



# TECHNICAL

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## NOTES & MANUALS

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### **Generative Artificial Intelligence for Compliance Risk Analysis: Applications in Tax and Customs Administration**

Joshua Aslett, Thomas Cantens, François Chastel,  
Emmanuel Crown, and Stuart Hamilton



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# Generative Artificial Intelligence for Compliance Risk Analysis: Applications in Tax and Customs Administration

Joshua Aslett, Thomas Cantens, François Chastel,  
Emmanuel Crown, and Stuart Hamilton

Authorized for distribution by Ruud De Mooij

**This technical note and manual (TNM) addresses the following questions:**

- What is generative artificial intelligence (GenAI), and how does it work?
- How can current GenAI services support compliance risk analysis?
- What are practical examples that demonstrate GenAI's current utility?
- When using GenAI for risk analysis, what guidelines should be adhered to?
- What probable future developments are likely to influence planning?

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The demonstrations and prototypes featured in Sections IV and V of this note are experimental in nature and intended for educational purposes only. In exploring any operational applications, care should be taken to ensure that associated risks are understood and addressed. For further guidance, see *Understanding Artificial Intelligence in Tax and Customs Administration* (Aslett and others 2024a), specifically Section V and Annex 3. Section V of the note outlines 10 actions that promote responsible use of artificial intelligence (AI). Annex 3 provides an AI risk assessment methodology that is tailored to tax and customs administration and suitable for evaluating AI use cases, including those that involve GenAI specifically.

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## Abbreviations

AI	artificial intelligence
APA	advanced pricing agreement
API	application programming interface
ASYCUDA	Automated System for Customs Data
AUC	area under the curve
BEPS	base erosion and profit shifting
BI	business intelligence
CIF	cost, insurance, and freight
CRM	compliance risk management
CTE	common table expression
FN	false negative
FP	false positive
FX	foreign exchange
GenAI	generative artificial intelligence
HS	Harmonized Commodity Description and Coding System (Harmonized System)
ICT	Information and Communications Technology
ISORA	International Survey on Revenue Administration
IT	Information Technology
LLM	large language model
MNC	multinational corporation
NLP	natural language processing
OECD	Organisation for Economic Co-operation and Development
RAG	Retrieval-Augmented Generation
RLHF	reinforcement learning with human feedback
ROC	receiver operating characteristic
SDK	software development kit
SME	small and medium enterprises
SQL	Structured Query Language
TN	true negative
TNM	technical note and manual
TP	true positive
UNCTAD	United Nations Conference on Trade and Development
VAT	value-added tax
VITARA	Virtual Training to Advance Revenue Administration

# I. Introduction

**This technical note describes generative AI's (GenAI) ability to support compliance risk analysis in tax and customs administration.**<sup>1</sup> Written for a technical audience, the purpose of the note is to raise awareness of GenAI by explaining and demonstrating its capabilities. To that end, the note opens with a brief conceptual overview of GenAI technology. It then describes four generalized use cases where GenAI can augment the work of risk analysts. As proofs of concept, the note presents practical examples of how GenAI can be used to better understand taxpayer (and trader) compliance. Having demonstrated GenAI's potential, the note then provides basic guidelines to help administrations that may be considering implementing the technology in an operational setting. The note concludes with forward-looking statements on likely developments.

**Among GenAI's capabilities, three have transformational potential for risk functions in tax and customs administration: natural language research, analysis, and analytics.** Historically, the effectiveness of risk analysis has been constrained by the ability to source, process, and make sense of data and information. At the center of these processes are human analysts who rely on a collection of tools to apply both expert-driven and quantitative methods. With the arrival of GenAI, the barriers that have limited analysts are rapidly receding due to advancements with one idea—the ability to interact with AI directly, like a human, in natural language. The adoption of this capability for risk analysis may be revolutionary, prompting a rethink of the fundamental relationship between analysts and technology.

**With the ability for natural interactions, what role will AI begin to take—AI as an assistant, consultant, collaborator, or replacement?** Already, the current iteration of GenAI tools can facilitate impressive enhancements to risk work, from informing analysis of technical tax matters to generating code for analytics and then, impressively, interpreting the results. Should the pace of GenAI development continue, with rapid growth in the size and sophistication of the models it relies on, AI's utility may soon eclipse that of human analysts. As this transition takes place, questions of how AI can or should be best used are increasingly important.

**Answers to these questions are explored in this note, where principles of compliance and GenAI's utility have the potential to intersect.** This exploration benefits from prior exposure to compliance risk management (CRM), analytics for CRM, and AI in tax and customs administration more generally. Those unfamiliar with the subjects should (1) review the respective materials available from the IMF and (2) consider the online course on CRM provided through the Virtual Training to Advance Revenue Administration (VITARA) program.<sup>2</sup> As a matter of policy, the IMF does not endorse specific technology or suppliers. Accordingly, the GenAI demonstrations presented in this note, developed with both commercial and noncommercial resources, do not specify the underlying technology, services, or suppliers used.

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<sup>1</sup> The full impact of GenAI on tax and customs administration is not yet known. Accordingly, this note is intentionally limited in scope to compliance risk analysis for the purpose of demonstrating emerging but practical, high-value applications of the technology.

<sup>2</sup> See Betts (2022), Aslett and others (2024, 2024a, 2024b), Chooi and Pemberton (2023), and Pérez and others (2022, 2025).



## II. Understanding Generative AI

### What Is Generative AI?

**Generative AI (GenAI) is a category of AI designed to work with patterns—for recognition, synthesis, and modeling—to produce humanlike content.** This content can take many forms, including text, video, images, audio, or data, often generated based on patterns learned from vast stores of data and information, including material published on the internet. To produce content, GenAI systems leverage advanced machine learning techniques, with a particular focus on deep neural networks, to model relationships found in training data, enabling algorithms to generate novel, contextually appropriate outputs. This allows GenAI to learn and interact in human languages. With access to more information than any individual could process, GenAI systems can increasingly produce content faster and more accurately than humans.<sup>3</sup>

**The current iterations of GenAI systems build from decades of research and development in data science.** With origins in machine learning algorithms, today GenAI represents its own branch within the field of AI more broadly. What sets GenAI apart from other branches is its focus on creating models that are capable of generating original content (often referred to as “foundation models”) rather than narrow tasks involving analysis or classification of data. These capabilities stem from successive breakthroughs in neural networks in the 1980s, deep learning in the 2000s, Generative Adversarial Networks in 2014, and Transformer-based models in the following years, which today form the technological foundations for much of the GenAI development underway.<sup>4</sup>

**Through the widespread integration into digital services and automation, interactions with GenAI systems are quickly becoming a feature of daily life.** In isolation, GenAI’s capabilities have limited utility. It is their mainstream integration into digital services, tools, and information technology (IT) platforms—the broader digital ecosystem—that is disrupting and potentially revolutionary. To the extent that channels for integration preserve some memory of interactions between humans and GenAI systems, experiences can be emulated with GenAI that blur the lines between real and artificial intelligence, increasingly satisfying criteria of the seminal Turing Test.<sup>5</sup> As advancements continue, access to GenAI services is likely to become ubiquitous in digital environments.

### How Does GenAI Work?

**GenAI works through a combination of technologies typically designed to process large volumes of data and provide access to pretrained foundation models.** These models facilitate the open-ended interactions that are typical of chatbots and virtual assistants, among other services that are now widely used. Box 1 provides an overview of the terminology needed to explore the technical aspects. Figure 1 then provides a graphical overview describing relationships between GenAI’s key components, followed by a short explanation of each.

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<sup>3</sup> Inaccuracy and biases in GenAI outputs remain important challenges, including in the form of AI hallucination.

<sup>4</sup> Referencing advancements in machine learning, including back-propagation, deep belief networks, adversarial training through minimax games, and self-attention mechanisms. For details, see Rumelhart, Hinton, and Williams (1986); Hinton, Osindero, and Teh (2006); Goodfellow and others (2014); and Vaswani and others (2017).

<sup>5</sup> The Turing test evaluates a machine’s ability to exhibit behavior indistinguishable from a human by examining its capacity to engage in humanlike conversation. See Turing (1950) for the original theory.

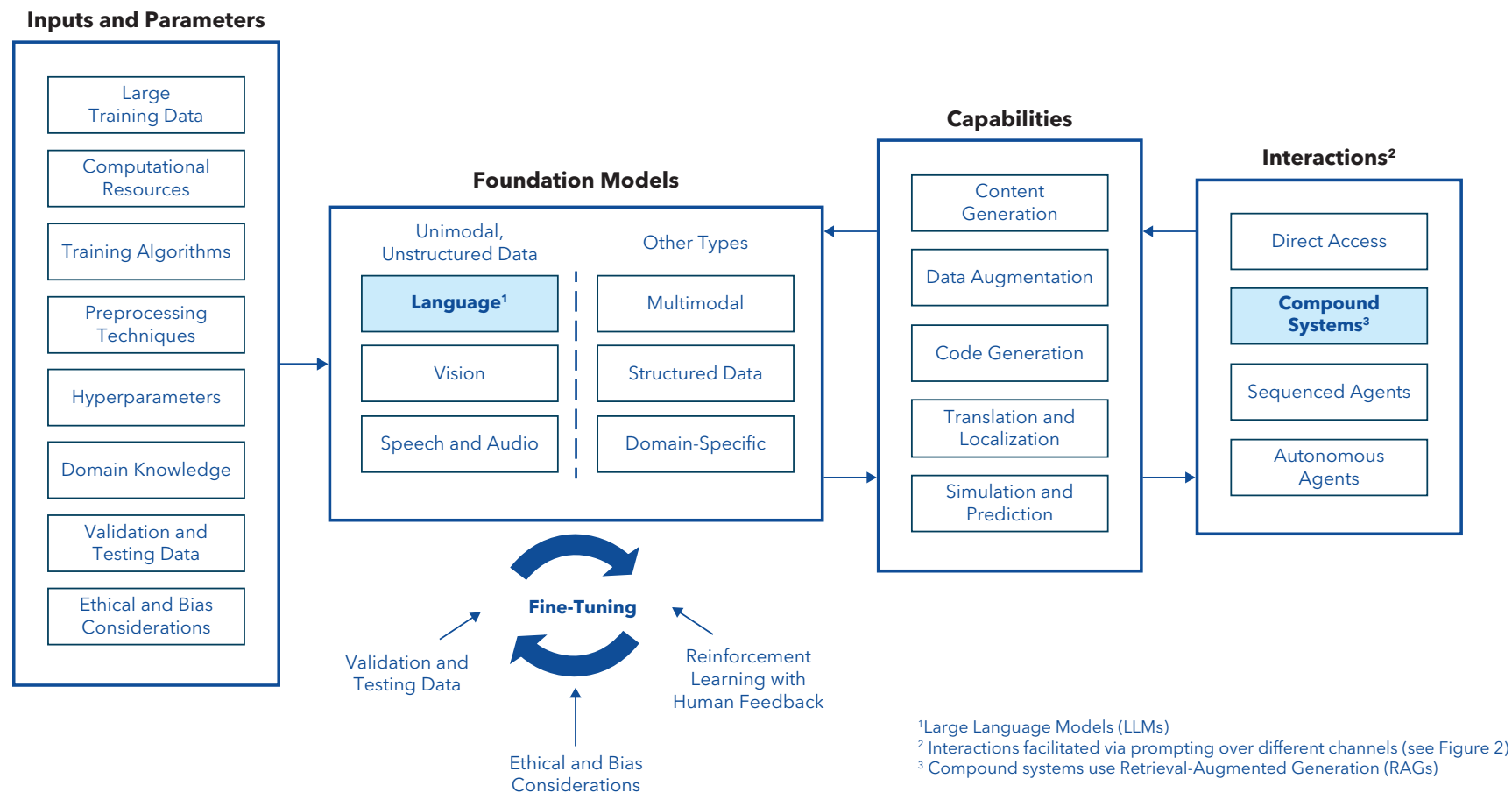
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### BOX 1. Essential Terminology

- **Artificial Intelligence.** The simulation of human intelligence conducted using computer systems, relying on statistics, data science, and machine learning.
- **Machine Learning.** A major branch of artificial intelligence, the use of data and algorithms to enable computers to learn without explicit programming.
- **Algorithm.** Logic, methods, or sets of specific steps for solving a problem that may or may not be codified for use in a computer programming language.
- **Supervised Learning.** A category of machine learning that relies on humans to label data and train algorithms to make conclusions or predictions.
- **Unsupervised Learning.** A category of machine learning that does not require human “training” to identify patterns in data and make conclusions or predictions.
- **Structured Data.** Data with clearly defined relationships and data types that are easily searchable (“normalized” database tables, as one example).
- **Unstructured Data.** Data without clear definition, often stored in a format that requires specialized tools for analysis (for example, invoices scanned as images).
- **Training Data.** The data, both structured and unstructured, used to train machine learning algorithms to recognize patterns and inform AI models.
- **Generative Artificial Intelligence.** A branch of AI within machine learning that relies on pattern recognition, synthesis, and modeling to generate content.
- **Foundation Model.** Essential to GenAI, a general-purpose machine learning model trained on data to generate humanlike content and perform a variety of tasks.
- **Foundational Model Parameter.** An internal parameter in a model that is learned and adjusted during training, directly influencing a model’s output.
- **Hyperparameter.** A parameter external to a foundation model that governs the model’s training process and structure and is not determined from training data.
- **Large Language Model.** A category of foundation model trained on text data and designed to process, interpret, and generate natural language text.
- **Compound Systems.** A combination of AI models or complementary technology that improve GenAI’s utility (for example, retrieval-augmented generation, or RAG).
- **Sequenced Agents.** Systems or entities that perform small tasks in a step-by-step order to complete a larger task, relying on outputs of one step to inform the next.
- **Autonomous Agents.** Systems or entities that autonomously process tasks, using AI to make decisions and communicate with humans and other agents.

Source: IMF Staff.

Figure 1. How Does GenAI Work?



Source: IMF Staff.

Note: As part of fine-tuning, different strategies exist. These include Reinforcement Learning with Human Feedback (RLHF), as is illustrated here. Other strategies include "pure" reinforcement learning, which may exclude the human factor as limiting, including due to costs.

**At a technical level, GenAI can be notionally understood through an exploration of the four components illustrated in Figure 1.** While varying considerably, current GenAI systems can be generalized and decomposed for analysis by (1) inputs and parameters, (2) foundation models, (3) capabilities, and (4) interactions.

**Inputs and Parameters.** Nearly all GenAI systems rely on training data, computational resources (in the form of storage and compute cycles), and training algorithms. These components are the essential ingredients from which any given GenAI system is built. Usually, they are customized for anticipated scales of use, audiences, and domain subject areas. This typically starts by identifying appropriate preprocessing techniques to prepare and transform the training data to be used. The relevant hyperparameters are then configured and optimized to direct workflow and logic applied by training algorithms to produce foundation models. Throughout this process, domain knowledge sourced from subject matter experts is relied on. This expertise has special relevance during validation and testing of models, including for ethical and bias considerations.

**Foundation Models.** At the heart of GenAI systems are foundation models. Foundation models vary and range from large-scale, general-purpose neural networks trained on vast data sets to smaller, specialized models built for narrow purposes. All require training. In broad terms, two categories of models exist: (1) unimodal, making use of specific forms of unstructured data, and (2) other types of models. Unimodal models rely on one type of data—for instance, text data for large language models (LLMs), image and video data for vision models, and speech and sound data for audio models. Other types of models include multimodal, which are built from multiple data types, models based on structured data (as opposed to unstructured) and domain-specific models, which may be hybrids developed for specific applications. Foundation models may be continuously fine-tuned to perform different tasks, correct errors, or improve performance.

**Capabilities.** Across different categories of foundation models, a core set of capabilities exists. All of these derive from the basic ability to generate content. Generally, the types of content that can be created depend on the specific foundation models involved in handling a task—language, vision, speech and audio, or other types—and the underlying data types from which the models are trained and constructed. With the ability to create content, models can be further refined to support data augmentation (generation and analysis), generation of computer code, translation and localization across languages, and development of a range of simulations and predictions.

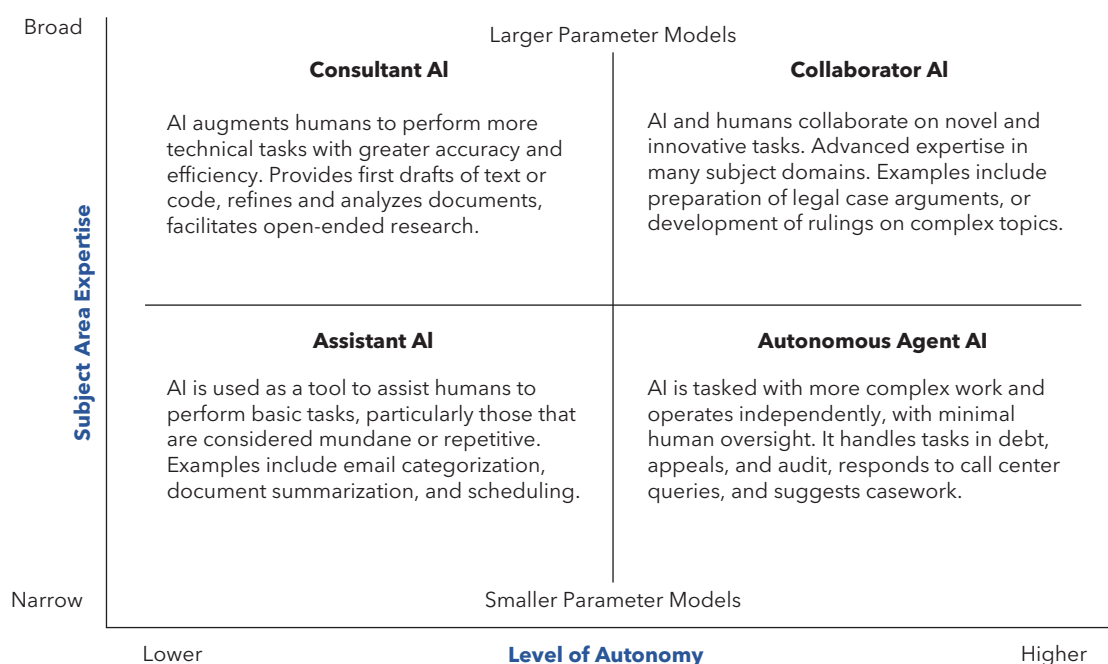
**Interactions.** GenAI's capabilities may be accessed directly or complemented by supporting technology. In one configuration, compound systems may be used, which augment the handling and processing tasks. These often rely on Retrieval-Augmented Generation, or RAGs, which are developed to provide GenAI services with context for a particular domain and can significantly improve the quality of outputs. In another configuration, a sequence of agents may be used to decompose tasks, supply them to different models, and then reconstruct the results. In yet another configuration, agents may be deployed that independently interact with GenAI, other agents, and humans. In doing so, they can automate some tasks and improve output quality.

## III. Using GenAI for Compliance Risk Analysis

### How Can Use Cases Be Generalized and Understood?

**Use cases for GenAI can be generalized irrespective of domain, beyond tax and customs administration.** In Figure 2, two dimensions are proposed to frame the outlines of potential use cases: (1) subject area expertise and (2) level of autonomy. The first dimension recognizes that foundation models comprised of larger numbers of parameters support GenAI services having broad expertise. The reverse is also true: smaller parameter foundation models generally support narrow expertise. In Figure 2, the second dimension proposed evaluates a potential level of AI autonomy. This concept allows for an intuitive segmentation of AI's potential applications into one of four generalized use cases.

Figure 2. Generalized Use Cases for GenAI



Source: IMF Staff.

### Use Case: Assistant AI

**In the assistant AI role, GenAI supports officials by quickly summarizing large bodies of text, reports, or even transcripts of meetings or hearings.** As one example, a tax official needs a summary of the latest amendments in international tax treaties. To save time, AI is tasked with scanning hundreds of pages of legal texts and providing a concise, easy-to-understand summary, saving the official hours of manual reading. As another example, a customs official is performing an analysis of import declarations to identify outliers. To expedite the work, the officer uploads the required data to a secure on-premises

GenAI service and, rather than manually developing spreadsheet formulas, uses natural language to task the GenAI service to perform the analysis.<sup>6</sup>

### **Use Case: Consultant AI**

**In the consultant AI role, GenAI provides deeper insights and serves as an expert advisor in decision-making processes.** Relying on larger parameter models, comprehensive analysis based on a deeper understanding of the data is provided by GenAI services. As one example, a customs official is investigating trade mispricing and asks the AI to analyze internal communication logs and documents from importers and key stakeholders involved, along with a price analysis. The AI then identifies patterns of ambiguous language that could indicate intentional misreporting. As another example, a tax officer asks AI to perform an analysis of key value-added tax (VAT) returns data, identifying anomalies based on typical patterns of fraud that the GenAI service itself is aware of. The AI generates a report highlighting high-risk entities and suggesting actions for further investigation.

### **Use Case: Collaborator AI**

**In the collaborator AI role, GenAI is used extensively by officials to perform a substantial portion of the administration's research, analysis, and report generation.** At this level, AI conducts research and analysis across both textual and numerical data sources. This may occur independently. As one example, a tax officer asks an AI agent to compile a high-quality dossier on a company under audit, summarizing legal documents, emails, and prior cases. The agent initiates the work, collaborating with other agents. Once completed, the agent provides an organized, evidence-backed summary, helping the officer prepare for interviews and enforcement actions. As another example, a customs officer tasks an AI agent to regularly analyze a decade's worth of trade data, identifying trends in mispricing and raising alerts when important findings emerge. The AI performs as instructed, contacting the officer as needed and providing comprehensive reports, highlighting periods of interest, and recommending corrective actions.

### **Use Case: Autonomous Agent AI (Replacement)<sup>7</sup>**

**At the most sophisticated level, GenAI is used autonomously within predefined decision-making boundaries, executing tasks and processes on behalf of the administration.** When deployed with an autonomous agent, GenAI is used to independently manage natural language tasks and data analytics processes, requiring minimal human oversight. For example, the AI might automatically review and approve routine correspondence from taxpayers, flagging only high-risk cases for human intervention. On the analytical side, it could autonomously handle complex compliance checks, such as reviewing financial records or processing customs declarations, making decisions based on predetermined thresholds. Operating from a smaller but specialized model, the AI's outputs are proven to be consistent and reliable, freeing up human officials to focus on more complex or higher-value work.

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<sup>6</sup> The expression "on-premises" is used to describe a scenario in which the IT infrastructure required to deliver a service is physically located on-site and typically managed by the same organization. It contrasts with hosted configurations, where the infrastructure is located off-site, provided, and often managed by an external party.

<sup>7</sup> Replacement of human resources with autonomous AI agents is a controversial topic. Beyond matters relating to the actual, proven utility of AI, any such consideration should carefully build from a complete understanding of the relevant legal frameworks and regulatory requirements.

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## How Can GenAI Support Compliance Risk Analysis?

**Practical uses of GenAI to support compliance risk analysis can be explored through the three components illustrated in Figure 3.** In the tax and customs administrations that elect to use GenAI, decisions will be needed relating to (1) deployment options, (2) channels to GenAI, and (3) use cases for risk analysis. Collaboration with IT staff is crucial throughout the decision-making process. However, as GenAI is evaluated to support specific use cases, leadership from risk analysts that understand compliance—at both strategic and operational levels—is paramount. As AI begins to influence operational risk-based decisions, extreme care is needed to ensure that it is used responsibly.<sup>8</sup>

**Deployment Options.** GenAI is being rapidly integrated into mainstream technology and the digital ecosystem that tax and customs administrations operate within. In support of this, a rich set of options for deployment of GenAI capabilities exists. These range from commercial cloud and on-premises offerings that make use of externally hosted services to fully offline open-source options suitable for use with sensitive information, including in low-capacity settings. Specialized and hybrid options also exist, including for “edge” devices such as mobile phones (and the apps that they support), wearable devices, cameras, robots, and drones. Enabling access to these options is a rich set of application programming interfaces (APIs) and software development kits (SDKs) around which software and tools can readily integrate.

**Channels to GenAI.** Having access to deployments, risk analysts are most likely to make use of GenAI services through the specific tools in Figure 3 highlighted in blue. At a basic level, these include the use of chatbots and virtual assistants (the latter of which are more complex than chatbots). With the ability to operate autonomously within a set of parameters, many analysts are likely to begin making use of configurable agents. These will be employed for a wide range of tasks, particularly those that are repetitive and considered to have lower consequences should the agents make a mistake or not perform as anticipated. With traditional tools for risk analysis using data, GenAI will either become fully embedded or an outright replacement. This includes advanced analytics suites and business intelligence (BI) tools in general.

**Use Cases for Risk Analysis.** With access to tools that consume GenAI services, four principled use cases for analyst augmentation with AI exist: (1) assistance, (2) consultation, (3) collaboration, and (4) autonomous agents (replacement). Described in Figure 2, these generalized applications of AI vary based on their subject expertise and degree of autonomy. Within this concept, GenAI can support *most aspects of compliance risk management* using natural language, including risk analysis. This support is fully consistent with the application of established frameworks, including the Organisation of Economic Co-operation and Development’s (OECD) CRM process.<sup>9</sup>

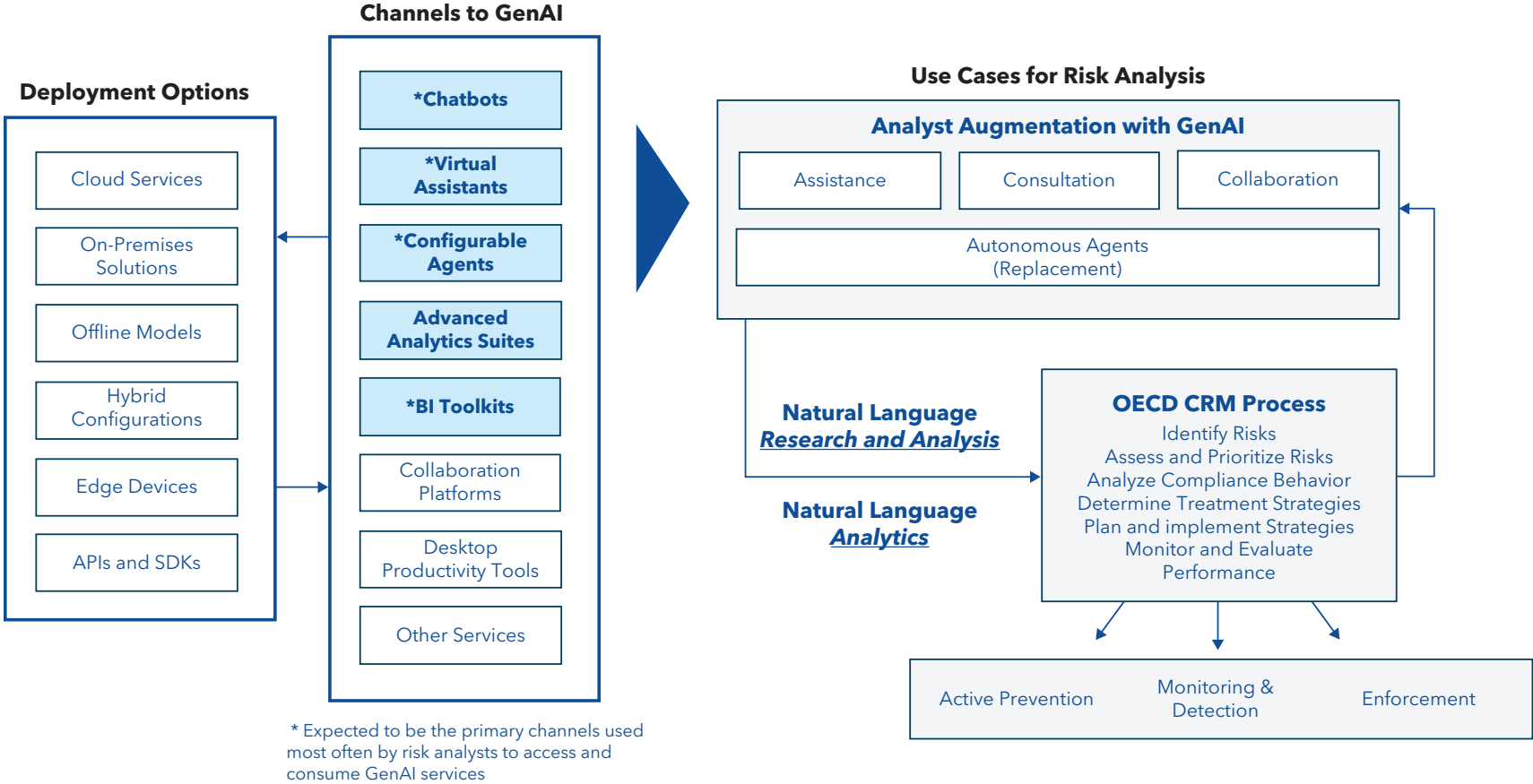
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<sup>8</sup> See Aslett and others (2024a) and the 10 suggested actions that promote responsible use of AI.

<sup>9</sup> See OECD (2004) for the original process and Betts (2022) for an expanded explanation.

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Figure 3. How Can GenAI Support Compliance Risk Analysis?



Source: IMF Staff.  
Note: API = application programming interface; SDK = software development toolkit; BI = business intelligence.



## IV. Demonstrations Using Hosted Services

**In the short term, tax and customs administrations that explore GenAI for risk analysis are likely to do so through externally hosted services.** For many, the challenges relating to ensuring the confidentiality of sensitive data will raise immediate limitations. Nonetheless, with adherence to the regulations that may be in place, considerable potential exists that should be possible for many administrations to evaluate. The following provides an overview of three demonstrations that have been prepared to support this premise, one each for natural language: (1) research, (2) analysis, and (3) analytics. A summary of outputs is presented in Figures 4–6. Annexes 1–3 include full details.

### Natural Language Research: Contingency Planning for Economic Crises

**What implications for tax revenue and compliance could arise from a 25 percent currency devaluation?** Such questions are instrumental in preparing contingency strategies in economies where fluctuations in commodity prices can lead to instability in revenues. In this demonstration, multiple GenAI services were used. The output from a first GenAI service was used to prompt a second service to elaborate on key aspects that may have been missed. This short demonstration shows how dialogue between GenAI services and their underlying models can be used to rapidly identify and assess potential risks from a change in the external environment. Further details are provided in Figure 4 and Annex 1.

### Natural Language Analysis: Risk-Reviewing a Large Taxpayer

**What tax compliance risks can be identified from an analysis of a particular multinational mining company’s published annual report?** In advanced tax administrations, large taxpayers may be subject to risk reviews after proxy indicators of risk are evaluated (for example, effective tax rates). Risk reviews are typically conducted as projects by teams of analysts who make use of concepts such as the “BISEP” framework.<sup>10</sup> In many jurisdictions, the ability of staff to perform full, contextually sensitive risk reviews of large taxpayers is limited. With GenAI, these constraints may begin to ease. The outputs in Figure 5 and Annex 2 demonstrate this potential, making use of the “bow tie” concept to structure an output useful in a large taxpayer office.<sup>11</sup>

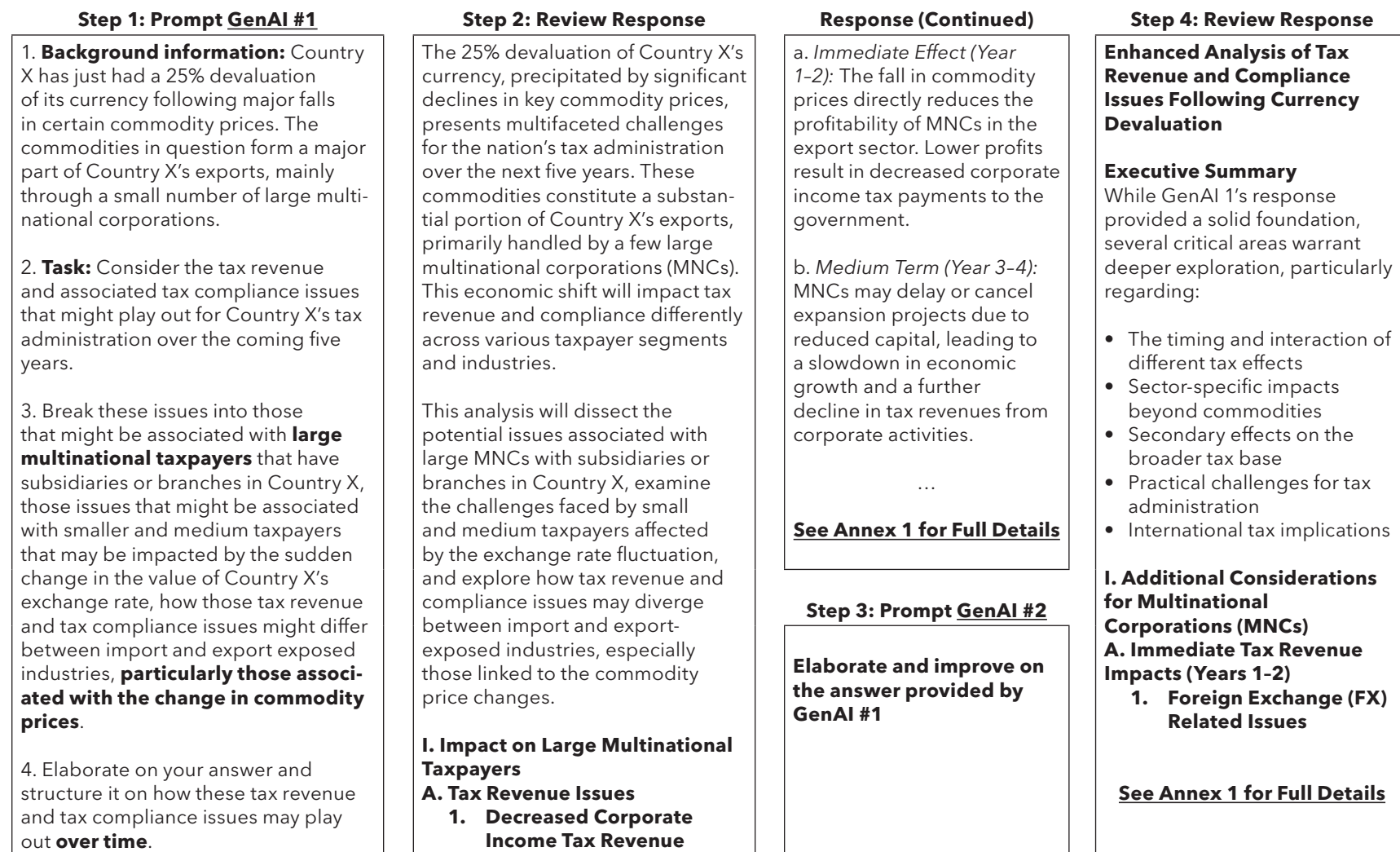
### Natural Language Analytics: Differentiating Risk Among Taxpayers

**Based on historic audit outcomes, which small- and medium-sized taxpayers are the most likely to be underreporting?** The ability to use predictive analytics in many administrations is today still limited. The goal of this demonstration is to again show how barriers may begin to drop, by employing GenAI to (1) generate the Python programming code required for important data analyses; and (2) then also, to correctly interpret results. In practice, this example shows how GenAI can be used in audit case selection to predict cases that may have compliance issues and rank them to maximize the return on investment – *all in natural language*.

<sup>10</sup> BISEP is an acronym for business, industry, sociological, economic, and psychological. The concept was developed by Dr. Valerie Braithwaite in the early 1990s. It can assist risk analysts in conducting holistic evaluations of large taxpayers, complementing numerical analysis with human judgment and qualitative insights.

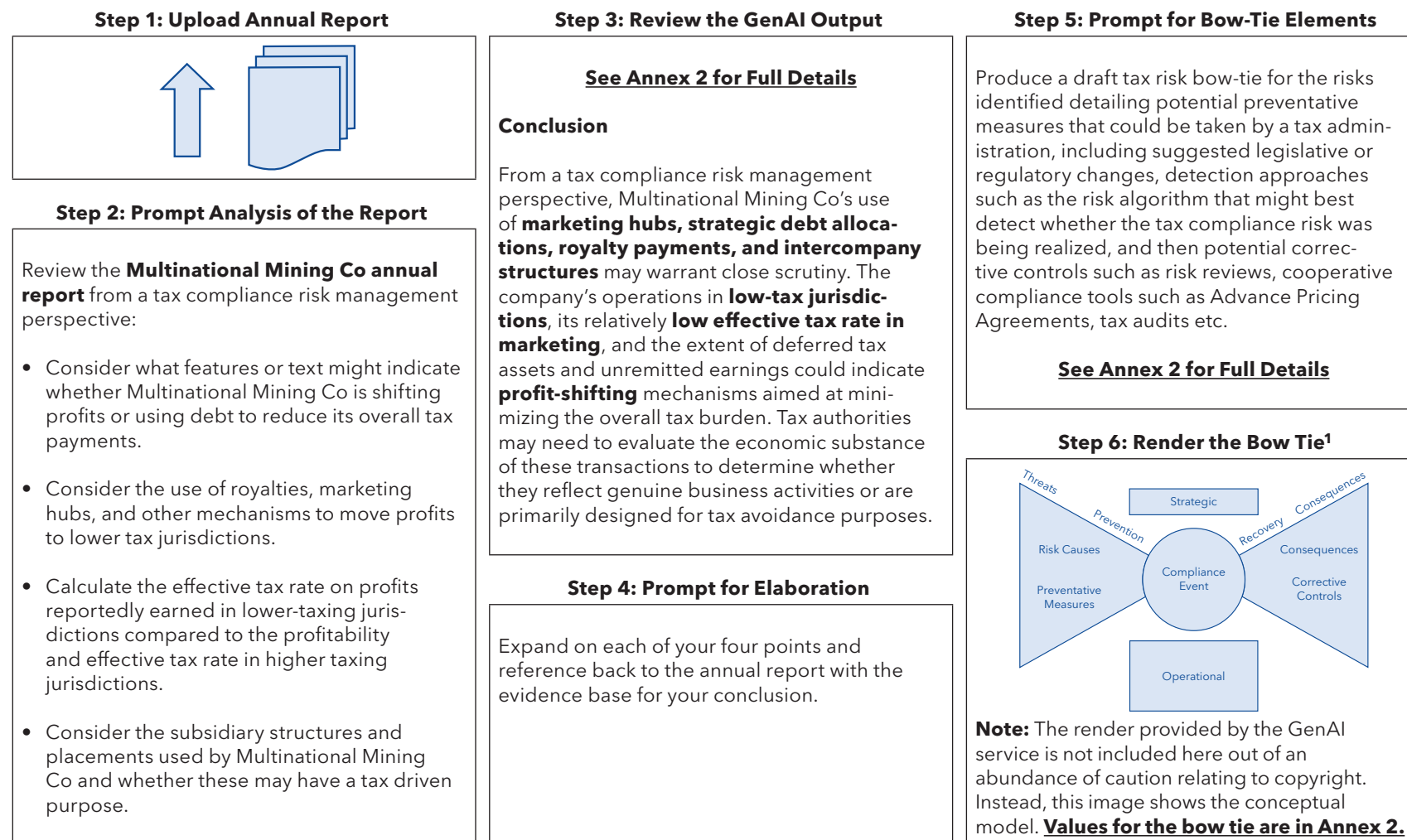
<sup>11</sup> A bow-tie analysis is a visual and analytical tool used to understand, assess, and manage risks by illustrating the relationships between causes, risk events, and consequences, as well as the controls that prevent or mitigate them.

Figure 4. Natural Language Research: Contingency Planning for Economic Crises



Source: IMF Staff.

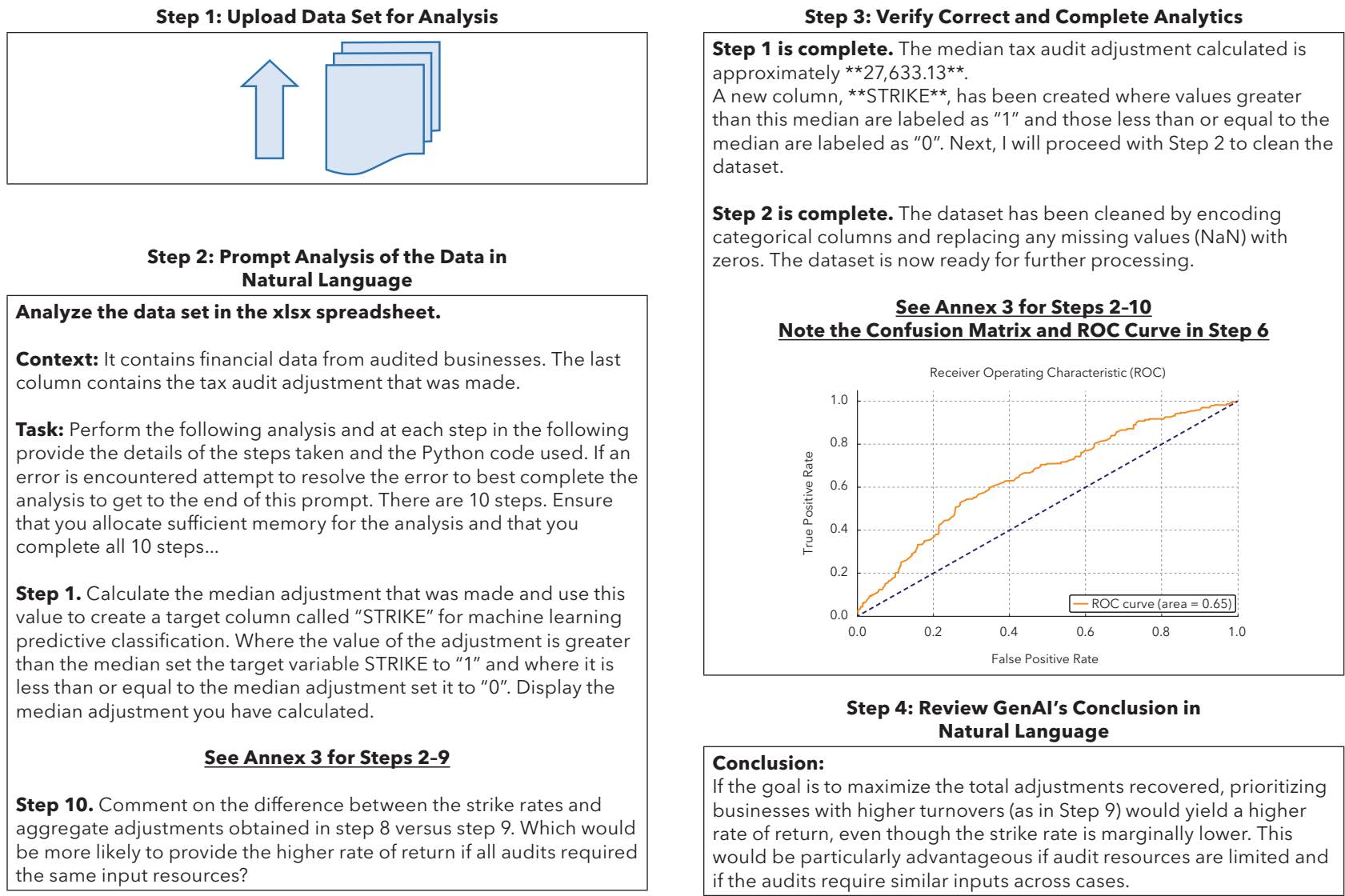
Figure 5. Natural Language Analysis: Risk-Reviewing a Large Taxpayer



Source: IGT 2013 and IMF Staff.

<sup>1</sup> See page 18 of IGT (2013) for a developed example of a tax risk bow-tie analysis.

Figure 6. Natural Language Analytics: Differentiating Risk Among Taxpayers



## V. Toward On-Premises Applications

**As options for accessing GenAI services expand, most administrations are likely to adopt on-premises configurations to mitigate perceived risks.** With legal requirements for data sovereignty and limited visibility into supply chains behind GenAI services, on-premises options, and particularly those based on open-source configurations, may become increasingly appealing. To many administrations, they are likely to be viewed as striking a good balance between cost and security, allowing GenAI to be used with internal data and information while safeguarding public interests, where privacy, accountability, transparency, and ethical use of AI are important.<sup>12</sup>

**Similar configurations for digital services are already proven, including with the ASYCUDA IT system now in widespread use in customs administration.**<sup>13</sup> Today, 102 countries operate the ASYCUDA system, developed and supported by the United Nations Conference on Trade and Development (UNCTAD). While not intended as a fully open-source platform, ASYCUDA makes heavy use of open-source technology, with many administrations opting for fully on-premises operation, both of which have helped advance its adoption. In many ASYCUDA implementations, reporting and analytics (including with AI) are also supported with open-source technology.

**To help illustrate the potential of on-premises configurations, Figure 7 presents a technical overview showing how GenAI can be integrated with ASYCUDA.** This concept makes use of three LLMs that, together, (1) handle tasks prompted by users, (2) generate code to facilitate user interactions, and (3) generate Structured Query Language (SQL) queries to interact with an ASYCUDA database. To facilitate generation of SQL statements through an LLM ("text-to-SQL"), metadata is compiled in advance that describe the ASYCUDA database schema.

**Moving beyond basic integration of GenAI services, Figure 8 illustrates the use of agents.** Among the generalized use cases described in Figures 2 and 3, the concept of agentic autonomy is crucial. When integrated into a digital environment, GenAI services can begin to assume roles traditionally taken by humans. In Figure 8, this concept is illustrated by the interaction between five AI agents: (1) "Administration," (2) "SQL coder," (3) "SQL Executor," (4) "Data Analyst," and (5) "Data Scientist." Interactions are facilitated through a common chat, in which the agents interact with each other—not using cryptic software-oriented messaging *but in natural human language* where the software-based agents speak to each other like humans.

**As demonstrations of agentic integration with ASYCUDA, Figures 9-10 provide the output of proofs of concept based on Figure 8.**<sup>14</sup> Note the interactions between agents and the similarity with conversations that could have been equally held by humans having assumed similar roles.

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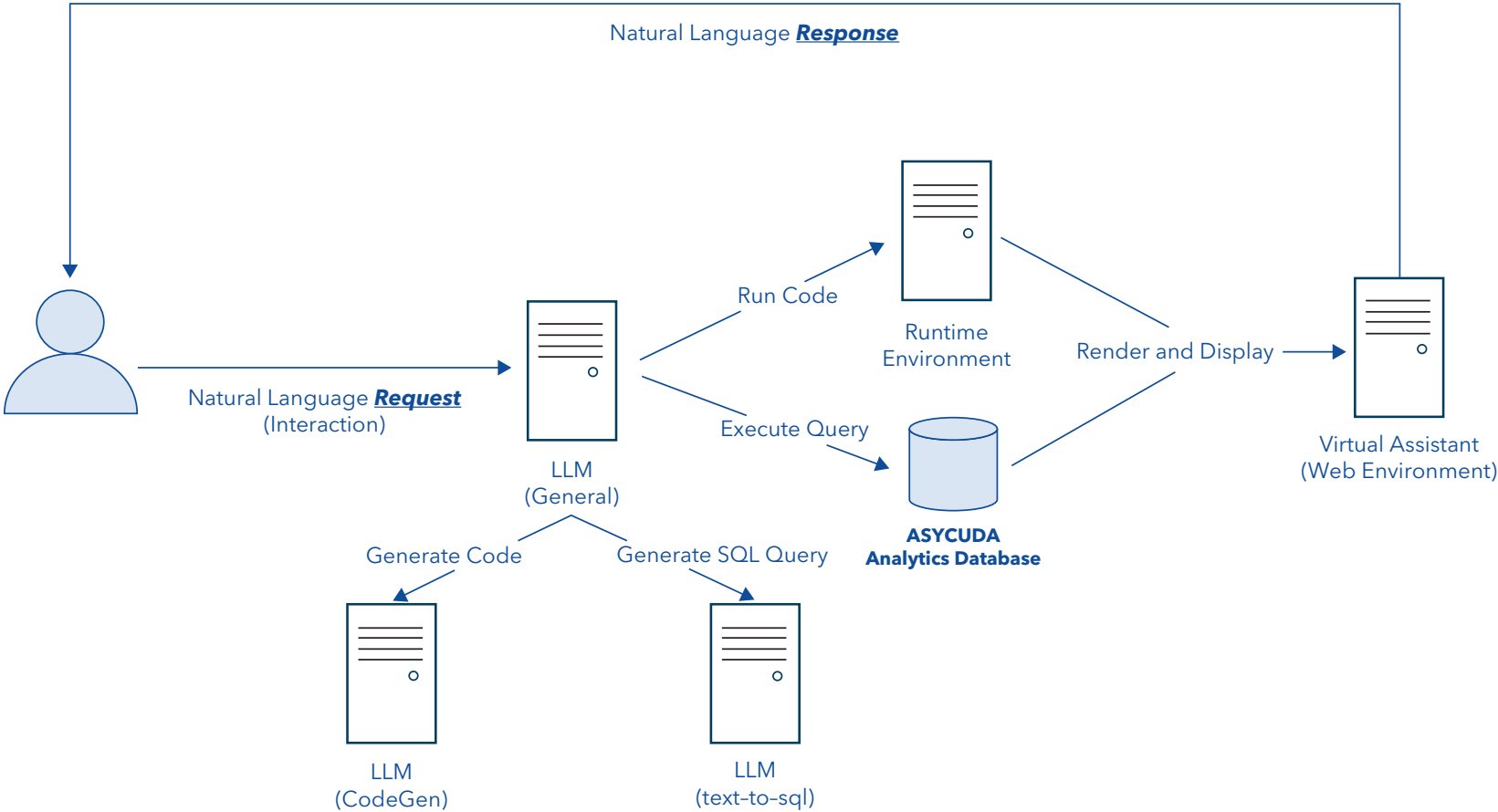
<sup>12</sup> Many factors influence the degree to which open-source technologies can or should be used. It is important to note that commercial providers of GenAI services often rely on and contribute to open source.

<sup>13</sup> ASYCUDA stands for Automated System for Customs Data. The system is heavily relied on globally to facilitate core customs administration operations.

<sup>14</sup> While the examples illustrate integration with ASYCUDA, the same concepts can be applied to other systems if underlying prerequisites are met.

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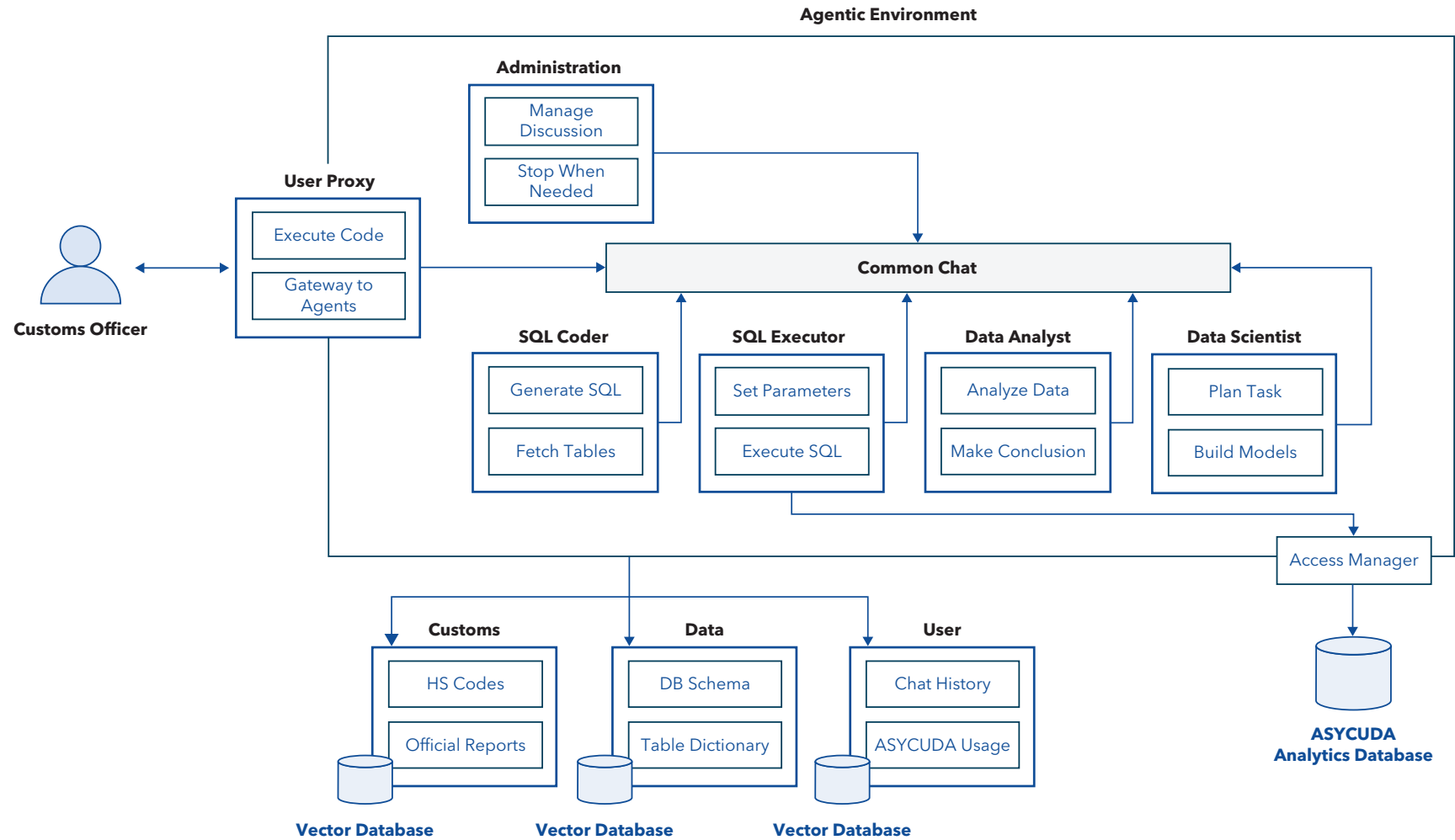
Figure 7. On-Premises GenAI Integration with Open-Source Tools



Source: IMF Staff.

Note: Conceptually, leveraging LLMs to translate natural language requests into SQL statements is an emerging technique best suited to well-defined, stable data models with appropriate oversight by qualified experts. In practice, these requirements are currently more frequently met in customs administrations than in tax administration, due largely to the prevalence of the ASYCUDA platform and standardized procedures in use across jurisdictions.

Figure 8. Agentic Integration in a Knowledge-Intensive Context



Source: IMF Staff.

Note: A vector database stores information as vectors, which are mathematical representations of data in multidimensional space. This format allows for fast retrieval and context-sensitive search by enabling similarity-based queries, making it particularly useful for natural language processing.

Figure 9. Agentic Integration: Interaction Between Agents (Data Analyst)

**Prompt #1:**

**What is the largest company importing using an hscode starting with 1511?**

**Agent SQL\_Coder (to chat\_manager):**

To find the largest company importing goods with an HS code starting with "1511", we need to join the `sad\_general\_segment` and `sad\_item` tables on the `instanceid` field. We will then filter the items based on the HS code and aggregate the import values by the company name. Finally, we will sort the results to find the company with the largest total import value.

**See Annex 4 and the SQL generated<sup>1</sup>**

This query does the following:

1. Joins the `sad\_general\_segment` and `sad\_item` tables on the `instanceid` field.
2. Filters the items to include only those with an HS code starting with "1511".
3. Groups the results by the exporter's name (`cmp\_exp\_nam`).
4. Sums the CIF values (`vit\_cif`) for each company.
5. Orders the results in descending order of the total import value.
6. Limits the result to the top company with the largest total import value.

**Agent SQL\_Executor (to chat\_manager):****See Annex 4 for the SQL execution and response****Agent Data\_Analyst (to chat\_manager):**

The largest company importing goods with an HS code starting with "1511" is [ANONYMIZED] with a total import value of [ANONYMIZED].

**Prompt #2:**

**What proportion of this company total imports does it represent?**

**Agent SQL\_Coder (to chat\_manager):**

To determine the proportion of the total imports that the company's imports with HS code starting with "1511" represent, we need to calculate the total imports for the company and then find the proportion of the "1511" imports within that total.

Here is the SQL query to achieve this:

**See Annex 4 and the SQL generated**

This query does the following:

1. Calculates the total import value for the company "[ANONYMIZED]" using a common table expression (CTE) named `company\_total\_imports`.
2. Calculates the total import value for the company's imports with HS code starting with "1511" using another CTE named `hs1511\_imports`.
3. Joins the two CTEs on the company name.
4. Computes the proportion of the "1511" imports within the total imports and multiplies by 100 to get the percentage.

**See Annex 4 and the iterations of SQL refined****Agent Data\_Analyst (to chat\_manager):**

The largest company importing goods with an HS code starting with "1511" is [ANONYMIZED], with a total import value of approximately [ANONYMIZED]. This represents [ANONYMIZED]% of the company's total imports.

Source: IMF Staff.

Note: CIF = Cost, Insurance, and Freight; HS = Harmonized Commodity Description and Coding System (Harmonized System); SQL = Structured Query Language.

<sup>1</sup> Note in this example, SQL\_Coder agent has incorrectly grouped by cmp\_exp\_nam (instead of cmp\_con\_nam), a mistake easily also made by human analysts.



Figure 10. Agentic Integration: Interaction Between Agents (Data Scientist)

**Prompt:**

**Create a clustering for the hscode starting with 1511 for the importers, on their volume and weight. Agent SQL\_Coder (to chat\_manager):**

**Agent SQL\_Coder (to Agent chat\_manager):**

To create a clustering for the HS code starting with "1511" for the importers based on their volume and weight, we need to extract the relevant data from the `sad\_item` table and join it with the `sad\_general\_segment` table to get the importer information. We will then use the `tar\_hsc\_nb1` column to filter for HS codes starting with "1511".

Since SQL does not have built-in clustering algorithms, we will prepare the data in a format that can be used for clustering in a data analysis tool like Python or R. The query will select the importer name, volume, and weight for the specified HS codes.

Here is the SQL query to extract the necessary data:

**See Annex 5 and the SQL generated**

This query will provide a dataset with the importer name, total weight, and total volume for all items with HS codes starting with "1511". You can then use this dataset in a data analysis tool to perform clustering.

**Agent SQL\_Executor (to chat\_manager):****See Annex 5 for the SQL execution and response****Agent Data\_Analyst (to Data\_Scientist):**

Perform clustering on the importers based on their volume and weight for HS codes starting with 1511.

**Agent Data\_Scientist (to chat\_manager):**

Code running:

```
df = dfs[0]
X = df[['total_weight', 'total_volume']]
kmeans = KMeans(n_clusters=2, random_state=42)
df['cluster'] = kmeans.fit_predict(X)
```

...

**See Annex 5 and for the full Python code****Data\_Analyst (to Data\_Scientist):**

Plot the clustering results for importers based on their volume and weight for HS codes starting with 1511.

**See Annex 5 and the Python code for plotting****Agent Admin:**

Based on the data provided and the clustering analysis performed, we can observe the following:

1. **\*\*Volume and Weight Distribution\*\***: The dataset includes importers with varying total weights and volumes. Some importers have significant volumes but zero weight, which might indicate discrepancies in data reporting or specific types of goods (e.g., high-value, low-weight items).

...

**See Annex 5 for full interpretation of results**

Source: IMF Staff.

## VI. Suggested Guidelines for Operational Use

**A basic set of guidelines should inform the operational use of GenAI services.** The following are provided with the intent that they be considered by leadership or management accountable for the units engaged in compliance risk analysis.

### 1. Understand When to Use GenAI

**The use of AI is already established in tax and customs administration, and GenAI should be relied on only when and if it offers a clear advantage.** In the form of expert systems and machine learning for predictive analytics, AI has a long history of use in research and operations, including with targeting of enforcement activities (case selection and selectivity for examination in customs).<sup>15</sup> These applications have historically involved analysts or data scientists having the ability to work with quantitative methods to design, validate, and improve the predictive power of risk models.<sup>16</sup> When supported by legal powers, procedures, and appropriate oversight, AI's established uses offer important, proven capabilities that can be safely employed. With GenAI comes a new set of opportunities and risks that may be best evaluated in terms of its features.

### Features of GenAI that May Offer Advantages

- *Trained on large, public data sets.* Foundation models enabling many GenAI services facilitate open-ended, context-sensitive research and analysis. While this can provide important capabilities, models are not typically trained on taxation specifically, which may limit the quality of outputs, introduce biases, and increase hallucinations.
- *General-purpose design, not task specific.* Unlike both expert systems and predictive analytics, which primarily rely on explicit programming and structured inputs, GenAI can make use of unstructured data and adapt to a range of tasks without requiring expertise to program for specific outcomes. However, outputs may lack precision and accuracy, requiring careful validation to ensure reliability.
- *Augmentable for improved performance.* Using RAG techniques, the training data of foundation models may be augmented for specific domains and tasks. This can be performed using a wide range of both structured and unstructured data (documents, videos, images), the results of which can lead to improved outputs having higher levels of contextual understanding, accuracy, and relevance.
- *Capable to be integrated with internal data sources.* With its large, pretrained models, GenAI can be integrated with internal data sources to bring a new, powerful depth of AI knowledge and understanding into traditional forms of risk analysis. Integration with GenAI can also serve the purpose of "democratizing" data, making it accessible to a wider group of analysts, including those less technically proficient.
- *Facilitates interaction in natural language.* Among GenAI's features, the ability of an analyst to interact with it in natural language may be its most important. Although this capability has long existed in the form of natural language processing (NLP), GenAI has dramatically improved its utility and reduced the need for staff skilled in technical aspects of analytics, including programming and machine learning techniques.

<sup>15</sup> See Aslett and others (2024a) for (a) an overview of AI's broader use in tax and customs administration, along with a description of its historic adoption starting in the 1970s-1990s; (b) suggested actions to make responsible use of AI; (c) an example of an AI policy; and (d) methodology to risk assess AI use cases.

<sup>16</sup> Using concepts such as confusion matrices and Receiver Operating Characteristic (ROC) curves.

## 2. Mandate Human Accountability for Outcomes

**As part of a formal policy on AI usage, human responsibility for AI outcomes should be clearly stated as a core principle.** The risk analysts using AI, including GenAI, must (1) remain accountable for decisions that AI influences or determines and (2) be capable to explain which procedures were applied, why they are defensible, the boundaries within which AI may be used, and how the AI operates (technically and functionally). The principle of human responsibility for AI must extend across all stages of AI's development and use, starting from core data collection, management, and use in training AI systems. The principle requires that up-to-date governance frameworks and procedures be put in place. Within these, each aspect of AI's use must be fully scrutinized: input into AI systems, AI processing, outputs that AI generates, and the monitoring and evaluations required to determine whether AI is performing as expected.

## 3. Anticipate Changes and Prioritize Staff Training

**Organizational implications of GenAI may be counterintuitive and developing a plan for dealing with them should be considered in advance of adoption.** Because of its accessibility with natural language, GenAI will be relevant to more staff than other forms of AI have been in the past. While there may be gains in efficiency from staff using the technology, it is also likely that most administrations will experience significant new increases in overhead costs, both to responsibly maintain the technology and to make effective use of it. For many, costs will extend into needed enhancements to data and IT governance, while also requiring investments in staff. Among training needs for those engaged in risk analysis, priorities include exposure to (a) ethical and responsible uses of AI, (b) principles of individual duty of care, (c) information security, (d) predictive analytics, (e) prompt engineering, and (f) use of specific AI tools.

## 4. Build (and Secure) a Repository of Compliance Information

**To best benefit from GenAI, a repository of confidential compliance information should be compiled, secured, and very carefully monitored.** The foundation models that underly GenAI are pretrained on content intended for general consumption, often including by the public. However, information and data relating to taxpayer and trader compliance history, fraud, and investigations are by nature kept confidential by tax and customs administrations. Accordingly, GenAI's utility in risk analysis will be most effective when it is adapted to account for relevant domain knowledge and integrated with internal, confidential information. This adaptation is critical and likely to represent a significant hurdle for many administrations.

### Features of a Repository Adapted for Use by GenAI

- *Secure infrastructure for "big data."* Often built progressively, modern infrastructure includes a combination of centralized (a) reporting databases, (b) data warehouses, and (c) data lakes. These platforms host both structured and unstructured data. While many administrations now have assets in place and tools for working with structured data, using unstructured big data is less common and may require new investments.
- *Proactive management.* A well-administered repository will incur significant overhead costs, including for data management and application of information security policies and controls.<sup>17</sup> Priorities include ensuring the quality of data in the repository (which requires strong domain knowledge), introducing security classifications to manage access to different levels of information confidentiality, and mandating audit trails.

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<sup>17</sup> See Figure 3 in Aslett and others (2024b) for an illustrative roadmap describing implementation of data infrastructure to support compliance risk analysis. See Aslett (2024) and the online VITARA course on information technology and data management for guidance on data management practices and information security.

- *Structured for augmenting GenAI services.* By making use of RAGs and fine-tuning, the repository could include a wide range of artifacts and data sets, including legislation and procedures, environmental scans, industry benchmarks, prior rulings, data sets describing compliance history, risk profiles, declarations, the results of large taxpayer risk reviews, case files (service and enforcement), and reports from investigations.

## 5. Iterate Adoption of GenAI Slowly, with Caution

**Tax and customs administrations are not research laboratories, and while experimentation with GenAI should be encouraged, it should also be controlled.** Directionless introduction of the technology is likely to be counterproductive, raising risks and wasting staff time. Strong top-down governance is a critical starting point, from which small numbers of specific, risk-assessed use cases should be prioritized and developed. With proven use cases, the end goal should be to scale up for operational purposes. This end goal is key to maintain both within risk groups and beyond. However, because of the sensitivity of the information processed by risk analysts, special care should be taken to ensure that their experimentation also adheres to policies, both AI and security related, particularly when using any externally hosted GenAI services.

## VII. Conclusion

**In the introduction to this note, the question was raised: What role will AI begin to take—assistant, consultant, collaborator, or replacement?** Having explored the subject, perhaps the better question for most administrations is, how much AI can be responsibly administered? With its ability to support all facets of compliance risk analysis, GenAI is likely to take on many roles. Some will be short-lived, spanning the life of a particular project, and others will be long-running, with configurations put into operation allowing for independent, autonomous handling of routine tasks. More tantalizing is the possibility of deploying suites of AI agents to collectively navigate, understand, and proactively advance complex compliance activities. In whatever form AI is used, the onus for defensible, responsible applications will remain human far into the future. What might that future look like, and where will GenAI feature in it?

### GenAI's Systemic Impact

**Regardless of how tax and customs administrations benefit from GenAI, prudent planning will require taking a systemic perspective.** As GenAI is used to help improve compliance, so too is it likely to facilitate new and aggressive forms of tax planning, evasion, and fraud. The net impact, when considered globally, will likely be unbalanced. In leading administrations, additional capacity may be opened up by GenAI, but savings may also need to be reinvested into defensive thinking. For administrations in low-capacity settings, GenAI's arrival is likely to be experienced differently. In specialized areas, such as international taxation, GenAI could augment staff in a manner that supports better and previously weak technical analysis. However, as augmentation in some areas becomes possible, the space for comprehensive adoption may be limited and the digital divide that already exists may widen even further because of AI.<sup>18</sup>

### Probable Future Developments

**The future of GenAI is likely one of aggressive, mainstream integration into digital tools and managed agentic environments.** Underpinning these will be the emergence of customized solutions for augmentation in specialized domains, including tax and customs administration.<sup>19</sup> In the medium term, open-source and on-premises approaches are likely to gain momentum. However, through a combination of certification and technological innovation, some data privacy concerns with externally hosted GenAI services may be alleviated. The process of establishing repositories of compliance information for integration into GenAI services will become a key fixation for many administrations. Regardless, business intelligence platforms will increasingly incorporate GenAI and NLP into their offerings, reducing technical barriers to analysis and further democratizing access to data and information.<sup>20</sup> With foundations for GenAI in place, the management and use of agents will increasingly feature in conversation among risk analysts, and beyond.

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<sup>18</sup> See Amaglobeli and others (2023) for an overview of the digital divide in context of connectivity, noting that nearly 3 billion worldwide do not use the internet and another 2 billion are poorly connected. In addition, per data sets from the International Survey on Revenue Administration (ISORA), consider that median expenditure on information and communications technology (ICT) in tax administration varies dramatically by country group. As one example, in 2022, median ICT expenditure was 14.20 percent in major advanced economies (G7) but only 0.66 percent in the Middle East and Central Asia.

<sup>19</sup> Referring to the potential for tailored models and RAGs.

<sup>20</sup> Referring to the fact that some mainstream commercial platforms and tools already incorporate GenAI.

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## Final Thoughts

**While GenAI is likely to usher in important changes, principles of compliance are likely to persist well into the future.** Taxpayers will remain responsible for (1) registering correctly, (2) filing on time, (3) reporting accurately, and (4) paying on time. For those active in foreign trade, obligations will continue for correct (5) classification; (6) valuation; (7) other reporting, including origin; and (8) use of procedures. At the same time, the nature of these obligations and how they are fulfilled may change as AI itself evolves, reshaping aspects of policy and administration.

**In the past, advice around digital topics often suggested getting the fundamentals right before investing in other areas, but GenAI requires more nuanced thinking.** Over time, AI, including GenAI, is likely to become ubiquitous in digital environments. Rather than being considered as an add-on or extension of good practice digital operations, its actual use is likely to be embedded throughout. From that perspective, although GenAI will introduce new challenges, it cannot be ignored, including by the administrations that are still working to establish solid digital foundations. To the contrary, GenAI's arrival may accelerate that work while at the same time leading to new conceptions of how the fundamentals can be best administered. This may be true particularly in subjects rich in data and information, compliance risk analysis among them.

## ANNEX 1. Demonstration: Research

The following demonstrates how GenAI can be used to assist in the consideration of tax revenue and compliance issues potentially arising from changes to the external economic environment. By incorporating the output of one GenAI service as the input into another GenAI service, the overall analysis and response is broadened.

### **Step 1: Prompt GenAI #1: [Entered by a Human User]**

1. *Background information: Country X has just had a 25% devaluation of its currency following major falls in certain commodity prices. The commodities in question form a major part of Country X's exports, mainly through a small number of large multinational corporations.*
2. *Task: Consider the tax revenue and associated tax compliance issues that might play out for Country X's tax administration over the coming five years.*
3. *Break these issues into those that might be associated with large multinational taxpayers that have subsidiaries or branches in Country X, those issues that might be associated with smaller and medium taxpayers that may be impacted by the sudden change in the value of Country X's exchange rate, how those tax revenue and tax compliance issues might differ between import and export exposed industries, particularly those associated with the change in commodity prices.*
4. *Elaborate on your answer and structure it on how these tax revenue and tax compliance issues may play out over time.*

### **Step 2: Review Response**

#### **Introduction**

The 25% devaluation of Country X's currency, precipitated by significant declines in key commodity prices, presents multifaceted challenges for the nation's tax administration over the next five years. These commodities constitute a substantial portion of Country X's exports, primarily handled by a few large multinational corporations (MNCs). This economic shift will impact tax revenue and compliance differently across various taxpayer segments and industries.

This analysis will dissect the potential issues associated with large MNCs with subsidiaries or branches in Country X, examine the challenges faced by small and medium taxpayers affected by the exchange rate fluctuation, and explore how tax revenue and compliance issues may diverge between import and export-exposed industries, especially those linked to the commodity price changes.

### **I. Impact on Large Multinational Taxpayers**

#### **A. Tax Revenue Issues**

##### **1. Decreased Corporate Income Tax Revenue**

- a. *Immediate Effect (Year 1-2):* The fall in commodity prices directly reduces the profitability of MNCs in the export sector. Lower profits result in decreased corporate income tax payments to the government.
- b. *Medium Term (Year 3-4):* MNCs may delay or cancel expansion projects due to reduced capital, leading to a slowdown in economic growth and a further decline in tax revenues from corporate activities.

##### **2. Transfer Pricing Adjustments**

*Immediate to Medium Term (Year 1-4):* MNCs might adjust transfer pricing strategies to allocate more profits to subsidiaries in lower-tax jurisdictions, diminishing taxable income in Country X.

### 3. Dividend Withholding Taxes

*Long Term (Year 5 and beyond):* Reduced profits may lead to lower dividends paid to foreign shareholders, decreasing withholding tax revenues.

## B. Tax Compliance Issues

### 1. Increased Tax Planning and Avoidance

*Immediate Effect (Year 1-2):* Facing profit squeezes, MNCs may intensify tax planning efforts to minimize liabilities, exploiting gaps in tax laws.

### 2. Complex Financial Arrangements

*Medium Term (Year 3-4):* MNCs may engage in sophisticated financial transactions, such as intercompany loans or royalties, complicating the tax administration's ability to assess and collect the correct taxes.

### 3. Disputes and Litigation

*Long Term (Year 5 and beyond):* Aggressive tax positions taken by MNCs may lead to increased disputes, requiring more resources for audits and litigation.

## C. Over Time Dynamics

- *Year 1-2:* Immediate revenue decline from lower corporate taxes and increased tax avoidance efforts.
- *Year 3-4:* Heightened complexity in tax compliance as MNCs adjust strategies; possible policy responses from the government.
- *Year 5 and beyond:* Potential stabilization if commodity prices recover; ongoing challenges with compliance and enforcement.

## II. Impact on Small and Medium Taxpayers

### A. Tax Revenue Issues

#### 1. Reduced Profit Margins for Importers

*Immediate Effect (Year 1-2):* SMEs importing goods face higher costs due to the devaluation, squeezing profit margins and reducing taxable income.

#### 2. Competitive Advantage for Exporters

*Immediate to Medium Term (Year 1-4):* SMEs in export industries not affected by commodity price falls may benefit from a weaker currency, potentially increasing tax revenues from this sector.

#### 3. Business Contraction and Closures

*Medium to Long Term (Year 3-5):* Prolonged financial strain may lead to business downsizing or closures, shrinking the tax base.

## B. Tax Compliance Issues

### 1. Increased Non-Compliance Risk

*Immediate Effect (Year 1-2):* Financial stress may lead SMEs to underreport income, overstate deductions, or delay tax payments.

### 2. Cash Flow Challenges

*Medium Term (Year 3-4):* Ongoing exchange rate volatility can exacerbate cash flow issues, resulting in higher tax arrears.

### 3. Migration to Informal Economy

*Long Term (Year 5 and beyond):* Sustained economic pressure may push SMEs to operate informally, outside the tax net.



### C. Over Time Dynamics

- *Year 1-2*: Immediate compliance challenges due to cash flow issues; potential increase in tax arrears.
- *Year 3-4*: Possible adaptation through cost-cutting or business model changes; continued risk of non-compliance.
- *Year 5 and beyond*: Stabilization or further decline depending on economic conditions; need for targeted support to improve compliance.

## III. Differences Between Import and Export-Exposed Industries

### A. Import-Exposed Industries

#### 1. Tax Revenue Issues

- Immediate Effect (Year 1-2)*: Increased import costs reduce profitability, leading to lower income tax and value-added tax (VAT) collections.
- Medium Term (Year 3-4)*: Potential reduction in import volumes could decrease customs duties and import VAT revenues.

#### 2. Tax Compliance Issues

*Immediate to Medium Term (Year 1-4)*: Importers may misdeclare goods or underinvoice to reduce tax liabilities, challenging customs enforcement.

### B. Export-Exposed Industries

#### 1. Tax Revenue Issues

- Immediate Effect (Year 1-2)*: Exporters of commodities with falling prices see reduced revenues, lowering corporate tax contributions.
- Medium Term (Year 3-4)*: Non-commodity exporters may benefit from the devaluation, potentially increasing tax revenues from these sectors.

#### 2. Tax Compliance Issues

*Immediate to Medium Term (Year 1-4)*: Exporters might engage in transfer mispricing, undervaluing exports to shift profits abroad.

### C. Over Time Dynamics

- *Importers*:
  - *Year 1-2*: Struggle with higher costs; increased tax evasion risks.
  - *Year 3-4*: Possible shift to local sourcing; adjustment in tax revenues.
  - *Year 5 and beyond*: Stabilization if currency strengthens or businesses adapt.
- *Exporters*:
  - *Year 1-2*: Mixed impact; commodity exporters suffer, others may thrive.
  - *Year 3-4*: Potential growth in non-commodity exports; improved tax revenues.
  - *Year 5 and beyond*: Diversification may lead to a more robust export sector and tax base.

## IV. Policy Implications and Recommendations

### A. Strengthening Tax Administration

#### 1. Enhance Audit Capabilities

Invest in training and resources to better scrutinize complex MNC transactions and transfer pricing.

#### 2. Improve Compliance Support for SMEs

Offer assistance programs to help SMEs navigate tax obligations during economic hardship.

## B. Legislative Measures

### 1. Update Transfer Pricing Regulations

Align with international best practices to prevent profit shifting by MNCs.

### 2. Implement Anti-Avoidance Rules

Introduce laws to curb aggressive tax planning and abuse of tax treaties.

## C. International Cooperation

### 1. Exchange of Information

Collaborate with other tax jurisdictions to obtain information on MNC activities.

### 2. Participate in Global Initiatives

Engage in OECD's Base Erosion and Profit Shifting (BEPS) project to combat tax avoidance.

## Conclusion

The currency devaluation and commodity price decline in Country X will have immediate and long-term effects on tax revenue and compliance. Large MNCs may contribute less in taxes and present complex compliance challenges, while SMEs face increased financial pressure leading to potential non-compliance. Import-exposed industries will struggle with higher costs, whereas export-exposed sectors may have varied outcomes depending on their commodity linkage. The tax administration must proactively address these issues through strengthened enforcement, supportive measures for compliant taxpayers, and legislative reforms to safeguard the tax base over the coming five years.

### Step 3: Prompt GenAI #2: *[Entered by a Human User]*

*Elaborate and improve on the answer provided by GenAI #1*

### Step 4: Review Response

## Enhanced Analysis of Tax Revenue and Compliance Issues Following Currency Devaluation

### Executive Summary

While GenAI 1's response provided a solid foundation, several critical areas warrant deeper exploration, particularly regarding:

- The timing and interaction of different tax effects
- Sector-specific impacts beyond commodities
- Secondary effects on the broader tax base
- Practical challenges for tax administration
- International tax implications

## I. Additional Considerations for Multinational Corporations (MNCs)

### A. Immediate Tax Revenue Impacts (Years 1-2)

#### 1. Foreign Exchange (FX) Related Issues

- a. Timing of FX losses recognition and deductibility
- b. Treatment of hedging arrangements and their tax implications
- c. Complex tax accounting for unrealized FX gains/losses
- d. Impact on thin capitalization calculations due to revaluation of foreign debt

#### 2. Supply Chain Restructuring

- a. Tax implications of emergency supply chain reorganizations
- b. Permanent establishment risks from temporary relocations
- c. Changes in profit attribution among group entities

### **3. Working Capital Adjustments**

- a. Tax treatment of emergency capital injections
- b. Deductibility of increased financing costs
- c. Transfer pricing implications of intra-group financing

## **B. Medium-Term Effects (Years 2-4)**

### **1. Strategic Corporate Restructuring**

- a. Tax implications of potential mergers and acquisitions
- b. Treatment of business restructuring costs
- c. Impact on existing tax incentives and holidays
- d. Changes in effective tax rates due to altered business models

### **2. Investment Decisions**

- a. Tax treatment of abandoned projects
- b. Recognition of impairment losses
- c. Changes in R&D tax incentive utilization
- d. Impact on capital allowance claims

## **C. Long-Term Considerations (Years 4-5)**

### **1. Business Model Evolution**

- a. Tax implications of vertical integration strategies
- b. Changes in intellectual property holding structures
- c. Impact on existing advance pricing arrangements
- d. Evolution of permanent establishment footprint

## **II. Enhanced Analysis for Small and Medium Enterprises (SMEs)**

### **A. Sector-Specific Impacts**

#### **1. Service Sector**

- a. Treatment of long-term contracts denominated in foreign currency
- b. Impact on VAT/GST compliance for cross-border services
- c. Tax implications of changed payment terms with international clients

#### **2. Manufacturing Sector**

- a. Tax treatment of inventory value adjustments
- b. Impact on R&D tax incentives
- c. Treatment of equipment lease payments in foreign currency

#### **3. Retail Sector**

- a. Changes in transfer pricing for franchisee arrangements
- b. Impact on thin capitalization rules for retail financing
- c. Treatment of terminated commercial leases

## **B. Compliance Challenges**

### **1. Resource Constraints**

- a. Impact on tax function staffing and expertise
  - b. Ability to maintain proper documentation
  - c. Capacity to engage with tax authorities
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## **2. Systems and Processes**

- a. Currency translation in tax reporting systems
- b. Maintenance of dual-currency records
- c. Integration of tax and accounting systems

## **III. Cross-Cutting Issues**

### **A. VAT/GST Considerations**

#### **1. Timing Issues**

- a. Treatment of deposits and advance payments
- b. Impact on bad debt relief claims
- c. Changes in input tax recovery patterns

#### **2. Valuation Challenges**

- a. Treatment of related party transactions
- b. Impact on customs value calculations
- c. Changes in transfer pricing adjustments

### **B. Employment Tax Issues**

#### **1. International Assignments**

- a. Treatment of cost of living adjustments
- b. Impact on shadow payroll calculations
- c. Changes in social security obligations

#### **2. Compensation Restructuring**

- a. Tax treatment of currency protection schemes
- b. Impact on share-based payment arrangements
- c. Changes in bonus and incentive structures

## **IV. Administrative Challenges for Tax Authorities**

### **A. Operational Issues**

#### **1. Resource Allocation**

- a. Need for specialized forex expertise
- b. Training requirements for staff
- c. Technology system updates

#### **2. Audit Strategy**

- a. Development of new risk assessment criteria
- b. Changes in audit focus and methodology
- c. Resource allocation between taxpayer segments

### **B. Policy Responses**

#### **1. Guidance and Rulings**

- a. Need for real-time guidance on complex issues
- b. Development of practical compliance approaches
- c. Balance between enforcement and support

#### **2. International Cooperation**

- a. Enhanced information exchange requirements
  - b. Coordination on cross-border enforcement
  - c. Mutual agreement procedure capacity
-

## **V. Timeline of Critical Issues**

### **Year 1**

- Emergency response to forex losses
- Initial supply chain disruptions
- Immediate working capital challenges
- Initial compliance challenges

### **Year 2**

- Business model adjustments
- Transfer pricing modifications
- Initial restructuring activities
- Systems and process updates

### **Year 3**

- Strategic repositioning
- Enhanced compliance frameworks
- International structure changes
- Policy response implementation

### **Years 4-5**

- Long-term business model evolution
- Stabilization of tax base
- Enhanced administrative capacity
- International cooperation framework

## **VI. Recommendations for Tax Administration**

### **A. Short-Term Actions**

1. Establish emergency response team
2. Issue practical guidance on key issues
3. Implement flexible payment arrangements
4. Enhance technical capacity

### **B. Medium-Term Initiatives**

1. Develop specialized audit programs
2. Enhance international cooperation
3. Update risk assessment frameworks
4. Implement technology solutions

### **C. Long-Term Strategy**

1. Reform tax legislation
  2. Strengthen administrative capacity
  3. Enhance international engagement
  4. Develop specialized expertise
-

**Conclusion**

The currency devaluation creates complex and interrelated tax challenges that evolve over time. Success in managing these issues requires:

- Balanced approach between enforcement and support
- Enhanced technical capacity
- Strong international cooperation
- Flexible and responsive administrative systems

The tax administration must be prepared for both immediate challenges and long-term structural changes in the tax base and compliance landscape.

## ANNEX 2. Demonstration: Analysis

This example demonstrates how GenAI can be used to review a published annual report of a large multinational mining company (details anonymized) for potential tax compliance risks. A dialogue was entered into with the GenAI service to refine its analysis, and it was then asked to suggest compliance risk mitigation controls set out in the form of a risk bow tie, detailing suggested preventive, detective, and corrective risk controls. The results were quick and provided a useful starting point for potential compliance verification activity.

### **Step 1: Upload Annual Report**

### **Step 2: Prompt Analysis of the Report: [Entered by a Human User]**

*Review the Multinational Mining Co annual report from a tax compliance risk management perspective:*

- *Consider what features or text might indicate whether Multinational Mining Co is shifting profits or using debt to reduce its overall tax payments.*
- *Consider the use of royalties, marketing hubs, and other mechanisms to move profits to lower tax jurisdictions.*
- *Calculate the effective tax rate on profits reportedly earned in lower taxing jurisdictions compared to the profitability and effective tax rate in higher taxing jurisdictions.*
- *Consider the subsidiary structures and placements used by Multinational Mining Co and whether these may have a tax driven purpose.*

### **Step 3: Review the GenAI Output**

Reviewing the Multinational Mining Co Annual Report from a tax compliance risk management perspective involves examining several factors that could indicate potential tax avoidance strategies, such as profit shifting, debt structuring, and the use of lower-tax jurisdictions. Based on the document:

#### **1. Effective Tax Rate and Profit Shifting**

Multinational Mining Co's overall effective tax rate appears to be relatively low, particularly in its marketing activities. The report notes a 10% target effective tax rate for marketing activities, compared to a higher 25% rate for industrial activities (MULTINATIONAL MINING CO ---Annual-R...). The lower tax rate in marketing could suggest the use of mechanisms such as marketing hubs to shift profits to low-tax jurisdictions. Marketing hubs can serve as conduits to book profits in tax-favorable locations, even though the economic activities generating those profits may occur in higher-tax jurisdictions.

The use of royalties and service fees to transfer income from one entity to another within the same corporate group, especially to subsidiaries in lower-tax locations, might also contribute to this discrepancy.

#### **2. Subsidiary Structures and Placements**

The report also mentions intercompany transactions and allocation of debt between marketing and industrial activities. Around 85% of readily marketable inventories are financed by debt (MULTINATIONAL MINING CO ---Annual-R...), a strategy often used to allocate interest expenses to higher-tax jurisdictions to reduce taxable income in those regions. Multinational Mining Co's subsidiaries and investments are structured in a way that allows for interest deductions, thus lowering the overall tax burden.

Multinational Mining Co operates a wide array of subsidiaries globally, including in countries known for favorable tax regimes. For instance, income tax benefits from deferred tax assets related to tax losses and the use of deductible temporary differences in certain jurisdictions demonstrate strategic use of the tax code (MULTINATIONAL MINING CO ---Annual-R...)(MULTINATIONAL MINING CO ---Annual-R...). Unremitted earnings of \$50 billion retained in subsidiaries for reinvestment further point to a deliberate approach to avoiding repatriation taxes (MULTINATIONAL MINING CO ---Annual-R...).

### 3. Debt Usage and Leveraging

The company uses significant intercompany debt allocations, particularly within the marketing segment, to allocate interest expenses and reduce taxable profits (MULTINATIONAL MINING CO ---Annual-R...). Debt-financing strategies enable the group to offset profits with interest payments, which may lead to base erosion in higher-tax jurisdictions. The adjusted tax calculations based on the EBIT (Earnings Before Interest and Tax) show that the overall applicable tax rate was reduced to 17%, even though Multinational Mining Cooperates across multiple jurisdictions (MULTINATIONAL MINING CO ---Annual-R...).

### 4. Royalties and Other Deductions

The report includes a discussion of royalties and levies treated as income tax, suggesting that certain government-imposed charges are structured in a way that allows them to be deductible for tax purposes (MULTINATIONAL MINING CO ---Annual-R...). This can further reduce the group's effective tax rate.

### Conclusion

From a tax compliance risk management perspective, Multinational Mining Co 's use of marketing hubs, strategic debt allocations, royalty payments, and intercompany structures may warrant close scrutiny. The company's operations in low-tax jurisdictions, its relatively low effective tax rate in marketing, and the extent of deferred tax assets and unremitted earnings could indicate profit-shifting mechanisms aimed at minimizing the overall tax burden. Tax authorities may need to evaluate the economic substance of these transactions to determine whether they reflect genuine business activities or are primarily designed for tax avoidance purposes.

#### **Step 4: Prompt for Elaboration: [Entered by a Human User]**

*Expand on each of your four points and reference back to the annual report with the evidence base for your conclusion.*

### GenAI Response

To expand on the points from the - Multinational Mining Co Annual Report, I will detail how the report provides insights into Multinational Mining Co's potential tax strategies, referencing specific sections and excerpts from the report where relevant.

#### **1. Effective Tax Rate and Profit Shifting**

Observation: Multinational Mining Co reports a 10% effective tax rate for its marketing activities, which is substantially lower than the 25% tax rate applied to its industrial activities (MULTINATIONAL MINING CO ---Annual-R...).

Annual Report Reference: Multinational Mining Cooperates marketing hubs, entities that facilitate the purchase and sale of commodities but may do so in jurisdictions with favorable tax rates. These marketing hubs can book profits in low-tax jurisdictions even if the commodities are produced or used in higher-tax areas. The difference between the tax rates of marketing and industrial activities suggests that marketing



profits, which account for a significant portion of Multinational Mining Co's overall earnings, are potentially being shifted to lower-tax jurisdictions. This shift lowers Multinational Mining Co's overall tax liability.

**Risk Management Implications:** From a tax compliance risk management perspective, this significant tax differential raises questions about the economic substance of activities carried out by marketing hubs. If profits generated by real economic activity are being shifted to jurisdictions that offer lower tax rates without the corresponding business substance, this would indicate potential tax avoidance strategies. Tax authorities might examine the transfer pricing methods used between the marketing hubs and the operating companies in higher-tax jurisdictions to ensure that the arm's-length principle is being applied correctly.

## 2. Subsidiary Structures and Placements

**Observation:** Multinational Mining Co has a complex web of subsidiaries in numerous jurisdictions, some of which are in tax-favorable locations (MULTINATIONAL MINING CO ---Annual-R...). Additionally, Multinational Mining Co's financial reporting mentions the use of intercompany loans, which could be used to shift income or allocate deductible interest expenses to reduce taxable income in higher-tax jurisdictions.

**Annual Report Reference:** The report highlights that deferred tax assets relating to prior-year losses and other deductible differences are used across various subsidiaries to reduce current tax liabilities. For instance, Multinational Mining Co notes the existence of deferred tax assets valued at \$2 billion, much of which relates to tax losses carried forward (MULTINATIONAL MINING CO ---Annual-R...). Additionally, Multinational Mining Co retained \$50 billion in unremitted earnings across its subsidiaries, which are likely in low-tax jurisdictions (MULTINATIONAL MINING CO ---Annual-R...).

**Risk Management Implications:** The use of a wide network of subsidiaries, especially when concentrated in low-tax jurisdictions, is a common indicator of tax-driven structuring. These subsidiaries might be used for purposes beyond just operational efficiency, such as profit shifting through mechanisms like transfer pricing or intercompany loans. Tax authorities would likely investigate the functions, assets, and risks of these subsidiaries to determine whether they serve legitimate business purposes or merely exist to minimize taxes. The unremitted earnings, if located in low-tax jurisdictions, allow Multinational Mining Co to avoid paying taxes on repatriation until the funds are returned to the parent company, another potential red flag for tax avoidance.

## 3. Debt Usage and Leveraging

**Observation:** Multinational Mining Co uses intercompany debt to allocate interest payments within its group. Around 85% of its readily marketable inventories (a total of \$18 billion) are financed through debt (MULTINATIONAL MINING CO ---Annual-R...), indicating a potential strategy of loading certain subsidiaries with debt to reduce taxable profits through interest payments.

**Annual Report Reference:** Multinational Mining Co's use of leveraged debt in both its marketing and industrial divisions reduces its taxable income. Debt-financing strategies involve subsidiaries borrowing funds from other Multinational Mining Co entities, and interest on this debt can be deducted from taxable income in higher-tax jurisdictions. The report also states that overall net debt was reduced to \$30 billion during - due to sales of assets, but significant capital was still raised via bonds and debt facilities (MULTINATIONAL MINING CO ---Annual-R...). The allocation of this debt and the corresponding interest payments could serve to reduce tax liability in jurisdictions with higher tax rates.

**Risk Management Implications:** Leveraging is a common tax minimization strategy, where companies load subsidiaries in higher-tax jurisdictions with intercompany loans, allowing them to take significant interest deductions. This reduces taxable income without necessarily reflecting genuine economic substance. Tax authorities may scrutinize the interest rates applied on these intercompany loans to ensure they are in line with market conditions (i.e., they meet transfer pricing guidelines) and not artificially inflated to maximize tax benefits. This type of arrangement can lead to base erosion in higher-tax countries.

#### 4. Royalties and Other Deductions

**Observation:** Multinational Mining Co makes use of royalties, service fees, and other deductible payments, which may be structured to shift profits to lower-tax jurisdictions. The report notes that royalties are considered part of Multinational Mining Co's income tax calculation (MULTINATIONAL MINING CO ---Annual-R...), which can directly reduce taxable income in higher-tax jurisdictions.

**Annual Report Reference:** Payments such as royalties and levies can be structured as tax-deductible expenses, especially when the recipient is a related party in a lower-tax jurisdiction. In the report, royalties are mentioned in relation to resource extraction payments that are treated similarly to corporate income tax (MULTINATIONAL MINING CO ---Annual-R...). Multinational Mining Co also mentions operating expenses related to marketing, which could potentially include management and service fees paid to entities in lower-tax jurisdictions (MULTINATIONAL MINING CO ---Annual-R...).

**Risk Management Implications:** Royalties and service fees are often scrutinized by tax authorities because they can be used to strip profits from one jurisdiction and reallocate them to another. For tax compliance risk management, the concern is whether these payments reflect genuine business transactions at arm's length or if they are inflated to shift profits artificially. This type of arrangement is typically reviewed in transfer pricing audits, where authorities ensure that payments are commensurate with the economic value provided by the related-party entity. The inclusion of royalty payments in tax calculations raises the question of whether these deductions are being used to reduce tax liabilities beyond what would be expected in an arm's length transaction.

#### Summary of Tax Compliance Risks in Multinational Mining Co's - Report

Profit shifting through the use of marketing hubs in low-tax jurisdictions, particularly by achieving a much lower tax rate in marketing activities (10%) compared to industrial activities (25%) (MULTINATIONAL MINING CO ---Annual-R...).

Subsidiary structuring and deferred tax assets, especially unremitted earnings totaling \$50 billion, suggest strategic placement of subsidiaries in low-tax jurisdictions (MULTINATIONAL MINING CO ---Annual-R...).

Debt-financing and significant use of intercompany loans to shift interest expenses to higher-tax jurisdictions, reducing the overall tax burden (MULTINATIONAL MINING CO ---Annual-R...).

Royalties and service fees that could shift profits to low-tax jurisdictions through inflated or non-arm's length transactions (MULTINATIONAL MINING CO ---Annual-R...) (MULTINATIONAL MINING CO ---Annual-R...).

In conclusion, while Multinational Mining Co's use of these strategies might have legal justifications, they raise red flags from a tax compliance risk perspective. Tax authorities may need to review the economic substance of these structures, the appropriateness of intercompany pricing, and the legitimacy of debt allocation and deductions across jurisdictions.

#### **Step 5: Prompt for Bow-Tie Elements: [Entered by a Human User]**

*Produce a draft tax risk bow-tie for the risks identified detailing potential preventative measures that could be taken by tax administrations, including suggested legislative or regulatory changes, detection approaches such as the risk algorithm that might best detect whether the tax compliance risk was being realized, and then potential corrective controls such as risk reviews, cooperative compliance tools such as Advance Pricing Agreements, tax audits etc.*

#### **GenAI Response**

Draft Tax Risk Bow-Tie for Multinational Mining Co's Tax Compliance Risks

A Bow-Tie diagram is a useful tool to represent a risk and its controls by visualizing the causes and consequences of the risk, preventive and detective measures, as well as corrective actions that can mitigate the risk.

Below is a draft Bow-Tie framework focusing on the tax risks identified in the Multinational Mining Co - Annual Report, which is potentially applicable to other multinational enterprises.

**Central Risk:** Tax Avoidance through Profit Shifting, Debt Structuring, and Use of Low-Tax Jurisdictions

### Left Side of the Bow-Tie (Risk Causes)

#### Risk Drivers/Threats:

- **Profit Shifting via Marketing Hubs in Low-Tax Jurisdictions**

Cause: Use of marketing hubs to book profits in low-tax jurisdictions while the underlying economic activities take place in high-tax countries.

Example: Multinational Mining Co's marketing activities taxed at a 10% effective rate compared to 25% for industrial activities (MULTINATIONAL MINING CO ---Annual-R...).

- **Subsidiary Structures in Favorable Tax Jurisdictions**

Cause: Establishing subsidiaries in low-tax or no-tax jurisdictions, which may serve more for tax optimization than for operational purposes.

Example: Multinational Mining Co's complex subsidiary structure and unremitted earnings of \$50 billion retained in low-tax jurisdictions (MULTINATIONAL MINING CO ---Annual-R...).

- **Excessive Debt Allocation (Debt Structuring)**

Cause: Allocating significant debt to subsidiaries in high-tax jurisdictions to reduce taxable profits via interest deductions.

Example: Multinational Mining Co's allocation of debt-financing for 85% of its readily marketable inventories (MULTINATIONAL MINING CO ---Annual-R...).

- **Royalties and Management Fees**

Cause: High royalties or service fees charged between subsidiaries, shifting profits to low-tax jurisdictions where these fees are received.

Example: Royalties and levies treated as tax-deductible in Multinational Mining Co's report (MULTINATIONAL MINING CO ---Annual-R...).

### Preventive Measures (To Stop the Risk from Occurring)

- **Tightened Transfer Pricing Regulations**

Description: Enforce stricter rules on transfer pricing, particularly on the economic substance of marketing hubs and royalty payments.

Regulatory Measure: Implement Base Erosion and Profit Shifting (BEPS) Action 13 guidelines, mandating country-by-country reporting, to provide transparency on where profits are generated and taxed.

Detection Algorithm: Create risk indicators based on effective tax rate discrepancies between jurisdictions where a company operates vs. their global footprint. Significant deviations from expected rates would trigger further investigation.

- **Substance-over-Form Legislation**

Description: Enforce rules that require economic substance (real activities, personnel, and infrastructure) in the subsidiaries that report significant income.

Regulatory Measure: Introduce economic substance legislation, where subsidiaries in low-tax jurisdictions must demonstrate that the profits they declare are linked to real business activities.

Detection Algorithm: Use a jurisdiction risk scoring system, which flags subsidiaries in low-tax jurisdictions with disproportionately high revenue relative to their reported workforce, assets, and physical presence.

- **Interest Deduction Limits and Thin Capitalization Rules**

Description: Restrict the amount of interest a company can deduct based on the company's earnings, limiting excessive use of debt in high-tax jurisdictions.

Regulatory Measure: Cap interest deductions at a fixed percentage of EBITDA or enact thin capitalization rules, which limit the debt-to-equity ratio for tax purposes.

Detection Algorithm: A risk algorithm that analyzes the debt-to-equity ratio of subsidiaries and flags significant deviations from industry norms for closer scrutiny.

- **Limitations on Deductibility of Royalties and Fees**

Description: Restrict the deductibility of intra-group royalties and service fees, especially when paid to entities in low-tax jurisdictions.

Regulatory Measure: Require Advance Pricing Agreements (APAs) or transfer pricing documentation for all intra-group service and royalty arrangements to ensure they meet the arm's length principle.

Detection Algorithm: Use a transaction-based risk engine that flags large intra-group payments (e.g., royalties, fees) made to entities in tax-favorable jurisdictions, especially where the recipient has limited operational activity.

## **Right Side of the Bow-Tie (Consequences)**

### **Potential Consequences if Risk is Realized:**

- **Reduced Tax Revenue for Higher-Tax Jurisdictions**

Consequence: Profit shifting through low-tax jurisdictions reduces tax liabilities in the countries where real economic activities occur, lowering public revenues.

- **Distortion of Competitive Market Conditions**

Consequence: Companies that engage in aggressive tax avoidance might gain an unfair competitive advantage over companies that fully comply with tax obligations.

- **Reputational Damage and Legal Sanctions**

Consequence: Aggressive tax planning can lead to public backlash, damage to the company's reputation, and potential legal action from tax authorities.

### **Corrective Controls (Post-Event Actions to Mitigate Damage)**

- **Tax Audits Targeting Transfer Pricing**

Description: Conduct in-depth tax audits of companies with significant marketing hubs and intra-group transactions to verify the economic substance and pricing of intra-group payments.

Regulatory Measure: Tax authorities could increase the frequency of transfer pricing audits and expand the scope to cover royalty arrangements and intercompany loans.

Corrective Control: In the case of non-compliance, apply penalties and adjustments based on improper transfer pricing arrangements.

- **Advance Pricing Agreements (APAs)**

Description: Provide companies the option to enter into Advance Pricing Agreements (APAs) to ensure that intra-group pricing, including debt arrangements, royalties, and service fees, comply with the arm's length principle.

Regulatory Measure: Encourage companies operating in complex multinational structures to seek binding APAs to avoid future disputes.

Corrective Control: These agreements can clarify the expected tax treatment of intercompany transactions, reducing disputes and ensuring fair tax payment.

- **Risk Reviews and Data Analytics**

Description: Implement ongoing risk reviews using tax data analytics to identify patterns consistent with tax avoidance schemes, such as sudden shifts in profit allocation to low-tax jurisdictions.

Regulatory Measure: Tax authorities should leverage data analytics tools that track trends in effective tax rates, profit margins, and cross-border payments to identify unusual patterns.

Corrective Control: Based on the reviews, tax authorities could increase the monitoring of companies engaged in these patterns and conduct follow-up audits if red flags persist.

- **Cooperative Compliance Programs**

Description: Offer a cooperative compliance regime where taxpayers disclose their tax structures and engage with tax authorities early to avoid future issues.

Regulatory Measure: Introduce voluntary disclosure programs or tax transparency initiatives where companies can regularly report on their tax planning strategies to reduce aggressive tax structuring.

Corrective Control: In exchange for cooperation, companies could be offered reduced penalties in the event of discrepancies but would be expected to change behavior to remain in the program.

## **Summary of Suggested Legislative/Regulatory Changes**

### **Strengthening Transfer Pricing Rules:**

- Stricter regulations ensuring that pricing between related parties reflects genuine market conditions.

### **Economic Substance Legislation:**

- Requiring that profits declared in low-tax jurisdictions must be linked to substantive business activities.

### **Interest Deduction Limits:**

- Limit excessive deductions from interest payments that reduce taxable income in high-tax jurisdictions.

### **Royalties and Intra-Group Payments Regulation:**

- Restrictions on the tax deductibility of royalties and service fees when they lack proper economic justification.

### **Risk Detection Algorithms**

- Effective Tax Rate Discrepancies: Analyze deviations in effective tax rates compared to average rates for similar companies or industries.
  - Jurisdictional Risk Scoring: Identify subsidiaries in low-tax jurisdictions with limited personnel or assets relative to income.
  - Debt-to-Equity Ratio Tracking: Monitor excessive use of debt financing in high-tax jurisdictions.
  - Intra-Group Payments Analysis: Flag large intra-group payments to low-tax jurisdictions, especially where the receiving entity lacks economic substance.
-

This Bow-Tie model incorporates preventive, detective, and corrective actions to manage the tax risks identified in Multinational Mining Co's annual report.

**Step 6: Render the Bow-Tie**

**Details removed out of an abundance of caution relating to copyright. Note that the bow-tie may be constructed manually using the outputs produced in the prior step.**

## ANNEX 3. Demonstration: Analytics

In this demonstration, a leading GenAI model was asked to analyze a data set. The data, in the form of an Excel worksheet, contains anonymized financial and tax file data from audited businesses. The GenAI was asked to conduct a predictive analytics exercise using the Random Forest classifier and to then interpret the results and consider different risk ranking approaches, roughly approximating ranking by risk likelihood and ranking by risk consequence. The results were quick and impressive, providing a useful starting point for further research.

### **Step 1: Upload the Data Set for Analysis**

#### **Step 2: Prompt Analysis of the Data in Natural Language: [Entered by a Human User]**

*Analyze the data set in the xlsx spreadsheet.*

*Context: It contains financial data from audited businesses. The last column contains the tax audit adjustment that was made.*

*Task: Perform the following analysis and at each step in the following provide the details of the steps taken and the Python code used. If an error is encountered attempt to resolve the error to best complete the analysis to get to the end of this prompt.*

*There are ten (10) steps. Ensure that you allocate sufficient memory for the analysis and that you complete all ten steps...*

*Step 1. Calculate the median adjustment that was made and use this value to create a target column called "STRIKE" for machine learning predictive classification. Where the value of the adjustment is greater than the median set the target variable STRIKE to "1" and where it is less than or equal to the median adjustment set it to "0". Display the median adjustment you have calculated.*

*Step 2. Clean the data set. 1) Fix categorical data by Identifying Categorical Columns: Determine which columns are non-numeric and then Encode Categorical Data: Convert these columns to a format suitable for machine learning. 2) Fix NaN values by setting them to zero.*

*Step 3. Then randomly partition the data set into a training data set and a verification data set with 70% of the cases going to the training data and 30% for verification. Display the number of cases in each data set: training and verification.*

*Step 4. Then Exclude the adjustment data column from the data going into the classification algorithm. We are going to use a Random Forest of 500 trees to classify the verification data. In this step ensure that you always Include the STRIKE column as the target variable for the ML algorithm. (You've excluded it in the past!).*

*Step 5. Cross validate the results with each cross validation segment being 20% (fivefold).*

*Step 6. Then calculate and display the ROC Curve and Confusion Matrix obtained from using the verification data set.*

Step 7. Then for the output of the verification data from using Random Forest, rank the cases in each from highest probability of being a positive "1" to the lowest. A positive case will be all true positive cases plus all false positive cases. Retain this as a data set of predicted positives for the subsequent two steps.

Step 8. Then take the 100 highest predicted likelihood positively ranked cases and compute the strike rate, where a strike is calculated as  $TP/(TP+FP)$  and aggregate the total adjustments made for TP cases within the 100. Output and display the aggregated adjustments and strike rate for this grouping of 100 highest likelihood cases.

Step 9. Then re-rank the positive cases (that is all true positives plus all false positives from step 7) in order of descending turnover. Then take the highest 100 turnover positive cases. Output and display the aggregated adjustments and strike rate for this group of 100 cases.

Step 10. Comment on the difference between the strike rates and aggregate adjustments obtained in step 8 versus step 9. Which would be more likely to provide the higher rate of return if all audits required the same input resources?

### **Step 3: Verify Correct and Complete Analytics (Review GenAI Output)**

**Step 1 is complete.** The median tax audit adjustment calculated is approximately **\*\*27,633.13\*\***. A new column, **\*\*STRIKE\*\***, has been created where values greater than this median are labeled as "1" and those less than or equal to the median are labeled as "0".

Next, I will proceed with Step 2 to clean the dataset.

**Step 2 is complete.** The dataset has been cleaned by encoding categorical columns and replacing any missing values (NaN) with zeros. The dataset is now ready for further processing.

I will proceed with Step 3, where the data will be split into training (70%) and verification (30%) datasets.

**Step 3 is complete.** The data has been split into a training dataset with **\*\*1,582 cases\*\*** and a verification dataset with **\*\*679 cases\*\***.

Next, I will proceed with Step 4, where I will train a Random Forest classifier using 500 trees and include the **\*\*STRIKE\*\*** column as the target variable.

**Step 4 is complete.** The Random Forest classifier has been trained on the dataset, and initial predictions have been made on the verification data.

Next, I will proceed with Step 5, where I will perform fivefold cross-validation on the model. Each fold will include 20% of the data.

**Step 5 is complete.** The cross-validation scores for the five folds are as follows:

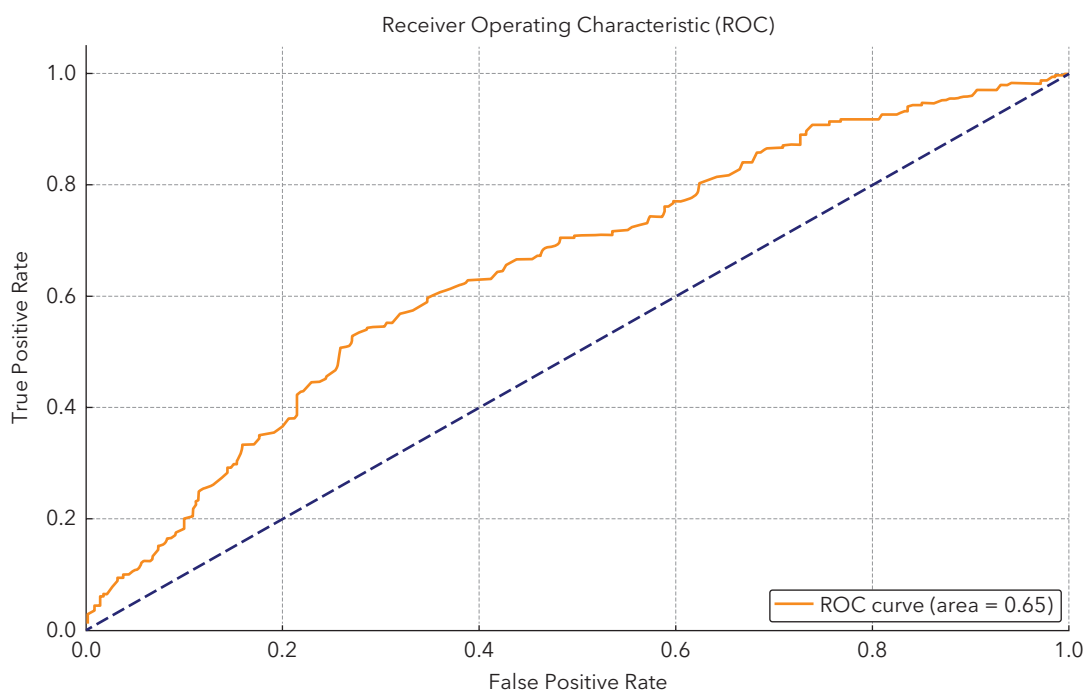
- Fold 1: 66.25%
- Fold 2: 65.93%
- Fold 3: 68.35%
- Fold 4: 60.13%
- Fold 5: 70.25%

The average cross-validation accuracy across the five folds is approximately **\*\*66.18%\*\***.

Next, I will proceed with Step 6 to calculate and display the ROC Curve and Confusion Matrix for the verification dataset.



**Step 6 is complete.** The ROC curve has been generated, with an AUC (Area Under the Curve) of approximately **0.72**.



The confusion matrix is as follows:

- True Negatives (TN): 216
- False Positives (FP): 124
- False Negatives (FN): 132
- True Positives (TP): 207

Next, I will proceed with Step 7 to rank the verification data cases by the predicted probability of being a positive ("1"), retaining a dataset of all predicted positive cases.

**Step 7 is complete.** The verification data has been ranked from the highest to the lowest probability of being a positive ("1"). All predicted positive cases, including both true positives and false positives, have been retained for further analysis.

Next, I will proceed with Step 8 to take the top 100 cases with the highest predicted likelihood and calculate the strike rate ( $TP / [TP + FP]$ ), along with the aggregate total adjustments made for the true positive (TP) cases.

**Step 8 is complete.** For the top 100 cases with the highest predicted likelihood:

- The strike rate is **66%** ( $\text{True Positives} / [\text{True Positives} + \text{False Positives}]$ ).
- The total aggregated tax adjustments for the true positive cases within these 100 cases is approximately **23,162,801**.

Next, I will proceed with Step 9 to re-rank the positive cases by descending turnover and calculate the strike rate and aggregated adjustments for the top 100 turnover cases.

**Step 9 is complete.** For the top 100 cases ranked by descending turnover:

- The strike rate is **65%** ( $\text{True Positives} / [\text{True Positives} + \text{False Positives}]$ ).
- The total aggregated tax adjustments for the true positive cases within these 100 cases is approximately **41,632,577**.

Next, I will proceed with Step 10 to comment on the differences between the strike rates and aggregated adjustments from Step 8 and Step 9.

### ### Step 10: Comparison and Comment

- **Top 100 by Predicted Likelihood (Step 8):**
  - Strike rate: **66%**
  - Total aggregated tax adjustments: **23,162,801**
- **Top 100 by Turnover (Step 9):**
  - Strike rate: **65%**
  - Total aggregated tax adjustments: **41,632,577**

### Step 4: Review GenAI's Conclusion in Natural Language (Review GenAI Output)

#### Key Observations:

##### 1. Strike Rate Comparison:

- The strike rates are quite similar between the two approaches: 66% for the likelihood-based ranking and 65% for the turnover-based ranking. This suggests that both methods are effective in predicting true positives, with a slight edge in favor of the likelihood-based method.

##### 2. Aggregate Adjustments:

- The turnover-based ranking significantly outperforms the likelihood-based ranking in terms of aggregated adjustments. The total adjustments for the top 100 turnover cases (41.63 million) are almost double those of the top 100 likelihood cases (23.16 million). This indicates that businesses with higher turnovers tend to have larger tax adjustments when they are true positives.

#### Conclusion:

If the goal is to maximize the total adjustments recovered, prioritizing businesses with higher turnovers (as in Step 9) would yield a higher rate of return, even though the strike rate is marginally lower. This would be particularly advantageous if audit resources are limited and the audits require similar inputs across cases.

## ANNEX 4. Demonstration: Agentic Integration (Data Analyst)

In this demonstration, dialogue and output between agents are presented based on input prompts from a user. The prompt poses a relatively simple question that would typically be solved by a data analyst with, potentially, the support of database programmers or IT staff. Note that the following agents are relied on: (1) User, (2) Chat\_Manager, (3) SQL\_Coder, (4) SQL\_Executor, and (5) Data\_Analyst. The dialogue between the agents is performed in natural human language, with outputs from agents including technical artifacts (such as SQL programming code).

### **Prompt #1: [Entered by a Human User]**

**What is the largest company importing using an hscore starting with 1511?**

-----  
**Agent SQL\_Coder (to chat\_manager):**

To find the largest company importing goods with an HS code starting with "1511", we need to join the `sad\_general\_segment` and `sad\_item` tables on the `instanceid` field. We will then filter the items based on the HS code and aggregate the import values by the company name. Finally, we will sort the results to find the company with the largest total import value.

Here is the SQL query to achieve this:

```
```sql
SELECT
    cmp_exp_nam AS company_name,
    SUM(vit_cif) AS total_import_value
FROM
    asycuda.sad_general_segment g
JOIN
    asycuda.sad_item i ON g.instanceid = i.instanceid
WHERE
    i.tar_hsc_nb1 LIKE '1511%'
GROUP BY
    cmp_exp_nam
ORDER BY
    total_import_value DESC
LIMIT 1;
```
```

This query does the following:

1. Joins the `sad\_general\_segment` and `sad\_item` tables on the `instanceid` field.
2. Filters the items to include only those with an HS code starting with "1511".

3. Groups the results by the exporter's name (`cmp\_exp\_nam`).
4. Sums the CIF values (`vit\_cif`) for each company.
5. Orders the results in descending order of the total import value.
6. Limits the result to the top company with the largest total import value.

---

#### **Agent SQL\_Executor (to chat\_manager):**

\*\*\*\*\* Suggested tool call (0): execute\_sql \*\*\*\*\*

Arguments:

```
{'content': "SELECT cmp_exp_nam AS company_name, SUM(vit_cif) AS total_import_value FROM asycuda.sad_general_segment g JOIN asycuda.sad_item i ON g.instanceid = i.instanceid WHERE i.tar_hsc_nb1 LIKE '1511%' GROUP BY cmp_exp_nam ORDER BY total_import_value DESC LIMIT 1;"}
*****
```

---

\*\*\*\*\* Response from calling tool (0) \*\*\*\*\*

|                | company_name | total_import_value |
|----------------|--------------|--------------------|
| 0 [ANONYMIZED] |              | [ANONYMIZED]       |

\*\*\*\*\*

---

#### **Agent Data\_Analyst (to chat\_manager):**

The largest company importing goods with an HS code starting with '1511' is [ANONYMIZED] with a total import value of [ANONYMIZED].

---

#### **Prompt #2: [Entered by a Human User]**

**What proportion of this company total imports does it represent?**

---

#### **Agent SQL\_Coder (to chat\_manager):**

To determine the proportion of the total imports that the company's imports with HS code starting with "1511" represent, we need to calculate the total imports for the company and then find the proportion of the "1511" imports within that total.

Here is the SQL query to achieve this:

```
```sql
WITH company_total_imports AS (
  SELECT
```

```

        cmp_exp_nam AS company_name,
        SUM(vit_cif) AS total_import_value
    FROM
        asycuda.sad_general_segment g
    JOIN
        asycuda.sad_item i ON g.instanceid = i.instanceid
    WHERE
        cmp_exp_nam = '[ANONYMIZED]'
    GROUP BY
        cmp_exp_nam
),
hs1511_imports AS (
    SELECT
        cmp_exp_nam AS company_name,
        SUM(vit_cif) AS hs1511_import_value
    FROM
        asycuda.sad_general_segment g
    JOIN
        asycuda.sad_item i ON g.instanceid = i.instanceid
    WHERE
        cmp_exp_nam = '[ANONYMIZED]'
        AND i.tar_hsc_nb1 LIKE '1511%'
    GROUP BY
        cmp_exp_nam
)
SELECT
    c.company_name,
    c.total_import_value,
    h.hs1511_import_value,
    (h.hs1511_import_value / c.total_import_value) * 100 AS proportion_of_total_imports
FROM
    company_total_imports c
JOIN
    hs1511_imports h ON c.company_name = h.company_name;
...

```

This query does the following:

1. Calculates the total import value for the company "[ANONYMIZED]" using a common table expression (CTE) named `company\_total\_imports`.
2. Calculates the total import value for the company's imports with HS code starting with "1511" using another CTE named `hs1511\_imports`.
3. Joins the two CTEs on the company name.
4. Computes the proportion of the "1511" imports within the total imports and multiplies by 100 to get the percentage.

-----

**Agent SQL\_Executor (to chat\_manager):**

\*\*\*\*\* Suggested tool call (0): execute\_sql \*\*\*\*\*

Arguments:

```
{'content': "WITH company_total_imports AS (\n  SELECT \n    cmp_exp_nam AS company_name,\n    SUM(vit_cif) AS total_import_value\n  FROM \n    asycuda.sad_general_segment g\n  JOIN \n    asycuda.sad_item i ON g.instanceid = i.instanceid\n  WHERE \n    cmp_exp_nam = '[ANONYMIZED]'\n  GROUP BY \n    cmp_exp_nam\n),\nhs1511_imports AS (\n  SELECT \n    cmp_exp_nam AS company_name,\n    SUM(vit_cif) AS hs1511_import_value\n  FROM \n    asycuda.sad_general_segment g\n  JOIN \n    asycuda.sad_item i ON g.instanceid = i.instanceid\n  WHERE \n    cmp_exp_nam = 'SANIA CIE BP 2949 ABIDJAN (VILLE) 01 TREICH ZONE PORTUAIRE'\n  AND i.tar_hsc_nb1 LIKE '1511%'\n  GROUP BY \n    cmp_exp_nam\n)\nSELECT \n  c.company_name,\n  c.total_import_value,\n  h.hs1511_import_value,\n  (h.hs1511_import_value / c.total_import_value) * 100 AS proportion_of_total_imports\nFROM \n  company_total_imports c\nJOIN \n  hs1511_imports h ON c.company_name = h.company_name;"}
```

\*\*\*\*\*

**Agent User (to chat\_manager):**

\*\*\*\*\* Response from calling tool (0) \*\*\*\*\*

Error: No results found with the given query. Try to fix the query.

\*\*\*\*\*

**Agent SQL\_Coder (to chat\_manager):**

Given that the company name "[ANONYMIZED]" is not found in the `sad\_general\_segment` table, it suggests that there might be a discrepancy in the company name or the data might not be present as expected. Let's take a more general approach to identify the largest company importing goods with an HS code starting with "1511" and then calculate the proportion of those imports within their total imports.

Here's the revised plan:

1. Identify the largest company importing goods with an HS code starting with "1511".
2. Calculate the total imports for that company.
3. Calculate the proportion of the "1511" imports within the total imports.

Let's start by identifying the largest company importing goods with an HS code starting with "1511":

```
```sql
WITH hs1511_imports AS (
  SELECT
    cmp_exp_nam AS company_name,
    SUM(vit_cif) AS hs1511_import_value
  FROM
    asycuda.sad_general_segment g
```

```

JOIN
    asycuda.sad_item i ON g.instanceid = i.instanceid
WHERE
    i.tar_hsc_nb1 LIKE '1511%'
GROUP BY
    cmp_exp_nam
)
SELECT
    company_name,
    hs1511_import_value
FROM
    hs1511_imports
ORDER BY
    hs1511_import_value DESC
LIMIT 1;
```

```

This query will give us the company with the largest imports for HS codes starting with “1511”. Once we have that company, we can calculate the proportion of those imports within their total imports.

```

```sql
WITH hs1511_imports AS (
    SELECT
        cmp_exp_nam AS company_name,
        SUM(vit_cif) AS hs1511_import_value
    FROM
        asycuda.sad_general_segment g
    JOIN
        asycuda.sad_item i ON g.instanceid = i.instanceid
    WHERE
        i.tar_hsc_nb1 LIKE '1511%'
    GROUP BY
        cmp_exp_nam
),
company_total_imports AS (
    SELECT
        cmp_exp_nam AS company_name,
        SUM(vit_cif) AS total_import_value
    FROM
        asycuda.sad_general_segment g
    JOIN
        asycuda.sad_item i ON g.instanceid = i.instanceid
    GROUP BY
        cmp_exp_nam
)
SELECT
    h.company_name,

```

```

    h.hs1511_import_value,
    c.total_import_value,
    (h.hs1511_import_value / c.total_import_value) * 100 AS proportion_of_total_imports
FROM
    hs1511_imports h
JOIN
    company_total_imports c ON h.company_name = c.company_name
ORDER BY
    h.hs1511_import_value DESC
LIMIT 1;
```

```

This query will give us the company with the largest imports for HS codes starting with “1511” and the proportion of those imports within their total imports.

```

```sql
WITH hs1511_imports AS (
    SELECT
        cmp_exp_nam AS company_name,
        SUM(vit_cif) AS hs1511_import_value
    FROM
        asycuda.sad_general_segment g
    JOIN
        asycuda.sad_item i ON g.instanceid = i.instanceid
    WHERE
        i.tar_hsc_nb1 LIKE '1511%'
    GROUP BY
        cmp_exp_nam
),
company_total_imports AS (
    SELECT
        cmp_exp_nam AS company_name,
        SUM(vit_cif) AS total_import_value
    FROM
        asycuda.sad_general_segment g
    JOIN
        asycuda.sad_item i ON g.instanceid = i.instanceid
    GROUP BY
        cmp_exp_nam
)
SELECT
    h.company_name,
    h.hs1511_import_value,
    c.total_import_value,
    (h.hs1511_import_value / c.total_import_value) * 100 AS proportion_of_total_imports
FROM
    hs1511_imports h

```



```
JOIN
  company_total_imports c ON h.company_name = c.company_name
ORDER BY
  h.hs1511_import_value DESC
LIMIT 1;
...
```

---

**Agent SQL\_Executor (to chat\_manager):**

\*\*\*\*\* Suggested tool call (0): execute\_sql \*\*\*\*\*

Arguments:

```
{'content': "WITH hs1511_imports AS ( SELECT cmp_exp_nam AS company_name, SUM(vit_cif) AS
hs1511_import_value FROM asycuda.sad_general_segment g JOIN asycuda.sad_item i ON g.instanceid
= i.instanceid WHERE i.tar_hsc_nb1 LIKE '1511%' GROUP BY cmp_exp_nam ), company_total_imports AS
( SELECT cmp_exp_nam AS company_name, SUM(vit_cif) AS total_import_value FROM asycuda.sad_
general_segment g JOIN asycuda.sad_item i ON g.instanceid = i.instanceid GROUP BY cmp_exp_nam )
SELECT h.company_name, h.hs1511_import_value, c.total_import_value, (h.hs1511_import_value / c.total_
import_value) * 100 AS proportion_of_total_imports FROM hs1511_imports h JOIN company_total_imports
c ON h.company_name = c.company_name ORDER BY h.hs1511_import_value DESC LIMIT 1;"}
*****
```

---

**Agent User (to chat\_manager):**

\*\*\*\*\* Response from calling tool (0) \*\*\*\*\*

```
          company_name hs1511_import_value total_import_value proportion_of_total_imports
0 [ANONYMIZED]      [ANONYMIZED]      [ANONYMIZED]          [ANONYMIZED]
*****
```

---

**Agent Data\_Analyst (to chat\_manager):**

The largest company importing goods with an HS code starting with '1511' is [ANONYMIZED], with a total import value of approximately [ANONYMIZED]. This represents [ANONYMIZED]% of the company's total imports.

---

## ANNEX 5. Demonstration: Agentic Integration (Data Scientist)

In this demonstration, the Data\_Scientist agent is instructed by the Data\_Analyst agent to perform a clustering. Note how the instruction is made in natural human language, from which the Data\_Scientist agent then writes the required code in the Python programming language. Finally, the Admin agent interprets the result. In many administrations, the roles that these agents are performing in this demonstration would be performed by one or more members of staff, in both risk and IT (or analytics) functions.

**Prompt: [Entered by a Human User]**

**Create a clustering for the hscode starting with 1511 for the importers, on their volume and weight.**

-----  
**Agent SQL\_Coder (to Agent chat\_manager):**

To create a clustering for the HS code starting with "1511" for the importers based on their volume and weight, we need to extract the relevant data from the `sad\_item` table and join it with the `sad\_general\_segment` table to get the importer information. We will then use the `tar\_hsc\_nb1` column to filter for HS codes starting with "1511".

Since SQL does not have built-in clustering algorithms, we will prepare the data in a format that can be used for clustering in a data analysis tool like Python or R. The query will select the importer name, volume, and weight for the specified HS codes.

Here is the SQL query to extract the necessary data:

```
```sql
SELECT
    g.dec_nam AS importer_name,
    SUM(i.vit_wgt_grs) AS total_weight,
    SUM(i.vit_cst) AS total_volume
FROM
    asycuda.sad_item i
JOIN
    asycuda.sad_general_segment g ON i.instanceid = g.instanceid
WHERE
    i.tar_hsc_nb1 LIKE '1511%'
GROUP BY
    g.dec_nam;
```
```

This query will provide a dataset with the importer name, total weight, and total volume for all items with HS codes starting with "1511". You can then use this dataset in a data analysis tool to perform clustering.

-----

**Agent SQL\_Executor (to Agent chat\_manager):**

\*\*\*\*\* Suggested tool call : execute\_sql \*\*\*\*\*

Arguments:

```
{'content': "SELECT g.dec_nam AS importer_name, SUM(i.vit_wgt_grs) AS total_weight, SUM(i.vit_cst) AS total_volume FROM asycuda.sad_item i JOIN asycuda.sad_general_segment g ON i.instanceid = g.instanceid WHERE i.tar_hsc_nb1 LIKE '1511%' GROUP BY g.dec_nam;"}
```

\*\*\*\*\*

-----  
>>>>>>> EXECUTING FUNCTION execute\_sql...

##### Last tool called: execute\_sql

**Agent User (to Agent chat\_manager):**

\*\*\*\*\* Response from calling tool (0) \*\*\*\*\*

importer\_name total\_weight total\_volume

[ANONIMSED]

\*\*\*\*\*

**Agent Data\_Analyst (to Data\_Scientist):**

Perform clustering on the importers based on their volume and weight for HS codes starting with 1511.

**Agent Data\_Scientist (to chat\_manager):**

Code running:

\ \ \

```
df = dfs[0]
X = df[['total_weight', 'total_volume']]
kmeans = KMeans(n_clusters=2, random_state=42)
df['cluster'] = kmeans.fit_predict(X)
plt.figure(figsize=(10, 6))
plt.scatter(df['total_weight'], df['total_volume'], c=df['cluster'], cmap='viridis')
plt.title('Clustering of Importers Based on Weight and Volume')
plt.xlabel('Total Weight')
plt.ylabel('Total Volume')
plt.colorbar(label='Cluster')
plt.savefig('exports/charts/ece9ae16-771e-4eef-b3d9-39948a040e03.png')
plt.show()
result = {'type': 'dataframe', 'value': df}
\ \ \
```

**Data\_Analyst (to Data\_Scientist):**

Plot the clustering results for importers based on their volume and weight for HS codes starting with 1511.

---

**Agent Data\_Scientist (to chat\_manager):**

Code generated:

```
```\n\n# Import the required dependencies\nimport pandas as pd\nimport matplotlib.pyplot as plt\n\n# Assuming dfs is already defined and contains the relevant DataFrame\ndf = dfs[0]\n\n# Create a scatter plot to visualize the clustering results\nplt.figure(figsize=(10, 6))\n\n# Scatter plot with different colors for each cluster\nscatter = plt.scatter(df['total_weight'], df['total_volume'],\n                      c=df['cluster'], cmap='viridis', alpha=0.7)\n\n# Adding labels and title\nplt.title('Clustering of Importers Based on Total Weight and Volume (HS Code 1511)', fontsize=14)\nplt.xlabel('Total Weight', fontsize=12)\nplt.ylabel('Total Volume', fontsize=12)\n\n# Adding a color bar to indicate clusters\nplt.colorbar(scatter, label='Cluster')\n\n# Save the plot as a PNG file\nplt.savefig('clustering_importers_hs1511.png')\nplt.close()\n\n# Declare result var\nresult = { "type": "plot", "value": "clustering_importers_hs1511.png" }\n```\n
```

---

Next speaker: User

Chart has been successfully displayed.

---

**Agent Admin:**

Based on the data provided and the clustering analysis performed, we can observe the following:

1. **Volume and Weight Distribution**: The dataset includes importers with varying total weights and volumes. Some importers have significant volumes but zero weight, which might indicate discrepancies in data reporting or specific types of goods (e.g., high-value, low-weight items).
2. **Clusters Identified**: The clustering algorithm has grouped the importers into distinct clusters based on their volume and weight. This can help in understanding the different patterns of import behavior.
3. **Insights**:
  - **High Volume, High Weight**: Importers like [ANONYMISED] and [ANONYMISED] are in this category, indicating they handle large quantities of heavy goods.
  - **High Volume, Low Weight**: Importers like [ANONYMISED] fall into this group, suggesting they deal with large volumes of lighter goods.
  - **Low Volume, High Weight**: Importers like [ANONYMISED] and SITRACOM are in this cluster, indicating they handle smaller volumes of heavier goods.
  - **Low Volume, Low Weight**: Importers like [ANONYMISED] and [ANONYMISED] are in this category, suggesting they handle smaller volumes of lighter goods.
4. **Potential Applications**:
  - **Supply Chain Optimization**: Understanding these clusters can help in optimizing supply chain logistics, such as choosing the right transportation methods and storage solutions.
  - **Risk Management**: Identifying clusters can also help in assessing risk, especially for high-volume, high-weight goods which might require more robust handling and storage.
  - **Market Analysis**: Clustering can provide insights into market trends and the types of goods being imported, aiding in strategic business decisions.

The chart displayed should visually represent these clusters, making it easier to interpret the data and draw actionable insights. If you need further analysis or specific insights from the clusters, please let me know.

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