

Date: 19 September 2023

Customs tariff classification and the use of assistive technologies

*Working paper*¹

Author: Dr Andrew Grainger, Director at Trade Facilitation Consulting; Adjunct Professor at Charles Sturt University, Australia; Author of “Cross-border logistics operations: effective trade facilitation and border management”, 2021 (London: KoganPage).

Abstract

This paper aims to help inform discussions about customs tariff classification and the use of assistive technologies, especially those found online. It offers a broad background overview of classification practices and requirements by reference to the WCO’s Harmonized System (HS), incurred challenges and costs, and the types of technologies deployed to assist users in their classification endeavours. Reviewed assistive technologies and solutions range from information tools that make it easier for users to find classification relevant information (such as rulings and guidance notes) to Artificial Intelligence (AI) approaches that aim to suggest the most appropriate codes – with varying levels of success. Suggestions with examples about how to evaluate assistive classification technologies are provided. And, it is argued that there is considerable potential for such technologies but, this inevitably depends on how well they can understand HS relevant characteristics, the quality of data that supports them, and how well they have been developed or trained. The prize includes better compliance outcomes and improved trade facilitation by reducing classification related costs. However, it is essential that policy makers and users understand the opportunities and limits of assistive classification technologies.

Funding: The author would like to express thanks to Avalara Inc. for supporting and sponsoring this paper. The work is that of the author alone.

Acknowledgments: Many people from across the global customs community have helped bring this paper into life. This might have been indirectly through casual conversations with the author over the years, or directly as anonymous research informants, interviewees, or peer reviewers. Particular thanks is due to Randy Rotchin at Avalara , my former colleague and friend Dr Duncan R Shaw, as well as Michael Doherty, Gavin Roberts, and Samuel Bautista. Not to be forgotten are the many conversations and insights gleaned from the author’s students at various Universities and elsewhere.

Disclaimer: The purpose of this paper is to help inform conversations about customs tariff classification practices with specific focus on supporting, assistive technologies. The author, Dr Andrew Grainger, has taken all reasonable care to make sure that the prepared content is accurate at the time of writing. However, it is important to stress that the subject matter is fast evolving and prone to change. No responsibility for loss or damage occasioned to any person acting, or refraining from action, because of the materials in this publication, can be accepted by Trade Facilitation Consulting Ltd or the author.

¹ In preparation for submission to an academic journal



1 Introduction

It is hard to imagine customs control arrangements without commodity codes. This is because there are all sorts of goods with differing characteristics – including shape, form, use, composition, and production stage. Categorisation into codes helps make their control and reporting more manageable. Some practitioners may even refer to commodity codes as “buckets” into which goods with similar characteristics can be sorted – classified – and be made subject to a trade tariff that is specific to the assigned code. Customs commodity codes are thus often also referred to as trade tariff or customs classification codes (Grainger 2021). Most tariff publications list applicable tariffs in a column next to the commodity code (Figure 1). And, in over 200 countries customs commodity codes are based on the World Customs Organization’s (WCO) Harmonized Commodity Description and Coding System (WCO 1983), commonly referred to as the Harmonized System (HS) in short. This “universal language for international trade” (PEN-CP 2023b; WCO 2018b) that is based on standardised classification codes is much preferable to the alternative, where each customs area or territory has its own approach to establishing how trade tariffs and other trade control measures should be attributed to the cross-border flow of goods.

Figure 1: Extract from the European Unions’ Common Customs Tariff for 2022 (European Commission 2021)

CN code	Description	Conventional rate of duty (%)	Supplementary unit
1	2	3	4
8471 30 00	– Portable automatic data-processing machines, weighing not more than 10 kg, consisting of at least a central processing unit, a keyboard and a display	Free	p/st

HS codes also serve as the starting point for preferential origin rules, quantitative restrictions, and tariff quotas, amongst other trade policy measures. Often, HS based customs codes are referenced in other regulatory domains, too, such as: in the collection of import Value Added Tax (VAT) and Excise Duties as may be indicated in national trade tariff publications (e.g., HMRC 2023b); Sanitary and Phytosanitary (SPS) type controls (e.g., DEFRA and APHA 2023); trade sanctions, prohibitions, and restrictions (e.g., European Commission 2023a); and many other trade and cross-border related control measures (JICA 2012; WCO 2013). HS codes are also used for the collation and analysis of international trade statistics. Correspondingly, customs commodity codes are a core feature in modern electronic control systems, such as those used by customs, other border agencies, and in single window environments (UNECE 2020). They are also integral to national trade information portals (Pugliatti 2012; UNECE 2021) and export market research tools (e.g., ITC 2023a). Economists, trade policy makers, and exporters also rely on commodity codes in their analyses of international trade activity when using specialist software and free online trade research tools (e.g., World Bank 2023; WTO 2023a). Perhaps unsurprisingly, there are a wide range of systems and services that draw on customs commodity code references (Table 1).

Table 1: Examples of public electronic systems and services in English that draw on customs commodity code references

Focus	Examples
Customs administration	<ul style="list-style-type: none"> ASYCUDA ‘s “Harmonized Commodities Code Database”: https://asycuda.org/en/online-hs



Trade Tariff Information (Online)	<ul style="list-style-type: none"> • Bahamas: https://bahamas.prod.3ceonline.com/bsgov • Canada's "Tariff Finder": https://www.tariffinder.ca/en/getStarted • European Union (EU) "TARIC Consultation": https://ec.europa.eu/taxation_customs/dds2/taric/taric_consultation.jsp?Lang=en • Netherlands: https://tarief.douane.nl • New Zealand: https://www.tariff-finder.fta.govt.nz/ • Samoa's "[ASYCUDA] Online Tariff": https://asyworld.revenue.gov.ws/portal/services/tariff/sections.jsf • UK: https://www.gov.uk/trade-tariff • USA's "Harmonized Tariff Schedule": https://hts.usitc.gov/
Trade Compliance Information (Online portals)	<ul style="list-style-type: none"> • Jamaica Trade Information Portal's "Code List": https://jamaicatradeportal.gov.jm/index.php?r=tradeInfo/listAll • Lao PDR Trade Portal's "Search Commodity [tool]": https://www.laotradeportal.gov.la/index.php?r=tradeInfo/index • Nepal Trade Information Portal's "Duty Calculator": https://nepaltradeportal.gov.np/web/guest/duty-calculator • Rwanda Trade Portal's "Calculate import duties & taxes": https://rwandatrade.rw/Tariffs?l=en
Information and support for statistical declarations	<ul style="list-style-type: none"> • EU's "Combined Nomenclature Search Engine": https://eurostat.prod.3ceonline.com/Germany's "Warenverzeichnis Suchmaschine": https://destatis.3ce.com • USA's "U.S. Census Bureau-Schedule B search Engine": https://uscensus.prod.3ceonline.com
Market access information	<ul style="list-style-type: none"> • EU's "Access2Markets": https://trade.ec.europa.eu/access-to-markets/ • ITC and UNCTAD's "Global Trade Helpdesk": https://globaltradeshelphdesk.org • ITC's "Market Access Map": https://www.macmap.org/ • UK's "Export goods from the UK: step by step [tool]": https://www.gov.uk/check-duties-customs-exporting • USA's "Country Commercial Guides": https://www.trade.gov/country-commercial-guides
Origin rules	<ul style="list-style-type: none"> • Australia's "Free Trade Agreement Portal": https://ftaportal.dfat.gov.au • ITC's "Rules of Origin Facilitator": https://intracen.org/resources/tools/rules-of-origin-facilitator • USA's "FTA Tariff Tool": https://www.trade.gov/fta-tariff-tool-search
SPS measures	<ul style="list-style-type: none"> • UK's "TOM risk categories for animal and animal product imports from the EU to Great Britain: searchable list with commodity codes" (DEFRA and APHA 2023)
Single Window service	<ul style="list-style-type: none"> • Ghana's Integrated Customs Management System, "Customs Tariff": https://external.unipassghana.com/login/login.do • Nigeria's Single Window for Trade "Artificial Intelligence powered HS Code Search Engine": https://trade.gov.ng/hscode-search/search?q • Singapore's TRADENET "HS/CA Product Code [search tool]": https://www.tradenet.gov.sg/tradenet/portlets/search/searchHSCA/searchInithSCA.do#
Trade statistics data with online research tools	<ul style="list-style-type: none"> • The World Bank's "World Integrated Trade Solution (WITS)": https://wits.worldbank.org/ • UK's "Trade info": https://www.uktradeinfo.com/ • UNCTAD's "Database on GSP utilization": https://gsp.unctad.org/home • UNCTAD's "UNCTADstat": https://unctad.org/statistics • USA's "DataWeb": https://dataweb.usitc.gov/ • WTO's "WTO STATS": https://stats.wto.org/

Source: author



At present, the WCO's Harmonized System (HS) consist of over 5000 standardised codes at the six-digit level (WCO 2018b). Additional national extensions to the standardised six-digit level are common. In the European Union, for example, the HS code is extended by a further 2 digits to form the 8-digit Combined Nomenclature (CN) code (used for export declarations and the reporting of intra-EU trade statistics) and another 2 digits to form the 10-digit TARIC code that is used for import declarations (European Commission 2023a). The pressure to add yet further codes (and sometime digits) to distinguish one type of goods from another is keenly felt in many policy areas including, for example, goods that are subject to growing "green" trade policy concerns (WCO 2023a). Likewise, there have always been ongoing pressures to amend and update codes to keep in step with product innovations. The HS system is thus often referred to as a "living document" (WCO 2018b) that is subject to regular updates and to differences in interpretation – evidenced, for example, by frequent customs tribunals and court decisions as well as review within the WCO itself (WCO 2022c).

The effort by customs administrations to ensure consistency in interpretation and application can be considerable – ranging, for example, from specialist training to the production and circulation of detailed guidance materials, review mechanisms, and support services. Cross-border operating businesses, who need to work out and declare the correct commodity code, can incur significant costs, too. This includes the need of having to appoint specialists (e.g., trained brokers and consultants), maintain trade and customs compliance systems (which can be tricky where classification decisions vary between countries or are subject to change), or the costs that result from the consequences of getting classification wrong.

Although strict classification rules apply, they are often considered to be difficult to comprehend. Extensive training is usually necessary (European Commission 2019b; WCO 2019), but errors are frequently thought to be made. The Auditor General of Canada, for example, estimates that 20% of goods brought into Canada during the fiscal year 2015-16 were misclassified (AGoC 2017). And it is no secret, evidenced by many tribunal and court rulings, not to mention the discussions amongst classification professionals, that classification rules and code descriptions can be interpreted differently. Most practitioners can give long lists of examples where tariff classification is difficult (Table 1). High instances of poor customs classification outcomes can pose significant challenges for the customs administration – especially where it needs to work out whether misclassifications are deliberate and seek to reduce customs liabilities or circumvent code specific conditions, or an honest mistake (which can lead to demands for over or underpaid duties). Known asymmetries in trade statistics between import and export data are also thought to be linked, in part, to challenges with customs tariff classification (e.g., HMRC 2023a).

Table 1: Examples of classification challenges; practitioner reports

- Goods mistakenly classified as "Other", not aware that more specific codes apply
- Between food supplements administered by medical professionals for the treatment of kidney patients and licensed prescription medicine
- Between incomplete computer networking kits where additional parts are added to the kit upon import and complete kits where no parts are added
- Between monitors for use with desktop computers and monitors for use with medical scanning instruments



- Between the many categories for shoes and textiles – such as the distinction between sport shoes and other types of shoes
- Processed food products where tariff classifications are dependent on the specific recipe
- Many types of chemicals, where classification is dependent on third party testing and the product's specific characteristics
- When the latest HS nomenclature edition adds new codes that apply to goods that were previously classified elsewhere
- Industrial plants and facilities that are shipped in split consignments (e.g., mobile field hospital)

Measures to reduce tariff classification challenges are well established. These include online tools and guidance notes, such as those produced by the WCO (2022d) and by customs administrations (CBP 2023a; GAC 2023b; HMRC 2022). Standard trade facilitation measures, such as online trade information portals detailing tariff classification relevant guidance, or Advance Tariff Rulings by the customs administration (also referred to in many countries as Binding Tariff Information; BTIs) that give business operators a greater level of legal certainty about their use of tariff classification codes, are, thanks to the WTO Trade Facilitation Agreement (WTO 2014), increasingly common (WTO 2023c, 2023d).

The advent of Artificial Intelligence (AI) promises further opportunities for cost and service improvements. These can be observed, for example, in biotech developments (e.g., Smyth 2023) as well as in financial (e.g., Tett 2020) and legal services (e.g., Criddle 2023). There are also a wide range of emerging AI applications in border management that include fingerprint and facial recognition, emotion detection, risk assessment, and in monitoring and forecasting (Dumbrava 2021). AI applications are also being explored within the context of strategic goods controls (Nelson 2020) and are discussed within the context of customs tariff classification (Lux and Matt 2021; UN/CEFACT 2023; WCO 2022e). And, in some places, as will be shown, AI based support tools are already in use. But, there may also be a strong case for regulators to step in, to make sure that new technologies are used responsibly (e.g., Harris and Raskin 2023). This paper reviews current tariff classification practices and the increasing use of new, assistive technologies – especially those found online. The underlying motivation is to help inform discussions amongst users, developers, and policy makers about tariff classification requirements, practices, and the responsible use of tariff classification technologies.

2 Methodology

The research took a mixed method approach that was conducted in an iterative manner and included several feedback cycles with key research informants. It was conducted by Dr Andrew Grainger, who has held senior responsibilities in various online tariff, single window, and trade information portal projects. The research thus draws on: his first-person insights; formal and informal conversations with peers in multiple countries; and detailed exchanges (including interviews) with tariff classification experts, policy makers, and senior staff in various administrations as well as within globally operating businesses. Interesting insights were also gleaned from: the study's sponsor, Avalara, a leading supplier of tariff classification software; numerous public funded customs training workshops for SME business owners (delivered by the study's author); various executive training activities for senior customs compliance managers (also

delivered by the study's author); and exchanges with data scientists. A key component of the research was to collate lists of available online classification tools and engage with those as an expert user. Although Avalara has a vested interest in the outcome of the study, Dr Grainger was given free reign. The sponsor's motivation for commissioning this study is to support conversations about the utility of various classification assistance technologies.

3 Customs Commodity Codes and the Harmonized System

Today, almost universally, customs tariff classifications are based on the WCO's Harmonized System (HS). Its nomenclature is structured hierarchically into 21 sections with a total of 99 chapters of which chapters 98 and 99 are reserved for national uses (if required). Chapter 77 is reserved for possible future use. Each chapter is subdivided into headings and subheadings. The first two digits of the HS code represent the chapter numbers (01 to 97), which are extended with an additional third and fourth digit to become 4-digit HS-headings. These in turn are usually subdivided by a further fifth and sixth digit into so-called subheadings (WCO 2022b). National extensions, which often differ from one customs territory to the next, add further digits. As far as possible, codes are arranged in order of the product's degree of manufacture, or in terms of its technological complexity. For example, the HS code for "Decaffeinated" coffee (0901.12) follows "Not decaffeinated" coffee (0901.11), "Flax yarn, multiple (folded) or cabled" (5306.20) follows "Flax yarn single" (5306.10), and "Platinum, unwrought or in powder form" (7110.11) comes before "Other" forms of platinum (7110.19). Being a "living document" (WCO 2018b), the HS evolves continuously in response to customs and border control needs. While historically tariffs may have been published using simple text descriptors (e.g. "Tea"), such approach can easily lead to confusion (e.g., whether the descriptor "tea" should also include "fruit teas"). By using numeric codes instead, it is possible to be more specific about which goods are subject to control, or if they are not (e.g., by using codes that refer to "Other"). The use of codes also makes it easy to differentiate between goods of similar characteristics. For example, "Tea, whether or not flavoured" (HS heading: **0902**) can be differentiated by reference to following subheadings:

- 0902.10 - Green tea (not fermented) in immediate packings of a content not exceeding 3 kg
- 0902.20 - Other green tea (not fermented)
- 0902.30 - Black tea (fermented) and partly fermented tea, in immediate packings of a content not exceeding 3 kg
- 0902.40 - Other black tea (fermented) and other partly fermented tea

Such differentiation is particularly useful for policy makers that wish to set different tariffs for similar goods (e.g., for black tea and green tea). It can also assist trade policies that seek to encourage or protect value added supply chain activity. One example is "tariff hopping"; some might use the term "tariff jumping". In the European Union, for instance, unroasted coffee (classified under heading 0901.11) has an import duty rate of zero, whereas roasted coffee (classified under heading 0901.21) has an import duty rate of 7.50%. It would thus make sense for coffee roasting facilities to be located within the European Union as opposed to where the unroasted coffee beans originate. Alternatively, supply chains could take advantage of lower EU import tariff rates for roasted coffee that originates from countries with access to the Generalized System of Preferences (GSP; 2.6%), GSP+ arrangements (zero %), or preferential trade agreements (e.g., zero for Central American countries).



Coded categories are also useful for grouping goods subject to specific uses or industries. The HS subheadings for “New pneumatic tyres, of rubber” (HS heading 4011), for instance, distinguishes between tyres used for: autocars (4011.10); buses or lorries (4011.20); aircraft (4011.30); motorcycles (4011.40); bicycles (4011.50); agricultural and forestry vehicles and machines (4011.70); construction, mining or industrial handling vehicles or machines (4011.80); and “Other” (4011.90) (WCO 2022b). Customs code definitions may also be informed by regulatory needs set by international conventions, such as those focusing on the illegal trade in drugs, endangered species, environmentally damaging substances and chemical weapons, or multilateral sector specific trade agreements (Table 3). Further granularity might also be deemed necessary at the national level. In the European Union, for instance, the duty rates for tyres used on aircraft might be zero if “for use on civil aircraft” (TARIC 4011.30.00.10), but 4.5% if “Other” (TARIC 4011.30.00.90) (European Commission 2023a).

Table 2: List of international conventions that have led to requests for HS code accommodations (examples) (WCO 2018b)

International Instrument	Objective
Single Convention on Narcotic Drugs, 1961, as amended by the Protocol amending the Single Convention on Narcotic Drugs, 1961 (UN 1975)	Safeguards against illegal drug trade and production
Convention on psychotropic substances (UN 1971)	
Convention against illicit traffic in narcotic drugs and psychotropic substances (UN 1988)	
Convention on international trade in endangered species of wild fauna and flora (CITES 1973)	Safeguards against illegal trade in endangered species
Montreal Protocol relating to substances affecting the ozone layer (UNEP 1987)	Control in the trade and disposal of environmentally damaging substances
Basel Convention on the control of transboundary movements of hazardous wastes and their disposal (UNEP 1989)	
Appendices 3 and 4 to the OECD Council Decision: the Green and Amber lists of wastes (OSCE 1992)	
Rotterdam Convention on the prior informed consent procedure for certain hazardous chemicals and pesticides in international trade (UNEP 2017a)	
Stockholm Convention on persistent organic pollutants (UNEP 2017b)	
Convention on the prohibition of the development, production, stockpiling and use of chemical weapons, and on their destruction (OPCW 1992)	Chemical weapons controls
WTO Agreement on trade in civil aircraft (WTO 1980)	Zero duty rates for specified industries
WTO Agreement on Trade in Pharmaceutical Products (also known as the Pharmaceutical Agreement or the Pharma Agreement) (WTO 2023b)	

Source: adapted from WCO (2018b)

Often, classification codes also contain reference to characteristics that are useful for the administration of other indirect taxes, such as Excise Duties (e.g., by referencing alcohol content) or Value Added Tax (e.g., where children’s clothes benefit from special treatment, as is the case for the UK). Quality characteristics with different levels of duty often need to be accommodated, too – as is, for example, the case for various types of butchery cuts (e.g., HS heading 0202) as well as rice (HS heading 1006), and wheat (HS heading 1001). Some customs areas may also extend their national tariff codes to distinguish goods by their recipe. The European Union’s *Meursing Code* does this by adding a further 4 digits (on top of its 10-digit HS derived TARIC code) to account for the agricultural





composition (i.e., milkfat, milk protein, sucrose/invert sugar/isoglucose, and starch/glucose) in confectionary, pastry, bakery, and dairy products (EU 2022: 717; Part III, Section I, Annex I). Additional code extensions are also used for reference to export manufacturers that are subject to anti-dumping, countervailing, or safeguard duties. In some cases, there can be hundreds of commodity code specific extensions. Porcelain or china that falls under the description " - Tableware and kitchenware : - - Other " with the TARIC code 6911.10.00.90, and originating from China, is one such example (European Commission 2023a).

Categorising goods by reference to classification codes also enables a more refined approach to the collection and analysis of trade statistics. It is perhaps telling that the original impetus for the HS system was shaped during the nine International Statistical Congresses between 1853 and 1876 (WCO 2018b). Today, we are accustomed to trade statistics that have been compiled by reference to customs commodity codes (e.g., ITC 2023b), though other classification conventions are prevalent, too – such as the Standard International Trade Classification (SITC) system (UNSD 2008), which can (with caveats) be correlated to HS subheadings.

A key feature of the HS is that codes are subject to constant review by the WCO (WCO 2013) and is formally updated every five years (WCO 2018b). Such updates result in new commodity codes and descriptions, amendments, or deletions. For example, the HS 2022 edition, when compared to the previous HS 2017 edition, includes major reconfigurations for the subheadings of heading 7019 for glass fibres and articles thereof; and for heading 8462, for metal forming machinery. The many changes to codes and their description can be explored in the WCO's correlation tables, although extensive updates in text also apply to classification specific chapters and section notes (Weerth 2017).

Formal updates at the national level can be more frequent than those of the WCO – e.g., annually as is the case in the European Union (EU 2022). In addition, there are also tribunal and court decisions as well as national guidance materials to consider, which are usually issued as and when. And with the evolving responsibilities of customs services – that include revenue collection, trade facilitation, and the protection of society (WCO 2022g) – categorisation and classification needs are likely to evolve at pace. The need to mitigate climate change amongst other “green” and sustainability issues is one such policy portfolio with potentially significant HS code implications (WCO 2023a). The alternative, where the granularity for HS codes is insufficient for control needs, customs administration may have to draw on additional coding systems – such as those used for customs processing (so-called “customs procedure codes”) – or avail themselves of HS Chapters 98 and 99, which are reserved for non-harmonised national requirements (WCO 2013).

4 Classification

A key principle of the HS is that there is always only one correct customs commodity code for a given product. That code must be determined by reference to the so-called General Interpretative Rules (GIRs) – of which there are six (Box 1) – and always starting with GIR1. GIR1 holds that tariff classification must be in accordance with the description of the heading. Identifying the correct HS heading may require some understanding – some might use the word “intuition” – about how the HS is structured, and what is covered in its various Sections and Chapters. Chocolate, for example, if containing cocoa, is likely to fall under heading 1806 (“Chocolate and other food preparations



containing cocoa”). But white chocolate that only contains cocoa butter and not cocoa belongs to heading 1704 (“Sugar confectionary including white chocolate, not containing cocoa”) (GAC 2023a). Similarly, an electric toothbrush is ordinarily classified as an “Electro-mechanical domestic appliances, with self-contained electric motor, - Other appliances” under 8509.80, and not under 9603.21, which provides for “ -- Toothbrushes, ..”.

Box 1: Abridged General Interpretive Rules (GIRs) for the WCO’s Harmonized System

The first rule of the Harmonized System (HS), General Interpretative Rule 1 (GIR1), is that tariff classification must be in accordance with the description of the Heading (i.e., the first four digits). Section notes, found at the beginning of each of the HS’s 21 Sections, along with chapter notes, are to be used in support of identifying the most appropriate Heading. Once the Heading is found, the most appropriate HS-subheading must be selected. A pure-bred horse, for example, is correctly classified within **Chapter 01** “Live Animals” under the **Heading 0101** “Live horses, asses, mules and hinnies” and the subsequent **Subheading 0101.21** for “pure-bred breeding animals.

Heading	H.S. Code	
01.01		Live horses, asses, mules and hinnies.
		- Horses :
	0101.21	-- Pure-bred breeding animals
	0101.29	-- Other
	0101.30	- Asses
	0101.90	- Other

Rule 2 (GIR2) is for incomplete, or unfinished goods and mixtures. It has an (a) and (b) component. 2(a) states that reference in a Heading to an article shall also apply to: incomplete and unfinished articles with the essential character of the complete or finished article; and articles in an unassembled or disassembled state. 2(b) states that reference in a Heading to a material or substance shall include mixtures and combinations containing those materials. It also states that goods made of a specific material include goods consisting wholly or partly of that material. However, where Rule 2(b) indicates two or more Heading options, Rule 3 also applies.

Rule 3 (GIR3) is the rule by which decisions are made. It states that where goods are *prima facie* classifiable in two or more Headings, the following principles apply:

- (a) the Heading which provides the most specific description shall be preferred to Headings providing a more general description. However, all Headings relating to only part of the goods are equally specific
- (b) mixtures, composite goods, and sets are to be classified according to material giving them their essential character
- (c) goods not classifiable under (a) or (b) are to be classified under the last applicable Heading (i.e., the higher number)

Rule 4 (GIR4), which is a catch-all rule that is rarely used, states that goods not classifiable under Rules 1-3 are to be classified as the goods to which they are most akin.

Rule 5 (GIR5) concerns the classification of cases and packaging materials and has an (a) and (b) component. 5(a) states that cases, boxes, and similar containers intended to fit and be sold with particular articles (e.g., camera case sold with camera) are to be classified with such articles unless the container gives the article its essential character. 5(b) states that subject to Rule 5(a), packing materials, and containers are to be classified with the goods therein (e.g., milk carton containing milk would be classified as milk). However, this provision is not binding within the framework of the HS if materials or packaging containers are clearly suitable for repetitive use (e.g., a reusable beer keg)

Rule 6 (GIR6) relates to subheadings and confirms that Rules 1-5 apply equally to both headings and sub-headings; that only sub-headings of comparable status (indicated by the number of dashes in front of them) can be considered; and that Section and Chapter notes apply to sub-headings unless the context requires otherwise.

Source: edited extract from Grainger (2021) and based on WCO (2022b)

Considering such complexities, detailed guidance notes and materials are often essential. These are provided in the form of binding Section and Chapter Notes within the HS nomenclature itself. Not binding but guiding are the extensive WCO's HS Explanatory Notes that are published by the WCO in addition to the HS (WCO 2022d). Often, customs authorities also publish their own explanatory notes for tariff classification (e.g., BAZG 2023; European Commission 2019a; Zoll 2023), along with guidance specific to particularly challenging classification tasks (e.g., CBP 2023a; GAC 2023b; HMRC 2022). Important to consider, too, are Court and Tribunal rulings (e.g., Courts and Tribunals Judiciary 2020), which may define and set further national principles about how the GIRs should be interpreted in specific circumstances (e.g., Lyons 2008). Prudent businesses that ship goods known to be ambiguous for tariff classification purposes will apply, where possible, for binding tariff classification rulings. These are usually valid for a specified period (e.g., three years for the EU) and reduce the risk of classification related challenges at border crossings or during post-clearance customs audits.

Inevitably, the process of establishing the correct commodity code must be based on the good's objective properties and characteristics (Lyons 2008). Classification workflows that draw on the GIRs may thus begin with an initial assessment of the good's purpose and its material composition and subsequent locations within the HS. For example, at face value, as explained by Witte and Wolfgang (2021), a furniture table made from wood may lend itself for classification in HS chapter 94 "Furniture" or chapter 44 "Wood and Articles of Wood". But the text in the subheadings, which in this case refer to materials and use, would suggest that the classification under "Other furniture" (HS heading 9403) in chapter 94 might be more appropriate (Table 3). It is also prudent to check the HS's respective section and chapter notes to establish whether any specific clarifications, or exclusions apply. And indeed, the notes for chapter 44 clarify that wooden furniture articles belong to chapter 94. Further clarifications, such as for wooden furniture made for specific purposes, or more than one type of material, can be found in in the HS Explanatory Notes (WCO 2022d), amongst other public guidance notes and opinions (e.g., European Commission 2019a).

Table 3: HS code extract for 9403 with reference to wooden furniture

9403 30	- Wooden furniture of a kind used in offices
9403 40	- Wooden furniture of a kind used in the kitchen
9403 50	- Wooden furniture of a kind used in the bedroom
9403 60	- Other wooden furniture

For most classification experts, probing evaluation questions for working out the most suitable HS heading are likely to focus on the goods': composition (e.g., leather or steel); the degree of processing (e.g., yarn, fabric, or shirt); intended use or purpose, or function (e.g., for medical, surgical, or veterinary uses); amongst other criteria like size, weight, method of operation, performance, contents, or ingredients (see Lux and Matt 2021). In cases of ambiguity, the goods'



essential characteristics may need to be considered, too. To give one example, in the case of a “Tweety [bird] interactive plush alarm clock” [an interactive soft toy with sewn in alarm clock capabilities] it was ruled by US Customs in 2000 (G82479) that the essential character is that of “Toys representing animals or non-human creatures...” (under heading 9503) and not that of an alarm clock.

Workflows that seek orientation within the HS code can also include the consultation of the WCO’s Alphabetical Index (WCO 2023c), or similar (HMRC 2023c; USITC 2022). These specialist publications seek to match common types of goods description – listed in alphabetical order – with possible HS heading contenders. Practitioners can also consult specialist research databases for reference to prior rulings and decisions (e.g., CBP 2023b; European Commission 2023c). And, if goods have already been classified, workflows may also include checks for code changes that have resulted from updates to the HS and national extension. Such checks are usually done manually or electronically using correlation tables in which code changes, amendments, and deletions between editions are highlighted (WCO 2022f).

For chemicals and pharmaceuticals, orientation within the HS can be guided by specialist databases that draw on Chemical Abstracts Service registration numbers (CAS RN) of the American Chemical Society and UN Dangerous Goods Numbers (UN 2021). The EU’s online European Customs Inventory of Chemical Substances (ECICS) consultation database (European Commission 2023) is such a tool that can also be used by reference to Customs Union and Statistical Numbers (CUS) and EC [chemical] Numbers. Ammonium Nitrate with the CAS RN 6484-52-2 may thus be matched to the HS code 3102.30 (“Ammonium nitrate, whether or not in aqueous solution”) or 3602.00 (“Prepared explosives, other than propellant powders”). Nevertheless, the classification of chemicals and pharmaceuticals is frequently considered to be particularly difficult and can require detailed product specific expertise – prominent experts in this field may have a PhD in Chemistry (listen to PEN-CP 2023a).

Noteworthy is that all classification experts, compliance professionals, and trainers consulted for this research shared anecdotes that suggest a prolific use of short-cuts (Table 4). Where such short cuts have been taken, the risk for misclassification is likely to be significant. It was also highlighted that the temptation for taking short cuts can be high when overwhelmed by the compliance burden, as might be the case for untrained or inexperienced staff.

Table 4: Commonly reported tariff classification short-cuts; anecdotes

Short-cut	Risk
“We used the tariff code indicated on the supplier’s invoice”	<ul style="list-style-type: none"> • There is no guarantee that suppliers classify their good correctly. Moreover, there is a high risk that the correct tariff classification for the country of export differs to that of the country of import – especially when taking non-standardised national extensions to the HS code into account • Dishonest suppliers may have a vested interest in suggesting false tariff codes that attract no duty (and thus making their goods appear to be more competitive).
“We used this code last time, so it must be correct this time”	<ul style="list-style-type: none"> • The HS is a living document, and codes are updated from time to time • Customs administrations may find it more effective to check the correct use of tariff classifications during periodic, post-clearance compliance audits (every few years) – and not when goods are declared for import or export.





“We just Google it”	<ul style="list-style-type: none"> Although search engines can lend some initial orientation, results are unlikely to be specific enough for a robust justification (e.g., during a customs audit).
“The software told us”	<ul style="list-style-type: none"> If not properly used or configured, this may be problematic. Several research informants have shared anecdotes of good and poor practices, as well as positive and negative experiences that can differ by industry sector and the software tool used.

5 Classification Costs

For most customs practitioners – whether in the public or private sector – a detailed understanding of tariff classification is an essential prerequisite for entering the profession. Customs commodity codes are the foundation upon which most customs controls rest. But the resulting expense associated with classification depends, to a large part, on the scale of classification specific activity, the volume of items that need to be classified, and the appetite for risks that result from misclassification. And perspectives about the costs and effort involved can differ significantly between those administering controls, and those that seek to comply. Many of the costs associated with tariff classification are self-evident, such as the time needed to become familiar with HS classification rules and understanding how to use them (European Commission 2019b; WCO 2019). In some countries, formal accreditation as a customs professional might also be necessary (Grainger 2021; WCO 2018a). Training costs can thus be substantial. And there is also a set-up cost to be considered. Commercial subscriptions to guidance documents and materials – especially those sold via the WCO Bookshop, for example – are essential for professional customs consultants and experts. There may also be language barriers and translation costs to consider, if operating languages are not the same as the official languages of the WCO (i.e., French and English).

5.1 Business compliance costs

These depend largely on the number of goods and their specific characteristics that need to be classified. For many types of businesses, the number of goods that need to be classified can be quite small. That’s because they only trade occasionally, or in goods that are relatively uniform and unambiguous from a classification point of view. After establishing applicable codes, the remaining task is to follow code specific developments in the HS (usually every 5 years), or national extensions (usually once a year) and then to update the used codes where necessary. Some businesses may draw on the services of specialist consultants or qualified brokers to assist with customs classification tasks. Advance binding tariff rulings issued by the customs administration can give applicants an additional layer of legal certainty – but these take time and effort to prepare.

For businesses with thousands, sometimes hundreds of thousands of items that need to be classified (as can easily be the case for operators in the automotive and retail sector), tariff classification can be an extensive undertaking. If the company has an operational footprint in multiple countries, it also needs to ensure that the correct codes, which can differ by country, are applied for each of those countries. In the event of errors, mistakes, or changes, a good record keeping system can support conversations with the administration about how to make retrospective corrections. It is usually also prudent to track how commodity codes are used for preferential origin rules and other measures with impact on trade tariffs, so that retrospective corrections – if necessary – can be





made. All these activities have a cost. And the implementation and maintenance of robust record keeping systems is an expensive undertaking.

A common approach to managing tariff classification requirements is to systematically identify and record applicable commodity codes in the company's electronic systems by reference to unique product identifiers – such as material reference numbers, product catalogue numbers, or so-called “stock keeping units” (SKUs). To keep the classifying task manageable, some compliance managers may distinguish between items critical to their business and those that are less so. Critical items receive close attention to make sure they are always correctly classified. For less critical items, minor non-compliance risks with subsequent implications may be deemed acceptable. Customs compliance managers may mitigate non-compliance risks through systematic probing. Third party classification audits may be procured to assist with such activities. Robust record keeping systems enable retrospective corrections where necessary. It is not uncommon for such companies to utilise specialist software to assist with the classification of less critical goods. It is also likely that such companies draw on the services of tariff classification specialists – and these, too, may be assisted by specialist (sometimes proprietary) software tools.

Indirect costs that result from misdeclaration, including disputes with the administration, can lead to adverse control outcomes. These include the risk of increased border delays with all their subsequent costs (e.g., Grainger et al. 2018) as well as the time and cost impacts that result from time-consuming customs compliance audits. Penalties and fines can be high. In extreme cases, where misclassification has been found to be deliberate, custodial sentences apply (e.g., BBC 2012). An important point to make in this context is that the fear of fines along with the HS's complex and technical language can be off-putting. New and inexperienced businesses may choose – unless helped – to forgo international trade opportunities. Practical training, guidance, and support – including the offer of free assistive classification tools – can help reduce such hesitancy.

5.2 Public administration costs

For public administrations, the costs associated with tariff classification can be significant, too. Staff need to be trained in how to use and check them. Detailed guidance materials along with instructions and internal support services are usually necessary to ensure consistently correct application. The ecosystem that maintains tariff classification codes also includes the cost of courts and tribunals. Tariff classification experts within customs administrations are usually also relied upon to assist and advise colleagues in organisations that are less familiar with classification. Subsequently, much of their work relates to the production of guidance materials.

Leading classification experts are also likely to spend some of their time coordinating classification views and opinions at international and global levels, such as through the WCO's Harmonized System Committee (WCO 2015) and the drafting of Explanatory Notes (WCO 2022d). Coordination of views may also be necessary at regional levels (e.g., ASEAN 2023; European Commission 2019a) and bilateral levels, such as within the framework of FTAs and international customs cooperating committees. There are also public service expectations, including, for example, online and telephone support services along with the publication of additional guidance materials. Often, this is offered as part of a wider online trade support service that includes: customs tariff publications; guidance tools for the reporting of trade statistics; and public tools to interact with statistical trade data. Many





traders also expect – for example, by reference to the WTO Trade Facilitation Agreement (WTO 2014) – that advance, binding tariff rulings can be provided within reasonable time frames.

A key cost area can also be the public expense associated with checking, testing, and auditing declared classifications – though in many countries such costs are passed on by the administrations to shippers in the form of customs and inspection fees (Grainger et al. 2018). Larger transport and shipping operators wishing to ensure smooth border clearance processes may also take on some of the enforcement burden. For example, they may check whether the goods descriptions offered by shippers match the provided HS codes. Prudent intermediaries may also check that goods descriptions do not contain any ambiguous wordings. For example, EU guidance about permitted goods descriptions state that “Auto Parts” would be an insufficient description, but that the more specific “Automobile Brakes” or “Windshield Glass for Automobiles” is acceptable (European Commission 2021).

A common concern by regulators are deliberate misclassifications that result in lower revenue yields. Dishonest operators could, for example, declare a code that has a lower tariff rate, achieve a more favourable preferential origin outcome, or circumvent additional antidumping duties. And the impact of such deliberate misclassification attempts, if not prevented, can be high (CBP 2020; Thibedeau et al. 2022). Thus, most customs administrations are likely to take actions that seek to reduce such revenue risks (WCO 2022a). Some administrations may even highlight which specific commodity codes are subject to closer attention (CBSA 2023). But, where tariff classification mistakes are accidental (“honest mistakes”), the cost to the revenue is less clear. Anecdotes offered by interviewed officials and customs compliance managers suggest that the likelihood of inadvertently using the wrong classification code with a higher, lower, or the same trade tariff is balanced. The Revenue – as far as honest mistakes are concerned – may thus be no better nor worse off. But further research to test this assumption against deliberate misclassification attempts would be prudent.

It is also observable that the regulator’s sensitivity about accuracy can differ. For example, pressure for accuracy may be less pronounced amongst those concerned with trade statistics, especially when analysis tends to deal in aggregates and can also draw on other sources of trade data (e.g., surveys, procurement data, transport data, etc). Nevertheless, policy makers concerned with the quality of trade statistics are keen to ensure that the datasets collected are as robust as possible. There are several examples where government agencies have procured or developed tools to help businesses with getting classifications right (e.g., DESTATIS 2023; eurostat 2023; USCB 2023). Businesses in the European Union that must make intra-EU statistical declarations (referred to as “Intrastat declarations”) may also avail themselves of a simplified non-binding “self-explanatory text”. A key characteristic of the self-explanatory text is that it aims to be easier to follow and omits much of the HS’s frequent use of “Other” categories. HS Code 0902.20 for “Other green tea (not fermented)”, for instance, is described in the self-explanatory text as “Green tea in immediate packings of > 3 kg” (eurostat 2023).

6 Electronic classification tools

There are many use cases for assistive tariff classification technologies. As touched upon, tariff classification software is routinely used – under the critical supervision of humans – in companies



where thousands, sometimes hundreds of thousands, of tariff classification codes need to be determined and monitored. Some of that software might be configured or developed in-house, or it might be accessed via procured services – such as those offered by customs brokers and tariff classification specialist. Some software solutions can be procured off-the-shelf and are advertised in journals like WCO News, amongst other places, and are often showcased at trade fairs (e.g., WCO 2023b).

But use cases have also been reported for the public sector, where commercial tariff classification software has been deployed to compare goods descriptions with the declared commodity codes. The resulting analysis can then be used to identify areas for concern and subsequent customs interventions (e.g., Thibedeau et al. 2022; WCO and WTO 2022). Potentially, publicly deployed tariff classification technologies can also be used to sense-check (some might use the term “validate”) commodity codes before they are declared via electronic means – e.g., by asking users whether they are sure the declared codes and goods descriptions are correct. Some interviewees explained that tariff classification technologies can also be used to support tariff classification helpline enquiries via phone or webchat – for example, for directing users to the right subject matter experts (triage). And, it was often suggested that good tariff based online business information services are essential for assisting SME businesses in their export ambitions (e.g., to better understand market opportunities, duty obligations, compliance requirements, and preferential origin rules).

Increasingly common for public administrations is to make sure their national tariff publications are published online – as might be expected under WTO Trade Facilitation Commitments (WTO 2014). Many such online tariff publications include functionalities aimed at assisting users with identifying relevant tariff classifications. A broad review of these suggests that there are three types of technological approaches to recommending tariff classifications (Table 5). These are: text and keyword enhanced search engines; expert systems; and machine learning tools. The latter two are often also referred to as AI types of technology. Results can be variable which, if not suitably caveated, can potentially leave users with little or no tariff classification knowledge at risk – unless solutions clearly explain how the correct tariff classification has been obtained.

Table 5: Examples of online tariff information sources by HS code search functionality

Technology	Country / Region	Name	URL
Text based approaches			
Search	Australia	Free Trade Agreement Portal	https://ftaportal.dfat.gov.au
Search	Dubai	HS Code Search	https://www.dubaitrade.ae/en/dc-hs-code-search
Search	European Union	TARIC Consultation	https://ec.europa.eu/taxation_customs/dds2/taric/taric_consultation.jsp?Lang=en
Search	Ghana	Ghana’s Integrated Customs Management System	https://external.unipassghana.com/login/login.do
Search	Jamaica	Jamaica Trade Information Portal	https://jamaicatradeportal.gov.jm/index.php?r=tradeInfo/listAll
Search	Lao PDR	Lao PDR Trade Portal	https://www.laotradeportal.gov.la/index.php?r=tradeInfo/index

Search	Nepal	Nepal Trade Information Portal	https://nepaltradeportal.gov.np/web/guest/duty-calculator
Search	Netherlands	Tariff	https://tarief.douane.nl/arctictariff-public-web/#!/home
Search	New Zealand	Tariff Finder	https://www.tariff-finder.fta.govt.nz
Search	Samoa	Online Tariff	https://asyworld.revenue.gov.ws/portal/services/tariff/sections.jsf
Search	Singapore	Singapore's TRADENET "HS/CA Product Code [search tool]"	https://www.tradenet.gov.sg/tradenet/portlets/search/searchHSCA/searchInitHSCA.do#
Search	USA	Harmonized Tariff Schedule	https://hts.usitc.gov/
Keyword enhanced	Switzerland	Swiss online tariff	https://xtares.admin.ch/tares/login/loginFormFiller.do?!=de
Keyword enhanced	United Kingdom	Trade Tariff: look up commodity codes, duty and VAT rates	https://www.gov.uk/trade-tariff
AI types of technology			
Expert System	Bahamas	Describe your product	https://bahamas.prod.3ceonline.com/bsgov
Expert System	Canada	Canada Tariff Finder	https://www.tariffinder.ca
Expert System	Germany	Warenverzeichnis Suchmaschine	https://www.destatis.de/DE/Methoden/Klassifikationen/Aussenhandel/warenverzeichnis-suchmaschine.html
Expert System	USA	U.S. Census Bureau-Schedule B search Engine	https://uscensus.prod.3ceonline.com/
Machine Learning	Abu Dhabi	Smart HS Classification Tool	https://www.tamm.abudhabi/services/mobility/adf/workspace/smart-classification-system/search
Machine Learning	Nigeria	Federal Government of Nigeria Single Window for Trade	https://trade.gov.ng/hscod-search/search?q
Machine Learning	WCO BACUDA project	AI HS Code Recommendation Platform	http://49.50.165.5:19090

6.1 Text and Keyword Enhanced Search Engines

Text search approaches draw on the text published in the customs tariff, including the respective commodity code descriptions. A search for “Computer” in the EU’s online TARIC tool (which includes text search functionality) would thus draw attention to a code listed in HS chapter 38 “Miscellaneous Chemical Products” for which one of the TARIC code descriptions includes the word “computer”² (European Commission 2023a). The search does not return any results specific to heading 8471 for “Automatic data processing machines”³ under which computers would normally be classified. Likewise, inexperienced users may be overwhelmed if searching for a “paper shredder” in the USA’s online Harmonized Tariff Schedule (USITC 2023). This yields 243 search results that refer to

² i.e.. TARIC 3824.99.96.55 which refers to “ - styrene acrylate copolymer to be mixed with the toner powder, in the manufacturing of ink/toner filled bottles or cartridges for facsimile machines, **computer** printers and copiers”

³ “Automatic data-processing machines and units thereof; magnetic or optical readers, machines for transcribing data onto data media in coded form and machines for processing such data, not elsewhere specified or included”



commodity code descriptions containing the words “paper” or “shredder” – and none for an office paper shredder that might be classifiable under 8472.90⁴. To reduce such confusion, text search functionality may accommodate Boolean Operators that reduce the number of search results. Online ASYCUDA based tariff publications (ASYCUDA 2023), for example, can restrict search from “Contains Any” to “Contains All” (e.g., MoCR 2023).

A text search functionality that is keyword enhanced can often offer more suitable results. The search for “Computer” within the online customs tariff of the Maldives Customs Service yields the correct HS heading 8471 (“Automatic data processing machines”) even though the text for that heading and its subheadings does not contain the word “Computer”. Such search also returns suggestions for classification falling under HS headings specific to chapter 85 that concerns electrical machinery and parts thereof, such as “CRT Monitors” (HS heading 8528) (MCS 2023). Given the prevalence of Alphabetical Index type publications (HMRC 2023c; USITC 2022; WCO 2023c), it is relatively easy to build and develop keyword enhanced search functionality.

6.2 Expert Systems

Expert systems in their early years of deployment were described as a significant innovation (e.g., Leonard-Barton and Sviokla 1988) and their use is now widespread. Commercial expert systems for tariff classification have been available for at least two decades; and subsequent to progressive developments have become increasingly sophisticated. Now the public can also access such systems free of charge by using a growing number of online deployments (Table 5). Expert systems are often described as computer programs that are designed to emulate the decision-making process of humans, mainly by applying “if-then rules” (Bidgoli 2003; Leonard-Barton and Sviokla 1988). And, expert systems are likely to have two components. One is the knowledge base that represents facts and rules about the commodities described in the HS nomenclature and is typically built by domain experts (e.g., mechanical engineers, minerologists, textile and fibre engineers, etc.). The other is an inference engine that applies logical rules to the knowledge base to deduce new information (built by AI specialists and HS classification experts).

A key feature of expert systems is that users may be required to interact with them before query results are returned. For example, within the context of tariff classification, user may have to answer a set of questions before a tariff code is suggested – especially, if the initially entered goods description and underlying assumptions are insufficient for definitive HS classification purposes. Such probing questions by the software about the goods help build a more complete picture of its HS-relevant defining characteristics. These then enable the software to deterministically orientate itself – just like a human – within the HS nomenclature before making a classification suggestion. Such software, as has been explained by developers, usually also relies on sophisticated language models to help make sense of the user’s commercial goods descriptions – for example by recognizing that a “blow dryer” is referred to in the HS as a “hairdryer” falling under heading 8516 (“Electrothermic hairdressing or hand-drying apparatus”); and that “3d printers” equals “Machines for additive manufacturing” (heading 8485).

⁴ “Other office machines (for example, hectograph or stencil duplicating machines, addressing machines, automatic banknote dispensers, coin-sorting machines, coin-counting or wrapping machines, pencil-sharpening machines, perforating or stapling machines). – Other”





The Canada Tariff Finder is one example of a publicly accessible expert system (BDC et al. 2023). If tasked with classifying “woven men’s blazers”, for instance, the user is prompted to provide further product details, including the blazer’s composition, as it works its way towards the appropriate commodity code. Users can, if they so choose, also change their answers to explore whether this has an impact on the suggested code. Users can also send feedback to the software developers, which is then used to improve the service. In this context, it is worth highlighting that expert system software is only as good as the expert knowledge it has been imbued with. Just like humans, they can fail if the given textual description of the goods is not understood, or if details necessary for making the correct classification decision are missing or out of date. However, where such information is complete, the software can – as highlighted by several interviewees – be remarkably reliable, quick, and intuitive. Other examples of online expert system implementations include the EU’s *Eurostat* Combined Nomenclature Search Engine (eurostat 2023) and the German Statistics Office’s goods list search engine (DESTATIS 2023). Both are designed to assist users with finding the right customs commodity codes for inter-EU statistical declarations. Similar expert system technology is also deployed by the United States Census Bureau (USCB 2023) to assist exports with determining the correct Schedule-B Number (consisting of the six digit HS code and an additional 4-digit US-code for statistical analysis).

6.3 Machine Learning

Machine Learning approaches in public tariff classification services are a more recent phenomenon – but the underlying ideas date back a few decades. Machine Learning is often described as “the field of study that gives computers the ability to learn without explicitly being programmed” – a definition that is attributed to the work of one of its pioneers, Arthur Samuel (Brown 2021; Samuel 1959). In practice, machine learning is commonly referred to as an automated method for searching patterns in data. Techniques include supervised, unsupervised, and reinforcement learning methods (Shaw 2022). A prominent example of machine learning approach to tariff classification is the recently launched “AI HS Code Recommendation Platform” that was developed under the framework of the WCO’s BACUDA Project in collaboration with the Nigerian Customs Service (WCO 2023d). It has been designed to predict the most likely HS code by drawing on a model that uses historical customs declaration data. Answers are presented as a list of recommend HS codes in order of the model’s predicted likelihood (WCO 2022e). When testing the model for the purpose of writing this paper, it suggested that the correct HS code for a “drone” might be 8525.90 (with a probability of 54.16%), 9007.10 (with a probability of 23.96%), or 8543.70 (with a probability of 21.88%). However, all suggested answers do not appear to match the WCO’s most recent guidance materials, which would suggest a classification that falls under the HS 2022’s new heading 8806 (“unmanned aircraft”), nor does it distinguish between drones with utilitarian functions (like photography) and drones used as recreational toys. Another example of machine learning in tariff classification support services is Nigeria’s online Customs Single Window Service (NCS 2023), which suggests with 99.65% probability that the classification for a “drone” might fall under HS subheading 8802.11 for “ - Helicopters : - - Of an unladen weight not exceeding 2 000kg”. It would thus appear that these predictions do not take the drone’s specific characteristics into account, as a human or expert system might do. Predictions also appear to be bias to historic classification practices, including erroneous declaration data, as opposed to the latest requirements. For machine learning tools to be effective, it is thus important that the data used for training is suitably reliable (Redman 2018).





Perhaps also noteworthy is that Nigeria's and the WCO's online classification tools struggle with interpreting the meaning of user entered text. Their respective classification recommendations for a "mouse" fall under heading 8471, which is only appropriate if it were a computer mouse. But no heading suggestions are offered for pet rodents. And, if a user were to enter "pet mouse" into the WCO's tool, the resulting tariff classification recommendations (perhaps worryingly for the pet owner) fall under heading 3808 – as might be appropriate for rodenticides. Similar struggles can also be observed in the classification of "Jack" (a connector for headphones or misspelt jacket, but also a type of fish or bird [whiskey jack] as well as a lifting tool and a colloquial term for a famous American drink that is mixed with cola). Although the WCO system is experimental in ambition, the example of its predictions does reiterate that there are two parts to automatic tariff classification. The first is to understand the meaning of the described goods (e.g., is the mouse a living creature or something that you connect to a computer) and second, to then work out where in the tariff that good might be best classified.

6.4 Accuracy

The level of accuracy of electronic customs classification tools is a key concern for customs tariff classification experts. This is in part driven by the knowledge that many users might be prone to short cuts, and much of their professional life – especially if working for businesses – is to implement operating procedures and systems that ensure the company is always compliant (e.g., see Grainger 2016). Customs officers, too, are familiar with many examples that suggest large parts of the business community may be prone to getting classification wrong, especially when new to cross-border trade – more so, perhaps, with the rise of ecommerce related trade activities.

Inevitably, the level of accuracy depends on what classification tools have been deployed, and the types of goods that have been presented to them. For many types of goods and trades, the HS is likely to be unambiguous and, with a bit of induction, relatively easy to use. But, there are also many goods where classification presents challenges that apply to humans and electronic tools, too. A search for "pumps" with a solution that takes a keyword approach, may yield all sorts of confusing results – ranging from shoes (pumps are a type of shoe) to pumps that can be used for circulating liquids in a wide range of applications (e.g., medical equipment, construction, mining, fire engines, parts for all manner of machinery). Getting to the right code requires extensive analysis of the pump's characteristics which a keyword search or a machine learning approach on its own is likely to struggle with.

Table 6 illustrates some of the diversity in results that can present themselves when classifying "marmite" – a light-hearted test⁵ that was deployed to explore how the various tools (and experts) may approach customs tariff classification. This example offers some interesting insights. Human experts stated that it took them on average about 3 minutes to derive at their answer. However, several also stated that if they were to push for certainty, they would be inclined to press the customs administration for a binding tariff ruling. Some, who were not familiar with the product "marmite", used online search engines to read-up on the product, but also to check for published classification relevant materials. The successful keyword search in the UK tariff suggests that the UK Customs Administration (HMRC), at some point, felt the need to link the keyword "marmite" to 2103.90. (Perhaps, and this is speculation, because the product is widely available in the UK and is

⁵ with research informants and via a LinkedIn blog post



often shipped to expatriates living abroad). The Canada Tariff Finder, drawing on expert system software, appears to have been correctly trained for the type of product described in Box 2, too. However, it would let down English language users who typed “a marmite” and wanting the customs tariff classification for a marmite cooking pot (– although the description “marmite pot” would lead to the correct results). Interestingly, the French language version of the Canada Tariff Finder does ask users whether “*le marmite*” is a “*pot de caisson*” (cooking pot) or a “savoury food spread” before proceeding with offering the applicable tariff suggestions. Nigeria’s “Single Window: Artificial Intelligence powered HS Code Search Engine” which takes a machine learning approach, appears to be unaware of the marmite brand and only offers classifications relevant to cooking pots.

Box 2: Marmite – as described by Andrew Grainger in a LinkedIn hosted tariff classification challenge

“Marmite – it is a product that according to its marketers is much loved and hated in equal terms. In the UK you might find it on the breakfast table – or not – and is usually used sparingly as a spread on buttered toast. In our household, we also use it to make Nigella’s delicious “Marmite Spaghetti”. Marmite here serves as a substitute for the “leftovers-of-a-roast-dinner” (Intrigued? ... google it!). If you are at home in Malaysia or Singapore you might also be familiar with Marmite Chicken, for which Marmite is a key ingredient in the cooking sauce.

More details about Marmite can be found on Wikipedia (...where else?). And according to a recently attended YouTube factory tour, Marmite is made from concentrated yeast extract: a by-product of the brewing industry. Any alcohol contained within the yeast extract is evaporated and is used by the factory as an alternative energy source.

There are sister products, such as the Australian “Vegemite” and the German “VITAM-R”. The latter, as far as I am aware, is sold predominantly in health-food shops.”

Table 6: Recommended HS codes for “marmite” by technology type; May-June 2023

Tool by technology [url]	Recommended HS code	Commentary
Human tariff classification experts (worldwide); approached via social media, interviews, and email exchanges – largely by hand using Section and Chapter descriptions for initial orientation	2103.90 “Sauces and preparations therefor; mixed condiments and mixed seasonings; mustard flour and meal and prepared mustard - Other ”	There was consensus about 2103.90, but some mentioned that they initially also considered: 2106 “Food preparations note elsewhere specified or included : - Other “. Some also highlighted that a google search revealed a US tariff classification ruling that places marmite under 2103.90.4000 (NY041215), which in the US tariff is explicitly for “Non-alcoholic preparations of yeast extract (other than sauces)”. Finding this reference has influenced their thinking about the product and its classification.
UK “Trade Tariff: look up commodity codes, duty, and VAT rates” – keyword search [https://www.gov.uk/trade-tariff]	2103.90 “Sauces and preparations therefor; mixed condiments and mixed seasonings; mustard flour and meal and prepared mustard - Other ”	The keyword search for “marmite” points straight to the HS code 2103.90 but does not clarify what the most appropriate national extension (i.e., the four digits that follow the HS heading) might be.

Swiss online tariff – keyword search [https://xtares.admin.ch/tares/login/loginFormFiller.do?!=de]	No results	The absence of results may suggest that the keyword “marmite” has not been recognised by the software.
ASYCUDA ‘s “Online 2017 Harmonized Commodities Code Database” – keyword search [https://asycuda.org/en/online-hs]	No results	The absence of results may suggest that the keyword “marmite” has not been recognised by the software.
ITC and UNCTAD’s Global Trade Helpdesk “Advance HS code search” – text search [https://globaltradeshelphdesk.org/en]	No results	The absence of results may suggest that the keyword “marmite” has not been recognised by the software.
Australian Government Free Trade Portal – text search [https://ftaportal.dfat.gov.au/]	No results for “marmite” nor for the Australian “vegemite”	The absence of results may suggest that the keyword “marmite” has not been recognised by the software.
“Canada Tariff Finder [English language]” – Expert System [https://www.tariffinder.ca]	2103.90 “Sauces and preparations therefor; mixed condiments and mixed seasonings; mustard flour and meal and prepared mustard - Other ” Note: Identical HS codes recommendations have also been made by other 3CE/ Avalara-powered implementations, albeit with variations for the national extensions (BCD 2023; DESTATIS 2023; European Commission 2023b; USCB 2023)	The tool did not ask for any further clarifications about the product’s characteristics and immediately offered the right HS code, followed by an invitation to explore the most appropriate national extensions for imports into Canada. Interesting to note is that the tool’s “Review” button allowed users to change the presumed end-use characteristics from “Other” to “Animal feed” – in which case the tool suggested 2309.90 “ - Preparations of a kind used in animal feeding. - Other “
“Nigeria Single Window: Artificial Intelligence powered HS Code Search Engine” – Machine Learning [https://trade.gov.ng/hscodesearch/]	The tool suggests five headings of which none relate to food products. The suggested HS code with the highest probability factor (67.23%) is 7323.93 “Table, kitchen or other household articles and parts thereof, of iron or steel; iron or steel wool; pot scourers and scouring or polishing pads, gloves and the like, of iron or steel. - Of stainless steel”	The top suggestion might be based on the fact that in French a <i>marmite</i> (noun) is a type of cooking pot from which the product “marmite” has taken its name.
“WCO AI HS Code Recommendation Platform” – Machine Learning	2103.90 with 61.27% probability 2008.91 with 19.61% probability (“Fruit, nuts and other edible parts	2103.90 is likely to be the most relevant classification as suggested by humans for this specific research project.



[http://49.50.165.5:19090]	<p>of plants, otherwise prepared or preserved, whether or not containing added sugar or other sweetening matter or spirit, not elsewhere specified or included. - Other, including mixtures other than those of subheading 2008 19”</p> <p>2104.10 with a 19.12% probability (“Soups and broths and preparations therefor; homogenised composite food preparations. - Soups and broths and preparations therefor”)</p>	But 2104.10 is an interesting contender since marmite can also be used for making broths by simply adding hot water.
----------------------------	--	--

While the “marmite” example might be light-hearted and illustrative, it was highlighted by research informants that there are many classification problems that can be challenging for machines – and often for human experts, too (Table 1). Software dependent on text description needs to understand what the product is. In the case of marmite, for example, this is whether it is something you can eat or whether it is something you cook in, which can be a formidable task for machines; but humans, too, can struggle since language itself is often ambiguous – a “pump”, as already mentioned, can be an item of footwear, or something that is used to move fluids. Challenging, too, can be descriptions that contain more than one word, and the software needs to establish the principle meaning of the query – e.g., that a “chocolate milk shake” is a dairy based drink.

When using and comparing various online applications, it is relatively easy to push the services to their limits with queries that relate to goods that are incomplete or unfinished, are mixtures, or items with multiple applications and where the essential character (unless clarified in explanatory or guidance notes) is unclear (GIR2). Similar problems can arise with GIR3 where goods are presented as sets, as might be the case for product bundles (e.g., electronic games console with game and World Cup football shirt) and sets (e.g., a complete bathroom suite consisting of a sink, bath, shower, toilet, panelling, and all fittings).

Of note might be that several research informants expressed curiosity about how the relatively recent Generative AI technology might perform, such as OpenAI’s ChatGPT or Microsoft’s BingChat. The results are somewhat humorous, perhaps not surprising when considering that the tools currently draw their insights from internet sources (i.e., have not been trained by customs professionals) and appear to have learnt that “.. it’s always advisable to consult with the relevant authorities or experts to ensure compliance with the latest regulations and classifications” (Box 3).

Box 3: In conversation with ChatGPT about the HS classification for “Marmite”; 6 Sept 2023

User

Please tell me what the correct HS code for Marmite is.

ChatGPT



The Harmonized System (HS) code for a specific product can vary depending on the country and its customs regulations. HS codes are used to classify products for customs and tariff purposes, and they consist of a series of numbers and sometimes letters that indicate the product's category and characteristics.

Marmite is a food product, and its HS code generally falls under the category of food preparations. However, the specific HS code may vary depending on the formulation, packaging, and other factors related to the product.

To find the correct HS code for Marmite in a particular country, I recommend contacting the customs authorities or using an online customs tariff database provided by the relevant government agency or organization in your country. They can provide you with the most up-to-date and accurate HS code information for Marmite based on your location and the specific characteristics of the product.

User

That is good advice, but what HS code would you suggest?

ChatGPT

While I cannot provide specific HS codes for products, I can offer a general guideline for classifying Marmite-like food products. Marmite is typically considered a food spread or food preparation made from yeast extract. To classify such products, you would typically look within the HS code range for food preparations.

Here's a general suggestion for an HS code that might apply to Marmite or similar yeast extract products:

HS Code: 2103.90

HS Subheading: 2103.90.30 (Other food preparations not elsewhere specified or included)

However, please keep in mind that customs regulations and classifications can vary by country, and the specific HS code may depend on the formulation, packaging, and other factors. It's always best to consult with your country's customs authorities or use an official customs tariff database to determine the exact HS code for your specific Marmite product and location.

User

That looks like a really helpful recommendation. On what basis have you made it?

ChatGPT

I made the HS code recommendation for Marmite based on the general category and characteristics of the product. Marmite is a yeast extract-based food preparation that is typically used as a spread or seasoning. When classifying products for customs purposes, it's essential to consider their ingredients, intended use, and characteristics to determine the most appropriate HS code.

The HS code I suggested, 2103.90.30 (Other food preparations not elsewhere specified or included), is a common category for food preparations that don't fit into more specific categories within the Harmonized System. It's a broad category that can encompass various food preparations, including spreads, sauces, and seasonings.

However, it's crucial to emphasize that the correct HS code may vary depending on the specific formulation, packaging, and other factors related to the product, as well as the customs regulations of the specific country you are importing or exporting to. To ensure accurate classification and compliance with customs regulations, it's always best to consult with the customs authorities or use an official customs tariff database provided by your country's government. They can provide precise and up-to-date HS code information based on your product and location.

User

Thank you. May I publish this chat?

ChatGPT

Yes, you may publish this chat. However, please keep in mind that the information provided is based on general guidelines and recommendations. When dealing with specific customs and import/export matters, it's always advisable to consult with the relevant authorities or experts to ensure compliance with the latest regulations and classifications.

7 Discussion

The choice of tariff classification technology, to a large part, depends on the desired outcome. Most humans, for example, routinely draw on online tariff classification resources that include online tariff publications and tools that can quickly draw attention to applicable explanatory notes and court



rulings. Users rely on these, just as they may have relied upon their paper-based predecessors in the not-too-distant past. Such electronic online tools replace paper but are still used in a way that requires users to initially orientate themselves by reference to HS sections and chapters – though keyword lists and personal notations (which frequent users are likely to make) can speed up classification workflows. The ability to conduct text and keyword searches, if well considered, can often – with caveats – be useful for initial orientation within the HS code, too. Machine learning derived search suggestion may also prompt users to look at headings that may be relevant before selecting the one that is the most appropriate. The search service here, if used responsibly, is assistive in nature. But it is important that guidance and training materials make it explicit that the search suggestions could be flawed.

Expert system approaches, if well developed, can emulate human expert deliberations and suggest codes in line with the classification relevant described characteristics. However, users would require assurances that the offered classification code is indeed correct. This can, for example, be achieved in the form of a statement or report that could be kept for future customs audit purposes. An example of such functionality is provided by the Avalara (3CE) powered classification tool offered by the Bahamas Customs Department (BCD 2023). Users can ask it to produce summary reports that capture the considered HS relevant characteristics, the applied GIRs, and references to HS legal notes, national customs rulings and any other authoritative materials that may have been brought into consideration.

Organisations relying on automatic tariff classification software, as might be the case for companies with very large classification needs (e.g., in the order of tens or hundreds of thousand items), would also have to regularly audit classifications and continuously commit to updating and training software (just as they might to training staff) – and if necessary, make retrospective corrections. But, such an approach to compliance requires a tolerant and understanding customs administration.

Another point worth highlighting is that at present the reviewed tariff classification technology appears to draw exclusively on text inputs. This begs the question whether future developments might consider alternative data inputs. Some tariff classification tools, for example, accept Chemical Abstracts Service registration numbers (CAS RN) of the American Chemical Society instead of text descriptions. Some research feedback from informants also suggests that it could be a good idea to explore how standardised product codes – such as those of GS1 or Amazon's ASINs – can be used to help tariff classification software better understand the goods that are described.

Image recognition functionality might also be useful for establishing what is described to tariff classification software. There could, for example, be a use case that draws on image recognition capabilities to mine pictures appended to official classification rulings, such as those of the European Union (European Commission 2023b) or within the HS explanatory notes (WCO 2022d). Likewise, it was pointed out by some border management experts, that scanning technology is becoming more sophisticated at identifying the elemental composition of goods, thereby offering a potentially useful data source for assessing tariff classifications.

Several research informants also suggested regular competitions or tests to showcase the advantages of one technology or approach over another. This may serve benchmarking purposes, for example, when making procurement decisions, or for driving further innovation and competition. Inevitably, test design would have to be tailored towards the desired outcomes. This paper has



drawn on illustrative search terms that have included “marmite”, “paper shredder”, “pumps”, “chocolate”, “drones”, and “computers” amongst other terms. Businesses conducting a test for their own purposes may, for example, draw on a cross section of their product catalogue and test how software solutions perform for their specific needs.

Officials considering the development or upkeep of online tariff classification tools may wish to take inspiration from implementations elsewhere (e.g., Table 1), but also the specific needs of their key stakeholders. While some stakeholders may be quite at home with classification practices, others would need a lot of handholding. Tests could be designed to address frequently asked tariff classification enquires or made specific to the most declared commodities – which might serve occasional traders with small consignments (like those using e-commerce services) particularly well. More challenging tests may focus on problem areas that humans – and by extension – machines, find difficult. Evaluation features criteria might also extend to spelling checks, before queries are processed, and the desired functionalities to help users check suggested codes (e.g., by offering users sight of HS section and chapter notes, other guidance notes, and rulings). Table 7 offers an illustrative example of how the performance of online tools could be evaluated. The example could, of course, be developed further by extending the list of test descriptions, drawing in test suggestions from classification experts, and weighing scores in line with user priorities (e.g., ease of use, accuracy, nil-returns, etc.). It would probably also be worth considering variables that examine practical capabilities and useability (Box 4) – especially if integrated into an online tariff or trade portal type solution.

Box 4 : Evaluation relevant capabilities, attributes and criteria for electronic tariff solutions ; illustrative example considerations

- Ability to automatically incorporate updates, such as those made necessary from changes to the HS code or regional tariff code specific data feeds (e.g., daily EU electronic TARIC feeds; ASEAN tariff updates)
- Ability to understand and interpret historic commodity codes
- Incorporation or cross-reference to authoritative guidance materials
- Ability to apply GIRs effectively (see also Box 1)
- Ability to understand and interpret user provided goods descriptions
- Ability to provide a certificate or statement that explains the classification recommendation
- Ease of use for experienced and inexperienced tariff classification users
- The quality of tool specific training materials
- Accuracy (see also Table 7)
- Implementation costs
- User savings in terms of time, cost, and improved compliance outcomes

(Working Paper)

Table 7: Illustrative example of how online tariff classification tools could be evaluated

Test Date: 26 Jul 2023

count	Query	Selection Rationale	Target HS Code	Text Search ASYCUDA: Samoa Online Tariff**			Keyword Enhanced UK Online Trade Tariff			Expert System Example Canada Tariff Finder			Machine Learning Example Abu Dhabi Government Services [Customs] - Smart HS Classification Tool			Machine Learning Example WCO BACUDA project: AI HS Code Recommendation Platform			Machine Learning Example WCO BACUDA project: AI HS Code Recommendation Platform		
				No of Results	Target found	Match Ratio	No of Matches	Target found	Match Ratio	No of Matches	Target found*	Match Ratio	No of Matches	Target found	Match Ratio	Min. Matches*	Target found	Match Ratio	Max. Matches*	Rank	Prob.
1	"Frozen durian"	To test if the tool can distinguish between items and attributes	0811.90	105	no	0.000	0	no	0.000	1	yes	1.000	4	yes	0.250	1	no	0.000	10	-	-
2	"video drone" [remote controlled for professional use; 1.2kg in weight]	To test if source data takes the latest HS 2022 edition and guidance materials into consideration	8806.22	10	no	0.000	1	outdated	0.000	1	outdated ***	-	16	yes	0.063	1	no	0.000	10	outdated	-
3	"Ultrasonic cleaner"	To test if it can correctly classify to a residual heading ("Other")	8479.89	7	no	0.000	0	no	0.000	1	yes	1.000	10	no	0.000	1	no	0.000	10	3	11.85%
4	"Huggies"	To check the ability to understand frequently used brand names	9619.00	0	no	0.000	0	no	0.000	1	yes	1.000	1	yes	1.000	1	yes	1.000	10	1	28.70%
5	"Laptop computer"	To check for capabilities beyond text search	8471.30	0	no	0.000	0	no	0.000	1	yes	1.000	6	yes	0.167	1	yes	1.000	10	1	28.50%
6	"Soap" [toilet soap bar]	To differentiate between hand soaps and other soaps	3401.11	5	yes	0.200	8	yes	0.125	1	yes	1.000	1	yes	1.000	1	yes	1.000	10	2	9.94%
7	"Chocolate" [white]	To check if software correctly offers results that are not cacao derived	1704.90	8	yes	0.125	10	yes	0.100	1	yes*	1.000	13	yes	0.077	1	no	0.000	10	-	-
8	"Woven men's blazer" [50% wool; 50% cotton]	Check useability for complex product classification journeys and GIR 3(c)	6203.32	103	yes	0.010	0	no	0.000	1	yes	1.000	6	yes	0.167	1	no	0.000	10	3	10.38%
9	"Tomato juice" [10% dry weight content]	To test whether it can consider and apply HS legal notes (Ch. 20 Note 4)	2002.90	25	yes	0.040	0	no	0.000	1	yes	1.000	3	yes	0.333	1	yes	1.000	10	1	20.58%
10	"Automotive fuel tank"	To test capabilities for classifying parts	8708.99	43	no	0.000	0	no	0.000	1	yes	1.000	3	yes	0.333	1	no	0.000	10	3	10.73%
				Max	Pass	Total	Max	Pass	Total	Max	Pass	Total	Max	Pass	Total	Max	Pass	Total	Max	Pass	-
				105	40%	0.375	10	20%	0.225	1	90%	9.000	16	90%	3.389	1	40%	4.000	10	70%	-

Footnotes:
 * requiring user intervention or actions
 ** search set to "contains any"
 *** in a repeat test (4th September 2023) the tool was able to take the new HS 2022 and related notes into account and subsequently suggest the correct target HS code

<https://asvworld.revenue.gov.ws/portal/services/tariff/sections.isf>

https://www.trade-tariff.service.gov.uk/find_commodity

<https://www.tariffinder.ca/en/>

<https://www.tamm.abudhabi/services/mobility/adc/workspace/smart-classification-system/search>

<http://49.50.165.5:19090>

<http://49.50.165.5:19090>

8 Conclusion

No doubt, the ability to quickly access useful tariff classification relevant information – like national tariff publications along with WCO guidance materials – helps speed up manual human tariff classification workflows. In applications where AI emulates expert human deliberations, workflows can – with caveats – be automated. Inevitably, the quality of AI generated results depend on how well the AI has been developed and trained. Just like the work of humans, classification outcomes need to be robust enough to withstand customs audit. And, trust in the generated results needs to be earned. Already, one can witness use cases where goods are automatically classified at scale. And, AI classification software could also be deployed by customs administrations to conduct business audits. It can also be used to evaluate the quality of declared goods descriptions and their commodity codes, and be used to inform strategies that weed out revenue losses that might result from deliberate misclassification attempts. And if built into applications that distribute classification data – such as single window systems – good electronic classification tools can be used to double-check and validate data before it is sent on.

But, conversations should not just limit themselves to the accuracy of current solutions and their implementations. They can be extended to also exploring how software could be better developed or trained, and how that might help build trust and confidence in the suggestions offered by assistive customs classification tools. There may also be scope for practical measures that improve the quality of training data; for example, by removing chunks known to be more prone to error (such as declaration data that has been declared by less experienced or trusted traders) or removing codes known to be outdated. Domain experts have a valuable role to play, be it to help tidy up training data, and ensuring that applied automated knowledge is relevant and correct. For public services, there may also be an audit role to periodically test the quality of automated services provided.

There may also be a case for trade partners to work closely together to explore asymmetries between declared import and export tariff classifications. This could then inform conversations about whether users of specific codes require closer attention or support. Inevitably, when sharing data (including images) for training purposes, conversations also need to be had about regulatory constraints. Regulators may also need to think about standards for safeguarding the quality of training reference data. Historic customs declaration data, unless cleaned, is likely to be inadequate. By contrast, data that has been checked or provided by experts would be more suitable. Publishers of authoritative data, like the WCO, might also need to think about how to make such data available to AI developers.

It may also be a good idea to think about user feedback loops and safeguarding measures – perhaps standards – to make sure that AI is not poisoned with erroneous tariff classification suggestions; or as some might say, to make sure that machine learning does not go off the rails (see Babic et al. 2021). Much discussion – and research – about the role of the regulator is needed. Maybe, as a starting point, it would also be worth organising regular competitions – like in chess – that pit humans against machines. It is also easy to foresee a near future, which is already beginning to take shape amongst heavy users of classification software, where customs classification training is increasingly focused on the training machines as opposed to humans.

International trade has a long history in efforts that seek to reduce the impact of trade barriers whilst ensuring that control measures are in place. The HS is a prime example which, as a living document, has evolved considerably – and is likely to evolve further. But, it is important to also give attention to how codes are published and applied. HS codes are an institution in their own right – one might say “part of the furniture” – that is supported through a wide range of regulations, publications, and increasingly also with electronic tools. Just like the codes themselves, the tools, practices, and procedures that give them life deserve continued attention, too. The prize that can be derived from well-developed and trained AI technologies, if well implemented and responsibly used, are better compliance outcomes, and improved trade facilitation resulting from lower classification costs.

References

- AGoC (2017), 'Reports of the Auditor General of Canada to the Parliament of Canada', (Ottawa: Office of the Auditor General of Canada).
- ASEAN (2023), 'ASEAN Trade Repository: 1 Tariff Nomenclature', Available at <https://atr.asean.org/read/tariff-nomenclature/39> [Accessed 15 Jul 2023].
- ASYCUDA (2023), 'About ASYCUDA', Available at <https://asycuda.org/en/about/> [Accessed 5 Sep 2023].
- Babic, Boris, et al. (2021), 'When Machine Learning Goes Off the Rails', *Harvard Business Review*, January - February.
- BAZG (2023), 'Erläuterungen zum Zolltarif - Tares', Available at <https://www.bazg.admin.ch/bazg/de/home/dokumentation/richtlinien/d6-erlaeuterungen-zum-zolltarif.html> [Accessed 15 Jul 2023].
- BBC (2012), 'Ireland garlic scam: Paul Begley jailed for six years', (updated 10th March) Available at <http://www.bbc.co.uk/news/world-europe-17320460> [Accessed 19 May 2023].
- BCD (2023), 'Tariff Search', Available at <https://bahamas.prod.3ceonline.com/bsgov> [Accessed 15 Jul 2023].
- BDC, EDC, and TCS (2023), 'Canada Tariff Finder', Available at <https://www.tariffinder.ca> [Accessed 15 Jun 2023].
- Bidgoli, Hossein (2003), *Encyclopedia of information systems* (Amsterdam ; London: Academic Press).
- Brown, Sara (2021), 'Machine learning, explained', *MIT Management* (updated 21 Apr 2021) Available at <https://mitsloan.mit.edu/ideas-made-to-matter/machine-learning-explained> [Accessed 15 Jun 2023].
- CBP (2020), 'CBP Prevents \$287M of Duty Evasions through “Game-Changing” Enforce and Protect Act', *National Media Release* (Washington: US Customs and Border Protection).
- (2023a), 'Informed Compliance Publications', Available at <https://www.cbp.gov/trade/rulings/informed-compliance-publications> [Accessed 15 Jun 2023].
- (2023b), 'Customs Rulings Online Search System (CROSS)', Available at <https://rulings.cbp.gov/home> [Accessed 15 Jun 2023].
- CBSA (2023), 'Trade compliance verifications: July 2023', Available at <https://www.cbsa-asfc.gc.ca/import/verification/menu-eng.html#s4-1> [Accessed 15 Jul 2023].
- CITES (1973), 'Convention on International Trade in Endangered Species of Wild Fauna and Flora (as amended)', The World Conservation Union, (Washington: United Nations).
- Courts and Tribunals Judiciary (2020), 'Decisions', Available at <http://financeandtax.decisions.tribunals.gov.uk/Aspx/default.aspx> [Accessed 3 January 2020].
- Criddle, Cristina (2023), 'Law firms embrace the efficiencies of artificial intelligence', *Financial Times*, 4th May 2023.

- DEFRA and APHA (2023), 'TOM risk categories for animal and animal product imports from the EU to Great Britain: searchable list with commodity codes [downloadable MS Excel spreadsheet]', Available at <https://www.gov.uk/government/publications/risk-categories-for-animal-and-animal-product-imports-to-great-britain> [Accessed 15 Jun 2023].
- DESTATIS (2023), 'Warenverzeichnis Suchmaschine', Available at <https://www.destatis.de/DE/Methoden/Klassifikationen/Aussenhandel/warenverzeichnis-suchmaschine.html> [Accessed 7 Jul 2023].
- Dumbrava, Costica (2021), 'Artificial intelligence at EU borders – Overview of applications and key issues', European Parliamentary Research Service, (Brussels: European Parliament).
- EU (2022), 'COMMISSION IMPLEMENTING REGULATION (EU) 2022/1998 of 20 September 2022 amending Annex I to Council Regulation (EEC) No 2658/87 on the tariff and statistical nomenclature and on the Common Customs Tariff', (L 282; Brussels: Official Journal of the European Union).
- European Commission (2023), 'ECICS - European Customs Inventory of Chemical Substances', Available at https://ec.europa.eu/taxation_customs/dds2/ecics/chemicalsubstance_consultation.jsp?Lang=en [Accessed 15 Sep 2023].
- European Commission (2019a), 'Explanatory notes to the Combined Nomenclature of the European Union', *Official Journal of the European Union*, 62 (C119).
- (2019b), 'The CustComp(eu)', (Brussels: European Union).
- (2021), 'Guidance on acceptable and unacceptable terms for the description of goods', (Brussels: TAXUD Working Document).
- (2023a), 'TARIC Consultation', Available at https://ec.europa.eu/taxation_customs/dds2/taric/taric_consultation.jsp?Lang=en [Accessed 15 Jun 2023].
- (2023b), 'European Binding Tariff Information (EBTI)', Available at https://ec.europa.eu/taxation_customs/dds2/ebti/ebti_home.jsp?Lang=en [Accessed 15 Jun 2023].
- (2023c), 'CLASS Consultation [database]', Available at <https://webgate.ec.europa.eu/class-public-ui-web/> [Accessed 15 Jun 2023].
- eurostat (2023), 'Combined Nomenclature 2023 Search Engine', Available at <https://eurostat.prod.3ceonline.com> [Accessed 15 Jun 2023].
- GAC (2023a), 'Handbook of Export and Import Commodity Codes: G-4 Sugare Confectionary and Chocolate Preparations', Available at https://www.international.gc.ca/controls-controles/report-rapports/list_liste/handbook-manuel/g4-5206.aspx?lang=eng [Accessed 5 June 2023].
- (2023b), 'Handbook of Export and Import Commodity Codes', Available at https://www.international.gc.ca/controls-controles/report-rapports/list_liste/handbook-manuel/contents_contenu.aspx?lang=eng [Accessed 5 June 2023].
- Grainger, Andrew (2016), 'Customs Management in Multinational Companies', *World Customs Journal*, 10 (2).
- (2021), *Cross-border logistics operations : effective trade facilitation and border management* (London: KoganPage).
- Grainger, Andrew, et al. (2018), '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*, 12 (1), 1-28.
- Harris, Tristan and Raskin, Asza (2023), 'The A.I. Dillmma', *2023 Aspen Ideas Festival* Available at <https://www.aspenideas.org/sessions/the-ai-dilemma> [Accessed 6 Jul 2023].
- HMRC (2022), 'Finding commodity codes for imports into or exports out of the UK', Available at <https://www.gov.uk/guidance/finding-commodity-codes-for-imports-or-exports> [Accessed 15 Jun 2023].

- (2023a), 'Guidance: Reasons for trade in goods asymmetries', Available at <https://www.gov.uk/government/publications/uk-trade-in-goods-statistics-reasons-for-trade-in-goods-asymmetries/reasons-for-trade-in-goods-asymmetries> [Accessed 15 Jul 2023].
- (2023b), 'UK Integrated Online Tariff', Available at <https://www.gov.uk/trade-tariff> [Accessed 15 Jun 2023].
- (2023c), 'A–Z of Classified Goods', Available at Accessed 15 Jun 2023].
- ITC (2023a), 'Market Access Map', Available at <https://www.macmap.org> [Accessed 5 Sept 2023].
- (2023b), 'Trade Map', Available at <https://www.trademap.org/Index.aspx> [Accessed 15 Jun 2023].
- JICA (2012), *Harmonized System (HS) Handbook for Customs Administration in the East African Region* (Nairobi: Japan International Cooperation Agency).
- Leonard-Barton, Dorothy and Sviokla, John J. (1988), 'Putting Expert Systems to Work', *Harvard Business Review*, 66 (2), 91-98.
- Lux, Michael and Matt, Christopher (2021), 'Classification of Goods: What are the Hurdles and Pitfalls in the Use of Automation or IT Support?', *Global Trade and Customs Journal*, 237-47.
- Lyons, Timothy J. (2008), *EC customs law* (2nd ed. edn.; Oxford: Oxford University Press).
- MCS (2023), 'Tariff - HS classification and import duty rates', Available at <https://www.customs.gov.mv/eServices/findtariff> [Accessed 15 Jun 2023].
- MoCR (2023), 'Online Tariff [Samoa]', Available at <https://asyworld.revenue.gov.ws/portal/services/tariff/sections.jsf> [Accessed 5 Sep 2023].
- NCS (2023), 'Artificial Intelligence powered HS Code Search Engine', Available at <https://trade.gov.ng/hscodesearch/> [Accessed 7 Jul 2023].
- Nelson, Christopher (2020), 'Machine learning for detection of trade in strategic goods: an approach to support future customs enforcement and outreach', *World Customs Journal*, 14.
- OPCW (1992), 'Convention on the Prohibition of the Development, Production, Stockpiling and Use of Chemical Weapons and on their Destruction (as amended)', Organisation for the Prohibition of Chemical Weapons, (Geneva: United Nations).
- OSCE (1992), 'Decision of the Council on the Control of Transboundary Movements of Wastes Destined for Recovery Operations (as amended)', OSCE Council, (Paris: Organization for Economic Co-operation and Development).
- PEN-CP (2023a), '[Podcast with] Micha Slegt: Senior scientist in the customs laboratory of the Customs Administration of the Netherlands', in Tom Mueller (ed.), *Pencast 2023 Episode-9* (Youtube and Spotify: Cross-border Research Association for the Pan-European Network of Customs Practitioners).
- (2023b), '[Podcast with] Ricardo Treviño Chapa - World Customs Organization', in Tom Mueller (ed.), *Pencast 2023 Episode-1* (Youtube and Spotify: Cross-border Research Association for the Pan-European Network of Customs Practitioners).
- Pugliatti, Luc (2012), 'Developing a Trade Information Portal', (Washington: World Bank).
- Redman, Thomas C (2018), 'If Your Data Is Bad, Your Machine Learning Tools Are Useless', *Harvard Business Review*, 4.
- Samuel, Arthur L (1959), 'Some Studies in Machine Learning Using the Game of Checkers', *IBM Journal of Research and Development*, 3 (3), 210-29.
- Shaw, Duncan (2022), *Managing Emerging Data Technologies: Concepts and Use* (London: Sage).
- Smyth, Jamie (2023), 'Biotech begins human trials of drug designed by artificial intelligence', *Financial Times*, 26 June 2023.
- Tett, Gillian (2020), 'Artificial intelligence is reshaping finance', *Financial Times*, 19 November 2023.
- Thibedeau, Chris, et al. (2022), 'Bahamas Customs takes huge leap forward on recouping lost and evaded revenue', *WCO News*, 99 (3).
- UN (1971), 'Convention on psychotropic substances', Economic and Social Council of the United Nations, (Vienna: United Nations).

- (1975), 'Single Convention on Narcotic Drugs, 1961, as amended by the Protocol amending the Single Convention on Narcotic Drugs, 1961', (New York: United Nations).
- (1988), 'United Nations Convention against Illicit Traffic in Narcotic Drugs and Psychotropic Substances', United Nations, (Vienna: United Nations).
- (2021), 'UN Model Regulations Rev. 22 (2021)', Available at <https://unece.org/transport/dangerous-goods/un-model-regulations-rev-22> [Accessed 15 Jul 2023].
- UN/CEFACT (2023), 'White Paper on the use of Artificial Intelligence in Trade Facilitation', (Geneva: United Nations Economic Commission for Europe).
- UNECE (2020), 'Recommendation No.33 Recommendation and Guidelines on Establishing a Single Window', United Nations Centre for Trade Facilitation and Electronic Business, (Geneva: United Nations).
- (2021), 'Recommendation No.38 Trade Information Portals', United Nations Centre for Trade Facilitation and Electronic Business, (Geneva: United Nations).
- UNEP (1987), 'The Montreal Protocol on Substances that Deplete the Ozone Layer', United Nations Environment Programme, (Geneva: United Nations).
- (1989), 'Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal', UNEP, (Geneva: United Nations).
- (2017a), 'Rotterdam Convention on the Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade (revised)', UNEP, (Geneva: United Nations).
- (2017b), 'The Stockholm Convention on Persistent Organic Pollutants (revised)', UNEP, (Geneva: United Nations).
- UNSD (2008), 'Standard International Trade Classification, Revision 4', Available at <https://unstats.un.org/unsd/trade/sitcrev4.htm> [Accessed 15 Jun 2023].
- USCB (2023), 'Schedule B Search Engine', Available at <https://uscensus.prod.3ceonline.com> [Accessed 7 Jul 2023].
- USITC (2022), 'Alphabetical Index', (Washington: US International Trade Commission).
- (2023), 'Harmonized Tariff Schedule', Available at <https://hts.usitc.gov> [Accessed 15 Jul 2023].
- WCO (1983), 'International Convention on the Harmonized Commodity Description and Coding System (as amended)', (Brussels: World Customs Organization).
- (2013), *HS Classification Handbook* (World Customs Organization).
- (2015), 'Terms of Reference of the Harmonized System Committee', (updated June 2015) Available at [https://www.wcoomd.org/en/wco-working-bodies/tarif and trade/harmonized system committee.aspx](https://www.wcoomd.org/en/wco-working-bodies/tarif%20and%20trade/harmonized%20system%20committee.aspx) [Accessed 15 Jul 2023].
- (2018a), *WCO Customs Brokers Guidelines* (Brussels: World Customs Organization).
- (2018b), 'The Harmonized System – 30 Years On (1988-2018)', (Brussels: World Customs Organization).
- (2019), 'PICARD Professional standards', (Brussels: World Customs Organization).
- (2022a), 'WCO Customs Risk Management Compendium', Available at <https://www.wcoomd.org/en/Topics/Facilitation/Instrument%20and%20Tools/Tools/Risk%20Management%20Compendium> [Accessed 9 Dec 2022].
- (2022b), 'HS Nomenclature 2022 edition', Available at <https://www.wcoomd.org/en/topics/nomenclature/instrument-and-tools/hs-nomenclature-2022-edition/hs-nomenclature-2022-edition.aspx> [Accessed 5 June 2023].
- (2022c), 'WCO launches an exploratory Study Project on a possible strategic review of the HS', *WCO News*, 99 (3), 10-12.
- (2022d), *Explanatory Notes - HS 2022* (Brussels: World Customs Organization).
- (2022e), 'WCO BACUDA experts develop a neural network model to assist classification of goods in HS', *Newsroom* (updated 3rd March 2022) Available at <https://www.wcoomd.org/en/media/newsroom/2022/march/wco-bacuda-experts-develop-a-neural-network-model-to-assist-classification-of-goods-in-hs.aspx> [Accessed 7 Jul 2023].

- (2022f), 'Correlation Tables HS 2017 – 2022', Available at <https://www.wcoomd.org/zh-cn/topics/nomenclature/instrument-and-tools/hs-nomenclature-2022-edition/correlation-tables-hs-2017-2022.aspx> [Accessed 15 Jul 2023].
- (2022g), 'WCO Annual Report: 2021-2022', (Brussels: World Customs Organization).
- (2023a), 'Report on the HS symposia series on "Visualising a greener HS"', (Brussels: World Customs Organization).
- (2023b), 'WCO Technology Conference: 2023 & Exhibition', Available at <https://wcotechconf2023.wcoevents.org> [Accessed 15 Sep 2023].
- (2023c), 'Alphabetical Index', Available at <https://www.wcoomd.org/en/topics/nomenclature/instrument-and-tools/tools-to-assist-with-the-classification-in-the-hs/alphabetical-index.aspx> [Accessed 15 Jun 2023].
- (2023d), 'AI HS Code Recommendation Platform', Available at <http://49.50.165.5:19090> [Accessed 7 Jul 2023].
- WCO and WTO (2022), 'WCO/WTO Study Report on Disruptive Technologies', (Brussels/Genève: World Customs Organization and World Trade Organization).
- Weerth, Carsten (2017), 'HS 2002–HS 2017: Notes of the tariff nomenclature and the additional notes of the EU revisited', *World Customs Journal*, 11 (1), 49-68.
- Witte, Peter and Wolfgang, Hans-Michael (2021), *Lehrbuch des Europäischen Zollrechts* (Herne: NWB Verlag).
- World Bank (2023), 'World Integrated Trade Solution (WITS)', Available at <https://wits.worldbank.org/> [Accessed 15 Sept 2023].
- WTO (1980), 'Agreement on Trade in Civil Aircraft', Uruguay Round; Annex 4(a) Plurilateral Agreement, (Geneva: World Trade Organization).
- (2014), 'Agreement on Trade Facilitation (WT/L/931)', Preparatory Committee on Trade Facilitation, (Geneva: World Trade Organization).
- (2023a), 'WTO STATS', Available at <https://stats.wto.org> [Accessed 15 Sept 2023].
- (2023b), 'The WTO's Pharma Agreement', Available at https://www.wto.org/english/tratop_e/pharma_ag_e/pharma_agreement_e.htm [Accessed 24 May 2023].
- (2023c), 'Trade Facilitation Agreement Database: 1.2 - Information available through internet', Available at <https://www.tfadatabase.org/en/measures/article-3> [Accessed 15 Jul 2023].
- (2023d), 'Trade Facilitation Agreement Database: 3- Advance Rulings', Available at <https://www.tfadatabase.org/en/measures/article-3> [Accessed 15 Jul 2023].
- Zoll (2023), 'EZT-Online Einfuhr: Warennomenklatur', Available at <https://auskunft.ezt-online.de/ezt/SeqEinreihungSucheAnzeige.do?init=ja#ziel>.