule-based systems often grow unwieldy over time, accumulating numerous conditional branches that obscure their underlying logic. Machine learning models compound the problem by operating as “black boxes,” producing code predictions with little or no transparent rationale. Although explainable AI (XAI) research aims to address this gap, current solutions rarely offer the level of clarity that regulators need to verify compliance, this lack of explicit reasoning can impede widespread adoption and undermine the goal of consistent, justifiable classification outcomes.

Complexity and Challenge in HS Code Classification in PT XYZ

This thesis will focus on PT XYZ, a prominent entity in Indonesia's heavy equipment industry, as the primary case study for data observation. PT XYZ is actively involved in the importation and distribution of heavy machinery and related spare parts, serving various sectors including mining, construction, and agriculture. The company frequently encounters challenges in accurately classifying imported goods under the appropriate HS codes, leading to potential financial and operational consequences.

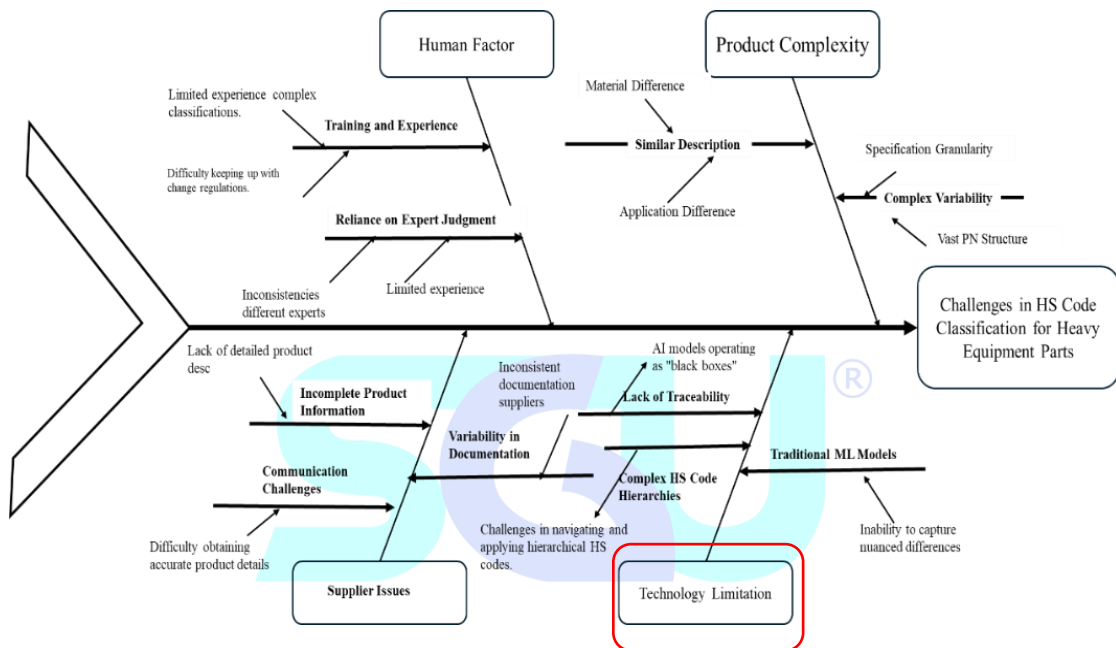


Figure 1.3 Fishbone diagram identifying key challenges faced by PT XYZ in classifying HS codes for heavy equipment parts.

A fishbone diagram illustrating the core challenges PT XYZ faces in classifying HS codes for heavy equipment parts refer to Figure 1.3. These challenges include:

1. **Material Differences:** Parts with identical functions but different materials often require distinct HS codes. Misclassification occurs when these nuances are overlooked.
2. **Similar Descriptions:** Many parts have overlapping or vague descriptions but differ in critical attributes like application or material composition. Without careful attention to these details, misclassification becomes likely.

3. Complexity of Part Numbers (PNs): Part Numbers encode extensive details about each item, but interpreting these intricate structures accurately is crucial for proper classification.
4. Reliance on Expert Judgment: The current process depends heavily on human expertise. This reliance introduces risks of inconsistency and human error, especially when descriptions are incomplete or ambiguous.
5. Technology Limitations: While Machine Learning (ML) systems are used, their "black box" nature can make the rationale behind classification decisions difficult. This lack of interpretability poses challenges in legal disputes or compliance reviews during customs processes.
6. Incomplete Product Information: Insufficient details about products make it challenging to assign the correct HS codes, resulting in delays, increased costs, and potential penalties.

These challenges highlight the need to overcome technology limitation utilize more advanced and automated methods to improve the accuracy and efficiency of HS code classification at PT XYZ. Using advanced technologies like Knowledge Graphs (KG), AI Large Language Models (LLM), and Machine Learning, the study aims to develop an automated and interpretable system that improves the accuracy and efficiency of HS code classification.

1.2. Research Problem

This research tackles the key challenges of classifying heavy equipment parts under the HS codes in Indonesia's import regulations. By using Knowledge Graphs and AI Language Models (LLMs), the study aims to improve accuracy and transparency in the classification process in heavy equipment parts. The main problems are:

1. Complexity in HS Code Classification

Heavy equipment parts often share similar descriptions but differ in material composition, intended use, or design features. These subtle variations make accurate classification highly complex, and traditional methods—both manual and automated—struggle to handle these nuances.
2. Navigating HS Code Hierarchies

The hierarchical structure of HS codes requires precise categorization of goods, starting from broad categories down to specific subcategories. Ensuring alignment with the detailed regulatory requirements of the BTKI adds an additional layer of complexity, particularly when handling overlapping categories.

3. Consequences of Misclassification

Errors in HS code classification result in penalties, regulatory delays, and inefficiencies, creating operational disruptions for businesses involved in global trade. These misclassifications also undermine compliance with trade regulations, further increasing financial and reputational risks.

4. Lack of Transparency and Traceability

Current AI-based classification models, particularly those reliant on "black box" machine learning methods, fail to capture the contextual and hierarchical relationships between part numbers (PN), product descriptions, and HS code rules. Furthermore, these models lack transparency, making it difficult for stakeholders to trace or validate classification decision.

5. Need for Innovation

There is a critical need for an automated classification system that combines advanced AI technologies, such as Knowledge Graphs and Large Language Models (LLMs). Such a system should improve classification accuracy while providing transparent, traceable reasoning for each decision.

1.3. Research Objective

The objectives of this research are focused on addressing the identified challenges in classifying heavy equipment parts under the HS codes within Indonesia's importation regulations. This study adopts a proof-of-concept approach to explore and validate innovative methods for HS code classification in the heavy equipment industry. The objectives of the research are:

1. To design a proof-of-concept system that integrates Knowledge Graphs (KGs) and Large Language Models (LLMs) to enhance the accuracy, efficiency, and transparency of HS code classification. The system aims to streamline

classification workflows and significantly reduce processing time while producing explainable and interpretable results.

2. To construct a Knowledge Graph that maps relationships between part numbers, product attributes, and regulatory HS code rules. This framework will enable contextual classification by incorporating hierarchical and domain-specific knowledge into the decision-making process.
3. To create a proof-of-concept AI system that integrates Knowledge Graphs and LLMs, ensuring transparent and traceable reasoning for each classification decision. This framework will support expert validation, enhance trust, and ensure compliance with Indonesia's BTKI regulations.
4. To evaluate the proof-of-concept system using real-world data from PT XYZ, demonstrating its potential to address challenges such as material variations, ambiguous descriptions, and reliance on tacit knowledge in HS code classification.

1.4. Research Question

This study adopts a proof-of-concept approach to investigate the integration of Knowledge Graphs (KGs) and Large Language Models (LLMs) for automating HS code classification. The research aims to address the following key questions:

1. Question #1: How can an automated AI classification system, integrating Knowledge Graphs and Large Language Models (LLMs), enhance the accuracy and transparency of HS code classification for heavy equipment parts under Indonesia's BTKI regulations?
2. Question #2: What methods can be employed to design and validate a proof-of-concept framework that combines Knowledge Graphs and LLMs, ensuring transparent, explainable, and traceable reasoning for HS code classification decisions?

1.5. Hypothesis

This research explores the integration of Knowledge Graphs (KGs) and Large Language Models (LLMs) into a proof-of-concept framework for automating HS code classification. The hypotheses guiding this study are:

1. Hypothesis #1: The integration of Knowledge Graphs and LLMs in an automated classification system will improve the accuracy and efficiency of HS code classification by providing context-aware decisions aligned with Indonesia's BTKI regulations.
2. Hypothesis #2: An explainable AI framework that integrates Knowledge Graphs and LLMs will enhance the transparency and traceability of HS code classification decisions, ensuring compliance with regulatory standards and supporting classification decision.

1.6. Research Scope and Limitation

This research focuses on addressing the challenges of HS code classification for heavy equipment parts within the context of Indonesia's BTKI regulations. It aims to develop an automated, explainable AI framework that integrates Knowledge Graphs (KGs) and Large Language Models (LLMs) to improve accuracy, efficiency, and transparency in the classification process.

The study is conducted as a proof of concept (PoC), demonstrating the feasibility of the proposed framework through controlled case studies. It specifically targets imported machinery parts such as excavators, bulldozers, and cranes, which present unique classification challenges due to material variations, complex part numbers, and the stringent requirements of Indonesia's customs regulations. By automating the classification process, the proposed framework seeks to streamline workflows, reduce manual bottlenecks, and accelerate decision-making while ensuring compliance with BTKI standards.

Technologically, the framework leverages Knowledge Graphs to structure relationships between part numbers, product attributes, and regulatory HS code rules into a machine-readable format. It incorporates LLMs to process unstructured data, such as product descriptions, extracting relevant details and aligning them with structured entities. To enhance trust and compliance, Explainable AI (xAI) is integrated into the framework to provide transparent and traceable reasoning for classification decisions.

The research is geographically focused on Indonesia and operationally based on data from PT XYZ, a key player in the country's heavy equipment industry. Using PT XYZ's real-world data—including part numbers, product descriptions, and historical classification records—the study validates the framework's effectiveness in addressing classification challenges.

While the scope is limited to heavy equipment parts and PT XYZ's operations, the PoC demonstrates the potential for adaptation and scalability across other industries facing similar HS code classification challenges. This targeted approach ensures a practical and impactful solution to the complexities of international trade compliance in Indonesia.

1.7. Significance of Study

This study is crucial both academically and practically for improving the classification of heavy equipment parts under HS codes in Indonesia. The key contributions are:

1. **Enhancing Classification Accuracy:** By integrating Knowledge Graphs (KGs) and Large Language Models (LLMs), this study demonstrates a proof-of-concept system designed to improve the accuracy of HS code classification. Reducing errors will help businesses avoid costly penalties and delays associated with misclassification.
2. **Supporting Regulatory Compliance:** The research introduces a systematic approach that aligns with Indonesia's BTKI regulations. By providing an automated and explainable AI framework, this study aids businesses in achieving compliance with customs requirements, reducing risks of non-compliance.
3. **Promoting Transparency:** The use of Explainable AI (xAI) ensures that the classification decisions are not only accurate but also transparent and traceable. This builds trust in the system among stakeholders, including businesses and regulatory authorities.
4. **Improving Customs and Operational Efficiency:** Automating the classification process reduces manual bottlenecks, accelerates decision-making, and optimizes workflows for businesses. This can lead to faster customs clearances, benefiting both businesses and government agencies.

5. **Ensuring Supply Chain Continuity:** Accurate and efficient classification minimizes supply chain disruptions, ensuring timely delivery of heavy equipment parts. This contributes to better project management and overall customer satisfaction.
6. **Providing a Scalable Framework:** Although the study focuses on PT XYZ and heavy equipment parts, the framework demonstrates scalability and adaptability for other industries facing similar challenges in HS code classification.

This thesis will explore the complexities of HS code classification in the heavy equipment industry, focusing on the challenges faced by businesses like PT. XYZ and proposing technological solutions to improve accuracy and compliance.

1.8. Thesis Structure

The following outlines the structure of this thesis:

1. Chapter 1 provides an introduction, including the research background, problem statement, objectives, research questions, hypotheses, scope and limitations, significance of the study, and an overview of the thesis structure.
2. Chapter 2 offers a literature review, encompassing theoretical perspectives and an examination of previous studies.
3. Chapter 3 details the research methodology, outlining the approaches and methods employed in the study.
4. Chapter 4 presents the data and discussions, including an overview, data presentation, analysis, and the results.
5. Chapter 5 concludes the thesis by summarizing the findings, offering conclusions, and possibly providing recommendations and suggestions for future research.