TECHNICAL ASSISTANCE REPORT

PEOPLE'S REPUBLIC OF CHINA

Advancing Risk Management for Large Taxpayers

JANUARY 2025

Prepared By
Cindy Negus, David Hadwick, Maureen Kidd, and Cameron Smith

Authoring Department
Fiscal Affairs Departments

The analysis and policy considerations expressed in this publication are those of the Fiscal Affairs Department.

International Monetary Fund, IMF Publications
P.O. Box 92780, Washington, DC 20090, U.S.A.
T. +(1) 202.623.7430 • F. +(1) 202.623.7201
publications@IMF.org
IMF.org/pubs

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Abbreviations and Acronyms

AI	Artificial Intelligence
API	Application Programming Interface
ATO	Australian Taxation Office
AUC	Area Under the Curve
CIP	Compliance Improvement Plan
CIT	Corporate Income Tax
COTS	Commercial-Off-The-Shelf
CRA	Canada Revenue Agency
CRM	Compliance Risk Management
CRR	Compliance Risk Register
CSI	Characteristic Stability Index
EOI	Exchange of Information
EU	European Union
FAD	Fiscal Affairs Department (of the IMF)
FTE	Full-time Equivalent
GDP	Gross Domestic Product
HMRC	His Majesty's Revenue and Customs (of the United Kingdom)
HQ	Headquarters
HR	Human Resources
IMF	International Monetary Fund
IRS	Internal Revenue Service (of the United States)
ISORA	International Survey of Revenue Administration
IT	Information Technology
ITAS	Integrated Tax Administration System
KPI	Key Performance Indicator
LETD	Large Enterprise Tax Administration Department
LTO	Large Taxpayer Office
OECD	Organisation for Economic Co-operation and Development
PIT	Personal Income Tax
RMB	Renminbi, Official Currency of the People's Republic of China
ROC	Receiver Operating Characteristic
SOE	State Owned Enterprises
SQL	Structured Query Language

STA	State Tax Administration (of the People's Republic of China)
TBDRM	Tax Big Data and Research Management Department
TNA	Transaction Network Analysis'
VAT	Value Added Tax

Preface

In response to a request from the State Taxation Administration of the People's Republic of China, a capacity development mission of the International Monetary Fund's (IMF) Fiscal Affairs Department (FAD) visited Yangzhou and Beijing, China, from November 4 to 15, 2024, to provide guidance on advancing risk management for large taxpayers. The first week of the mission was dedicated to delivering comprehensive training to STA officials on key topics essential for enhancing their understanding and capabilities in risk management practices. Presentation materials were shared prior to commencement of the mission. The second week focused on developing strategic recommendations aimed at effectively implementing risk management frameworks tailored to the needs of large taxpayers in China.

This revenue administration mission team was led by Ms. Cindy Negus (Senior Economist, FAD) and included: Messrs. David Hadwick, Cameron Smith, and Ms. Maureen Kidd (external experts). The team conducted a seven-day workshop at the Yangzhou Training Academy that focused on key topics essential for enhancing STA understanding and capabilities in risk management practices and held technical discussions in Beijing where it submitted its draft report.

During its visit, the team met with several officials from STA: Mr. Bu Xianglai, Director of the Large Enterprise Tax Administration Department, Ms Meng Yuying, Director of the International Tax Management Department, Ms. Li Na, Deputy Director of the Large Enterprise Tax Administration Department, Mr. Yue Song, Deputy Director of the Tax Academy of STA, Mr. Wang Dan, Director of the International Tax Teaching and Research Department of the Tax Academy of STA, Mr. Li Bin, Director of the Data Management Division of the Large Enterprise Tax Administration Department, Mr. Du Jianwei, Deputy Director of the Data Management Division of the Large Enterprise Tax Administration Department, Ms. Yang Xiao, Director of the International Cooperation Division of the International Tax Management Department, Ms. Liu Yingjie of the International Tax Management Department, and other officials from the STA central and provincial taxation authorities.

The team expresses its sincere appreciation to Mr. Liu Xin, Office of Academic Affairs of the National Tax Academy, Yangzhou Campus for the outstanding support and hospitality provided to the mission team.

This report represents the final version of the aide-mémoire that was presented to officials on November 15, 2024. It consists of an Executive Summary and the following sections: (I) Introduction; (II) Enhancing Risk Management (III) Governance and Accountability.

Executive Summary

In recent years, the State Taxation Administration (STA) of the People's Republic of China has made significant strides in modernizing its operations, particularly through the adoption of digital solutions aimed at enhancing tax administration. This modernization has coincided with the evolution of China's tax laws and regulations, resulting in a more transparent and effective system that prioritizes the integration of advanced analytics [1]. A key component of this strategy is the utilization of data analytics to strengthen risk assessment capabilities, which in turn aims to improve compliance, reduce compliance costs, and foster stronger relationships with the large business tax community.

To further advance these initiatives, this mission provided guidance on advancing risk management for large taxpayers in China. A series of lectures and technical discussions delved into critical areas such as organizational governance, the application of artificial intelligence (AI) and big data, and CRM. Key topics covered strengthening risk assessment approaches, strategic planning, developing treatment strategies, and compliance improvement plans (CIP), as well as building the necessary capabilities and skills to effectively manage large taxpayers. The discussions emphasized the importance of digital solutions in contemporary risk assessment processes, ensuring that large businesses operate within a framework that upholds accountability and transparency.

This report presents strategic recommendations to support the STA's administrative reforms. It builds upon insights from the 2023 report addressing selected issues in the administration of corporate income tax while considering good international practices and the specific conditions within China.[2] This report provides recommendations in two priority areas.

Enhancing Risk Management

The STA has implemented a focused approach for large taxpayer risk assessment, primarily focusing on an entity-by-entity basis. Transitioning from this individual perspective to a more holistic aggregate approach in risk assessment would enable the STA to identify and prioritize the highest risk cases within the entire large taxpayer population more effectively. This strategic shift would enhance the STA's capacity to recognize patterns and interconnections among various entities, fostering a deeper understanding of the overall risk landscape.

To further modernize STA's approach to risk management, it is essential to establish a proactive framework that anticipates the necessary data and technology requirements. By integrating strategies to identify emerging data sources and utilizing advanced analytical tools, the STA can significantly improve its analytical capabilities and responsiveness to evolving tax compliance challenges. This integrated approach would not only enhance the accuracy of risk assessments but also ensure that the STA is well-prepared to adapt to future developments in tax administration and CRM.

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[1] OECD (2016), *Advanced Analytics for Better Tax Administration: Putting Data to Work*, OECD Publishing, https://doi.org/10.1787/9789264256453-en.

[2] Cindy Negus, David Carr, Toshiyuki Kemmochi, and Sunita Lough. Selected Issues in Administering Corporate Income Tax. January 2024

Strengthening Governance and Accountability

To enhance organizational effectiveness, it is important to establish clear structures and responsibilities within the organization. Designating the Large Enterprise Tax Administration Department (LETD) as the primary functional department at headquarters will centralize the coordination of all large business programs and supporting functions, such as those carried out in the VAT Department, the Income Tax Department, Tax Big Data and Risk Management (TBDRM) Bureau, and the Auditing Department. This central focal point will facilitate better communication, streamline processes, and ensure that the various components work collaboratively towards common objectives, ultimately improving the management of large enterprises.

In addition to this structural realignment, it is essential that the STA establish a dedicated CRM unit to lead the CRM strategy and governance framework. A senior-level committee will provide the necessary oversight and strategic direction, ensuring the integration of risk management practices into the STA's operations. This focused approach to CRM will empower the STA to proactively identify, assess, and mitigate compliance risks, creating a robust environment for taxpayer compliance while enhancing overall tax administration effectiveness. Together, these changes will help establish a more organized and efficient framework for managing large taxpayers and compliance risks within the STA.

Recommendations

Pathway to Digital Risk Management	
II.1	The STA should shift from an entity-by-entity approach to risk assessment to a more comprehensive aggregate perspective that targets the highest risk cases within the large taxpayer population.
II.2	Establish a framework using ITAS and CRM principles that anticipates the data and technology needs necessary for effective risk management. This framework should incorporate strategies for identifying emerging data sources, leveraging advanced analytical tools and innovative technologies.
Governance and Accountability	
III.1	Designate LETD as the primary functional department at headquarters responsible for coordinating all large business programs and supporting functions from a central focal point.
III.2	Establish a dedicated CRM unit with a senior level committee to lead the STA's CRM strategy and governance framework.

I. Introduction

A. Background

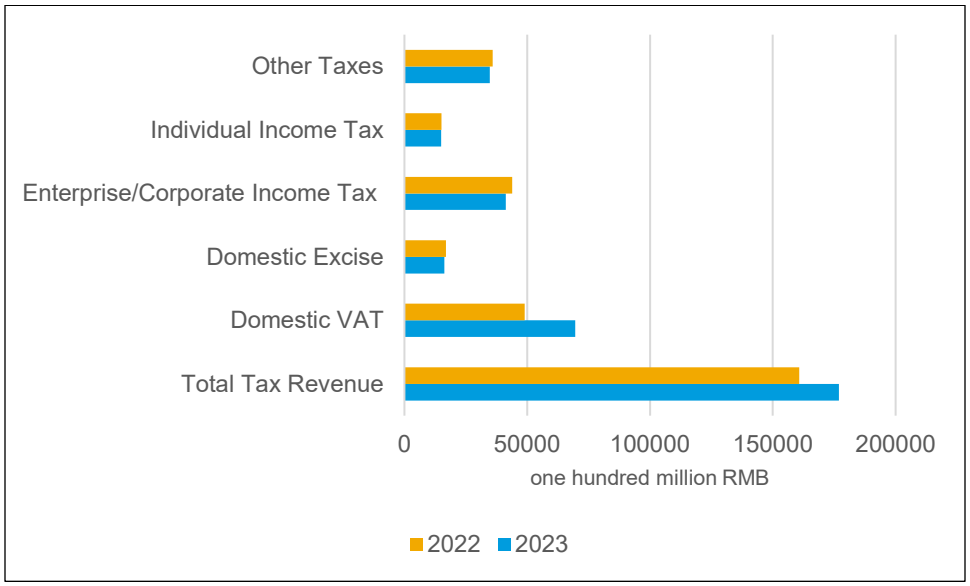
1. Growth in China has been remarkable over the past few decades, driven by economic reforms, globalization, and substantial investments in infrastructure and technology. As the country transitioned to a market-oriented economy, many state-owned enterprises were restructured, while private companies flourished, leading to a diverse and competitive business landscape. Major sectors such as manufacturing, technology, and services have seen significant expansion, with large firms increasingly contributing to national GDP and employment. Additionally, the rise of e-commerce and digital platforms has transformed the business environment, enabling large enterprises to engage in domestic and international markets. This growth has positioned China as a global economic powerhouse, with its large businesses playing a critical role in innovation, trade, and economic development.[3]

2. In 2023, the STA collected a total of 17.7 trillion RMB in tax revenues[4], fully meeting the budget target and reflecting a 10.1 percent year-on-year increase. After adjustments due to the excess input value-added-tax (VAT) credit refund policy, the effective increase in tax revenue was 2.3 percent, aligning closely with the growth rate of nominal gross domestic product (GDP). The largest gain was in domestic VAT, with an increase of 42.2 percent from 2022 to 2023, while corporate (enterprise) income tax (CIT) decreased by 5.9 percent in the same period.[5] Notably, the Large Taxpayer segment plays a crucial role in the overall achievement, contributing a substantial 45.70 percent of total revenue[6], underscoring its vital importance to the Chinese economy. Figure 1 provides a comparative breakdown of STA tax revenues for 2022 and 2023.

3. In line with the 2021 *Opinions on Further Deepening the Reform of Tax Collection and Administration* the STA has launched many reforms to enhance tax governance. With a focus on large business, significant reforms included the launch of a nationwide electronic tax invoice service platform and the advancement of a pilot program for fully digitalized tax invoices. Enhanced data security and a new governance model specifically for large taxpayers have also led to improved service and management capabilities. The policy promotes co-governance in taxation across all provinces to permit an aligned approach to tax compliance and administration.

[3] People's Republic of China IMF Article IV Consultation August 2024
[4] Approximately 2.478 trillion USD.
[5] State Taxation Administration Annual Report 2023.
[6] ISORA 2022.

Figure 1. Comparative Breakdown of STA Tax Revenues for 2022, 2023



Source: STA Annual Report 2023

4. The STA is advancing its risk management strategies for large businesses, aiming to enhance compliance rates, reduce costs, and promote transparency. By refining the risk assessment process, the STA seeks to alleviate the compliance burden on businesses while fostering a climate of trust and collaboration. Leveraging data analytics and digital technologies, the STA intends to establish a framework for real-time monitoring and analysis of taxpayer data, developing risk assessment models tailored to the complexities of large taxpayers. Additionally, the STA conducts training sessions to equip tax officials with the necessary skills to effectively utilize digital tools in risk assessment, focusing on data management and audit practices. The STA has also strengthened its collaboration with the international tax community to incorporate good international practices in risk management and compliance.

B. Administration of Large Taxpayers – Current Status

5. The LETD was created in 2008 to oversee the management of large taxpayers. The focus of the program has evolved considerably since that time with a growing emphasis on the effective management of these taxpayers through improved taxpayer service and a better understanding of risk. The STA has embraced international good practice in this important taxpayer segment while at the same time ensuring that its programs are tailored to the national context and priorities. The LETD is a hybrid department with both headquarters and operational roles. It determines procedures and oversees workload and results, but it also has an operational role related to an exclusive group of very large taxpayers. The LETD does not include debt management functions.[7] Appendix 1 contains the STA HQ Organizational Chart.

6. The work of LETD is closely coordinated with other functional departments. While LETD has oversight of the large taxpayer segment, the other functional departments retain a management role e.g. corporate income tax, VAT. Further, the LETD is supported by TBDRM that has responsibility for the

[7] ISORA 2022.

risk management model.[8] Each year, LETD formulates an annual risk management plan and consult in advance with the Big Data and Risk Administration Bureau and the Tax Inspection Department. Audit referrals are then sent to the Audit Department who may or may not undertake a proposed audit.

7. Large taxpayers are distributed throughout the country. The management of these taxpayers is carried out at the provincial and lower tax authorities located across the country**.** This underlines the importance of clear methods and procedures and of adequate reporting of results so that the STA can assure itself that the administration and enforcement of the tax laws is consistent and fair. The workflow and methods have been recently reviewed to ensure that they are consolidated but also appropriate to the growing pressures to establish effective risk management. The STA estimates that close to 10,000 staff are engaged in large taxpayer business management across the country while about 40 staff are in the LETD at HQ. Staff include professionals in accounting and law as well as a number of industry specialists at the post-graduate level.

8. There are 2,000 large taxpayers managed through large taxpayer management, with LETD oversight. Among them, 140 are considered particularly important, and are jointly managed by the General Taxation Department of the State Taxation Administration and the provincial and lower large taxpayer management departments. This system of overseeing the largest of the large is called headquarters-to-headquarters management. There is also a growing focus on the importance of management by industry to enable the STA to remain at the forefront of key developments in economic sectors and their potential tax consequences. Of these 2000 taxpayers, the top 1000 generate about 40 percent of STA revenue while the entire 2000 generates over 45 percent[9][10].

9. The future development of the large taxpayer program is predicated on the STA's digital transformation. The STA plans to accelerate this development as it recognizes the potential impact on both tax compliance and revenue results.

C. Mission Scope

10. The 2023 IMF Technical Assistance Report, *Selected Issues in Administering Corporate Income Tax* recommended enhancements for organizational effectiveness and improved CRM[11]. The report highlighted that the STA has established a clear strategic plan, which has resulted in strong outcomes. Consequently, the next logical step identified was to develop a comprehensive strategic management framework that incorporates operational work plans informed by risk assessments, resource availability, and emerging issues, along with robust governance processes and organizational support. Additionally, the report emphasized the critical role of a strong headquarters function in setting policy direction and ensuring adequate functional support, particularly in the context of the country's growth. By implementing a structured framework for CRM, the STA will be positioned to systematically identify, assess, rank, and address tax compliance risks, thereby improving decision-making and revenue outcomes. Moreover, as the number of large taxpayers continues to rise, it is essential to consider the

[8] In China, businesses are assessed for risk and the taxpayer is afforded the opportunity to dispute this rating.

[9] Provided by STA

[10] ISORA 2022

[11] Cindy Negus, David Carr, Toshiyuki Kemmochi, and Sunita Lough. Selected Issues in Administering Corporate Income Tax. January 2024.

introduction of new compliance strategies. Lastly, the establishment of a performance management framework with clearly defined key performance indicators (KPI)s will facilitate progress assessment and help ensure that STA personnel stay aligned with strategic goals and objectives.

11. This report is dedicated to enhancing risk management for large taxpayers. It presents considerations aimed at enhancing risk management and making the transition to digital risk management employing artificial intelligence and big data in Section II, as well as bolstering governance and accountability in Section III. Each section considers priority issues and incorporates good international practices in large taxpayer management. Outcomes and recommendations were developed through insightful discussions and dialogues during the Yangzhou workshop, as well as in-depth technical consultations with LETD officials from the STA HQ.

II. Enhancing Risk Management

A. Strengthening Foundations for CRM

12. To support the development of digital risk management for large taxpayers, guidance was provided across several key areas. They include defining the large taxpayer population and understanding industry sectors. The guidance also covered conventional risk assessment processes and the typical tax risks associated with large taxpayers. Together, these elements are foundational for the pathway to developing a digital risk management strategy. Additional context on can be found by accessing the CRM course in the Virtual Training to Advance Revenue Administration (VITARA) platform. The link is provided in Annex V.

Defining the large taxpayer population

13. The large taxpayer population encompasses entities with diverse ownership structures. They include state-owned enterprises (SOEs), privately-owned companies, and foreign-owned entities. Additionally, it was noted that a significant number of multinational enterprises (MNEs) are actively operating in China.

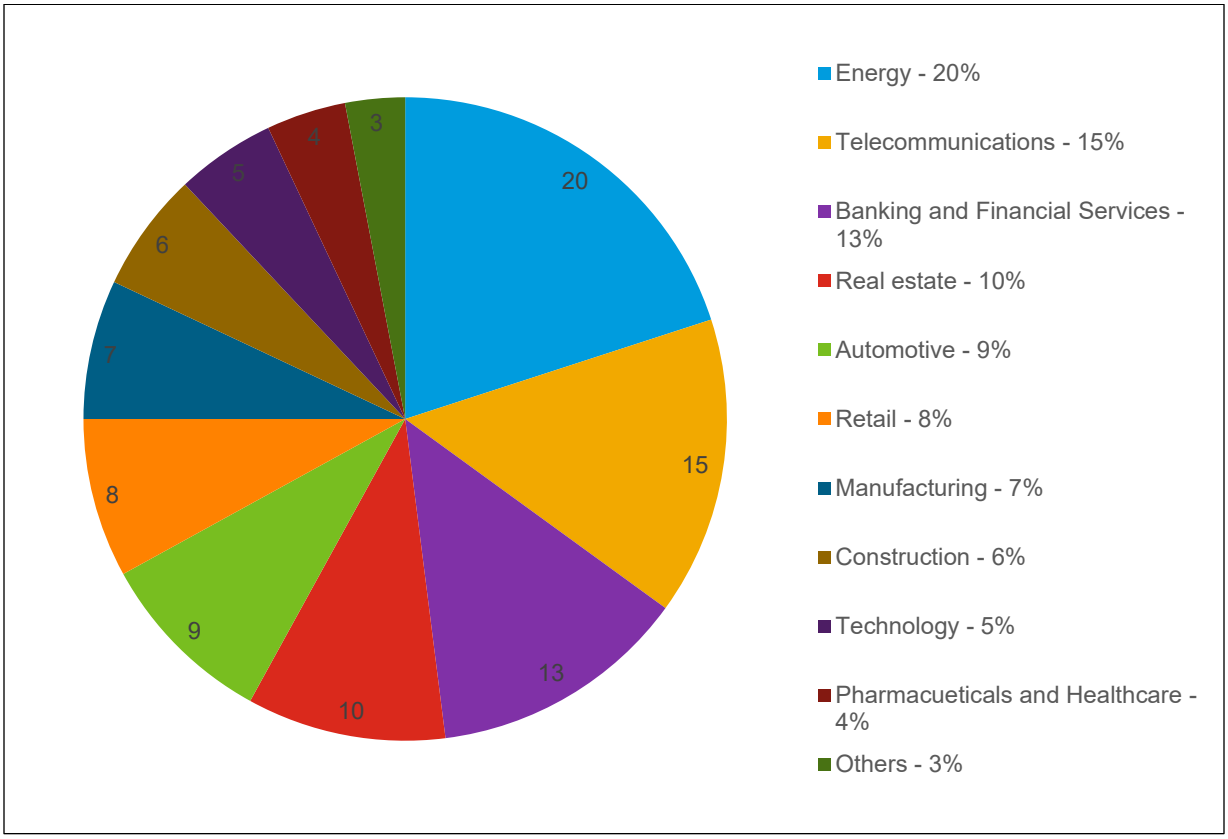
14. The STA uses both qualitative and quantitative criteria to classify large enterprise taxpayers. Qualitative criteria include whether the enterprise is a state-owned enterprise of central government and whether it is listed among the Fortune 500, etc. The quantitative criteria are based on six specific indicators: business revenue, annual tax payment, asset scale, industry influence, business region, and organizational structure. A comprehensive score is calculated based on these indicators and their corresponding weighting ratios, which ultimately determines whether a company qualifies for inclusion in the list of large taxpayers.

15. To further enhance its understanding of the large taxpayer population, the STA could further leverage external data sources. Alongside tax return information and forms detailing cross-border related party transactions, various additional sources can be utilized for cross-checking the taxpayer population, such as state registry offices for corporate ownership information and the department of statistics. Additionally, the composition of the large taxpayer population can be informed by the financial intelligence unit, which tracks cross-border flows, as well as studies from various institutions, including universities and media.

The importance of sectoral segmentation

16. Taxpayers in the large taxpayer segment are generally categorized by industry sectors. This classification enables tax administrations to identify and gain a clearer understanding of the largest industries contributing to economic growth within the jurisdiction. By adopting an industry-specific approach, tax administrations can more effectively analyze tax performance and assess potential risks associated with industry participants. Figure 2 illustrates the composition of industries, and their relative share represented in China's Fortune 500.

Figure 2. China's Fortune 500 Industries



17. Industry profiles provide insights into the specific risks and compliance challenges associated with different sectors. They permit tax authorities to tailor their risk assessment strategies and focus on high-risk areas, improving the efficiency of audits and compliance efforts. While the STA focuses on key industries it may benefit from developing industry profiles to enhance its understanding of industry-specific dynamics, and document industry determinants. Box 1 provides a summary of elements contained in typical industry profiles.

Box 1. Summary of Elements Contained in Typical Industry Profiles

- Name of industry
- Industry definition
- Industry characteristics (nature, operations, conditions, practices and demographics)
- Nature of the competition.
- Industry skill levels
- Industry key players
- Industry business models
- Industry association
- Industry profit margins and cost structures
- Industry regulators
- Industry financial performance (3 years)
- Industry tax performance (3 years, four compliance pillars for CIT and VAT)
- Tax issues, key risks, hot spots.

Risk assessment processes

18. The STA currently conducts risk assessments on an entity-by-entity basis, which can result in duplication of efforts and fragmentation. In order to more effectively identify and assess group-wide risks, it is important for tax authorities to conduct risk management by taking a holistic view of taxpayers, focusing on major events such as equity transfer, mergers and acquisitions, and related-party transactions at the group level, and conducting risk assessments through holistic, business-chain, and structural penetration analysis.

19. Many countries implement a two-tiered approach to identify and assess tax compliance risks within their populations. This method serves as a filtering process that enables tax administrations to identify the highest-risk taxpayers through increasingly targeted strategies.

20. The first-tier review involves screening all taxpayers in the population to pinpoint tax compliance risks. Identified risks are converted into risk filters, also known as indicators or criteria, which are then applied to the data of large taxpayer populations. Based on this analysis, the taxpayers are ranked according to their risk levels, guiding subsequent decisions on necessary actions.

21. The second-tier review entails a more in-depth risk assessment of selected complex, high-risk taxpayers. Tax authorities often employ this approach to better evaluate their highest-risk complex taxpayers. This tier ensures that available information—such as complete corporate structures, financial analyses, third-party data, and public information—is thoroughly assessed through internal workshops involving various specialists. This deeper analysis aims to identify priority risk areas that require further action, allowing subsequent audit efforts to focus on the most material risks.

22. A robust risk assessment framework in tax administration should incorporate both likelihood and consequence evaluations to determine the level of overall risk. This approach allows accurate identification, evaluation, and mitigation of risks to ensure that resources are allocated efficiently to address the most significant threats. While likelihood refers to the probability of a specific tax-related

risk event occurring, such as tax evasion or non-compliance, consequence denotes the potential impact or severity of that event on tax revenue, public trust, and overall fiscal stability. By evaluating both factors, tax authorities can prioritize risks based on their potential effects on revenue collection and compliance efforts. Figure 3 illustrates a risk rating matrix that can be used as a conceptual aid for displaying and considering relative levels of risks.

Figure 3. Risk Rating Matrix

Consequence	Likelihood			
		Unlikely	Possible	Likely
	High	Moderate	High	High
	Medium	Low	Moderate	High
	Low	Low	Low	Moderate

23. Effectively managing tax risks necessitates a comprehensive approach that incorporates robust risk management strategies and targeted interventions. This multifaceted framework is essential for identifying, assessing, and mitigating potential tax compliance issues that may arise. To address these challenges effectively, tax authorities must implement tailored strategies that account for the specific characteristics of each taxpayer segment. Furthermore, Appendix III provides a list of typical tax risks encountered by large taxpayers, along with detailed topic descriptions and associated summaries that can serve as valuable resources for tax officials.

B. The Transition to Digital Risk Management

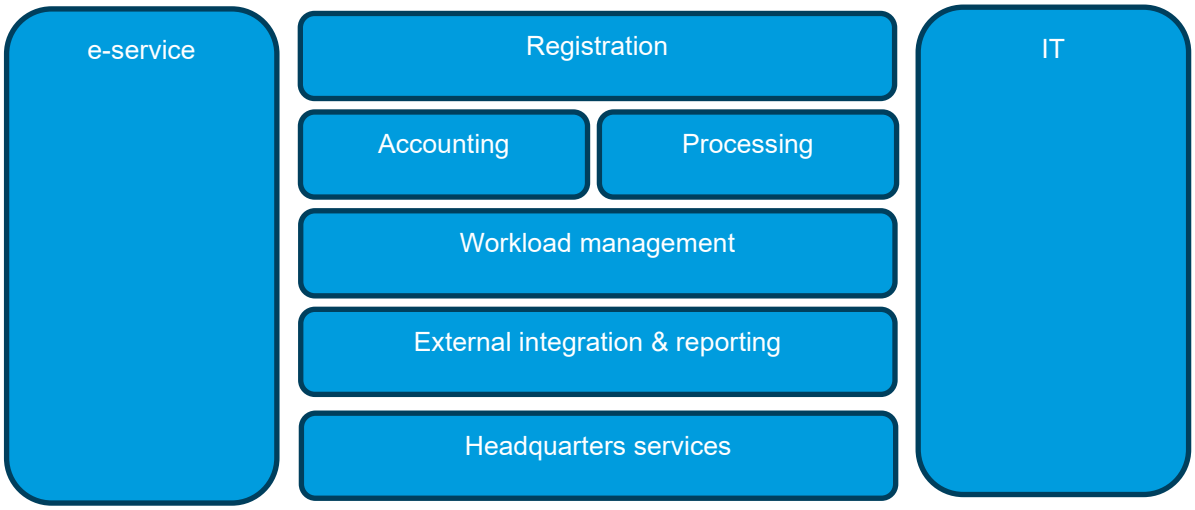
24. In the realm of tax administration, CRM processes have traditionally served as the foundation for identifying and mitigating compliance risks. These processes involve extensive data collection, analysis, and reporting, relying heavily on human intervention and standard procedures. However, as the landscape of taxation evolves and the complexity of taxpayer interactions increases, there is a growing need to transition from these manual methods to a more streamlined digital approach. Embracing digital technologies offers the potential to enhance efficiency, improve data accuracy, and facilitate real-time risk assessments. This digital journey not only transforms the way tax administrations operate but also enables a more proactive and responsive framework for managing compliance risks, ultimately fostering a culture of transparency and trust between tax authorities and taxpayers. For tax administrations, the pathway to digital risk management can be broken down into three core pillars: systems integration, data governance and AI. Additional context on can be found by accessing the Information Technology and Data Management course in the VITARA platform. See the link provided in Annex V.

Systems integration

25. The Integrated Tax Administration System (ITAS) provides a comprehensive framework designed to modernize and enhance tax administration. ITAS provides a suite of tools and practices that support tax authorities in improving their operational efficiency, compliance, and revenue collection. By integrating various tax functions—including registration, assessment, collection, and enforcement—

ITAS facilitates a more streamlined approach to tax administration. The system emphasizes the use of technology and data analytics to enhance decision-making processes, manage taxpayer information effectively, and improve service delivery. Figure 4 illustrates the core segments of an ITAS portfolio.[12]

Figure 4. Core Segments of an ITAS portfolio



26. A robust integration of tax administration systems relies on the simultaneous communication of over 100 discrete services working together as a cohesive unit. These services encompass both hardware and software communication. Effective digital risk management requires the comprehensive analysis of data from diverse sources by employing a range of analytical tools. A centralized nationwide access portal streamlines the analysis of diverse data sources using various analytical tools, enhancing digital risk management capabilities. This portal should feature individual dashboards that connect to various application programming interfaces (APIs) and analytics systems, facilitating streamlined access to critical data and enhancing overall efficiency.

27. The individual dashboard provides a set of protocols that enables software applications to communicate and to exchange data, features, and functionalities. A nation-wide connected dashboarding system consolidates the different ITAS segments into a single platform. In turn, the connection of individual dashboards into a single consolidated platform promotes end-to-end institutional planning to enhance modelling and statistical learning, to ensure rationalized decision-making.

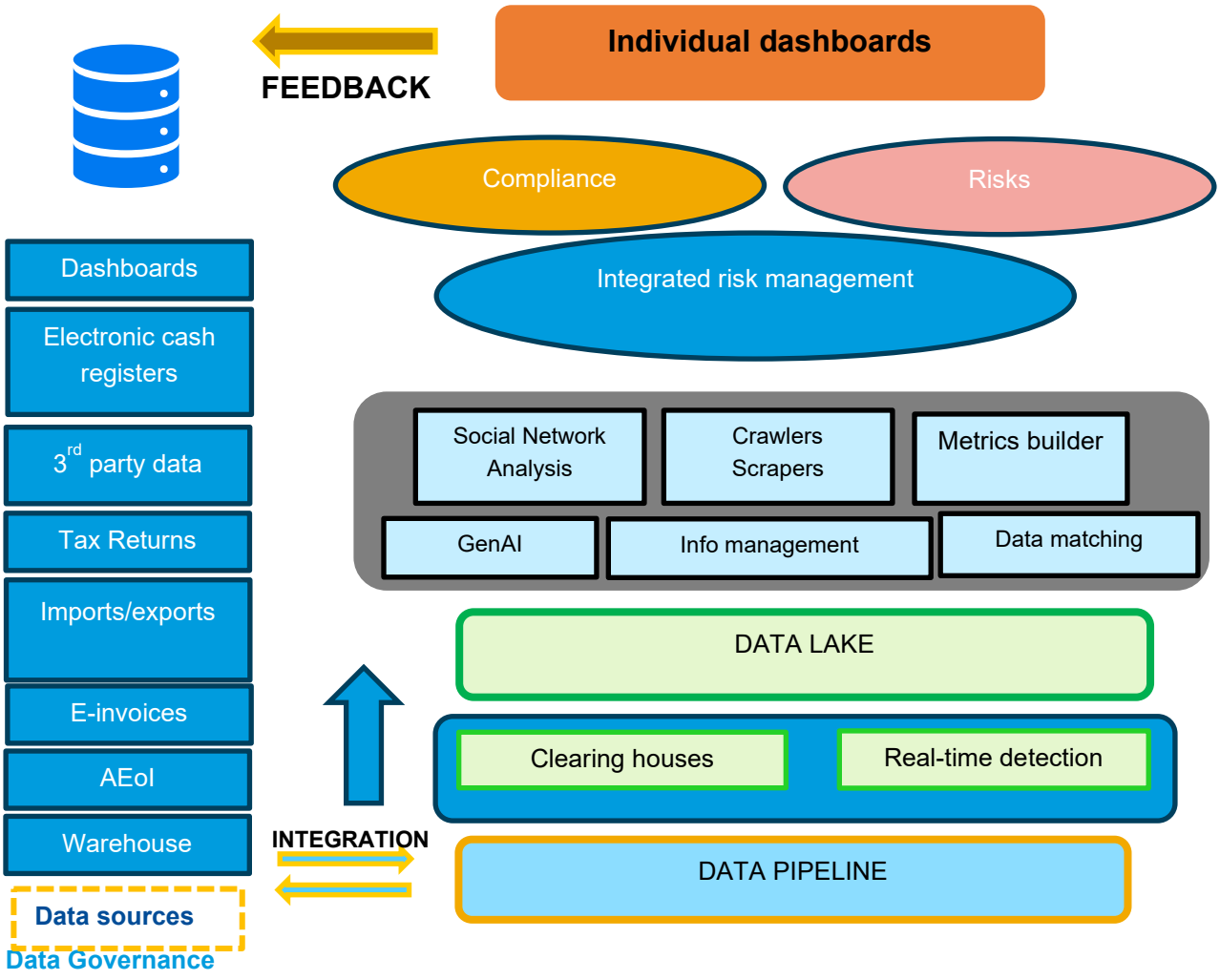
28. Large taxpayers are characterized by their high degree of complexity, primarily due to the high volume of transactions and the numerous entities that compose their businesses. Individual dashboards enable swift access to analytics tool, such as visualization, business intelligence and social network analysis tools with the integration of external reporting and 3rd party data into a single access point. In turn, the single access point can offer a 360-degree view of taxpayers to facilitate monitoring of complex structures and oversight over all the entities composing the enterprise. Tax administrations in

[12] World Bank (2022) 'Understanding an Integrated Tax Administration IT System (ITAS)', available at: https://documents.worldbank.org/pt/publication/documents-reports/documentdetail/099050124135542353/p16664011d99e7091a10c1e4e763e47f3e

advanced economies generally resort to commercial-off-the-shelf (COTS) solutions for the development of single access points and individual dashboards.

29. Large taxpayers generate diverse sets of assignments for tax officials that necessitate visualization of the entire corporate structure. This important group also requires complete oversight of the historic of tasks performed over an extended period of time. Such diversity of tasks generates the need for a centralized access to data warehouses and analytics tools, streamlining access requests and eliminating unnecessary burdens for individual officials. An example of a vertically integrated structure of the Spanish Revenue Authority, with a multilateral data pipeline is illustrated in Figure 5.

Figure 5. Vertically Integrated Structure of the Spanish Revenue Authority[13]



[13] For a comprehensive explanation of the different sub-components, see: B. D. Olivares Olivares (2020) Transparencia y aplicaciones informáticas en la administración tributaria, in *Crónica Tributaria*, n. 174, 2020.

B. D. Olivares Olivares (2020) Law and Artificial Intelligence in the Spanish Tax Administration in *European Review of Digital Administration & Law* 1(1-2), 229-230.

30. The architecture described above rests on two central components: a cohesive data governance standard and a data pipeline. Extracting accurate information from multiple streams require a cohesive data governance standard to ensure the correctness of statistical inferences. A cohesive data governance, 'data harmonization' or data integration, is the process of bringing together data from different sources and harmonizing it into a cohesive data model.

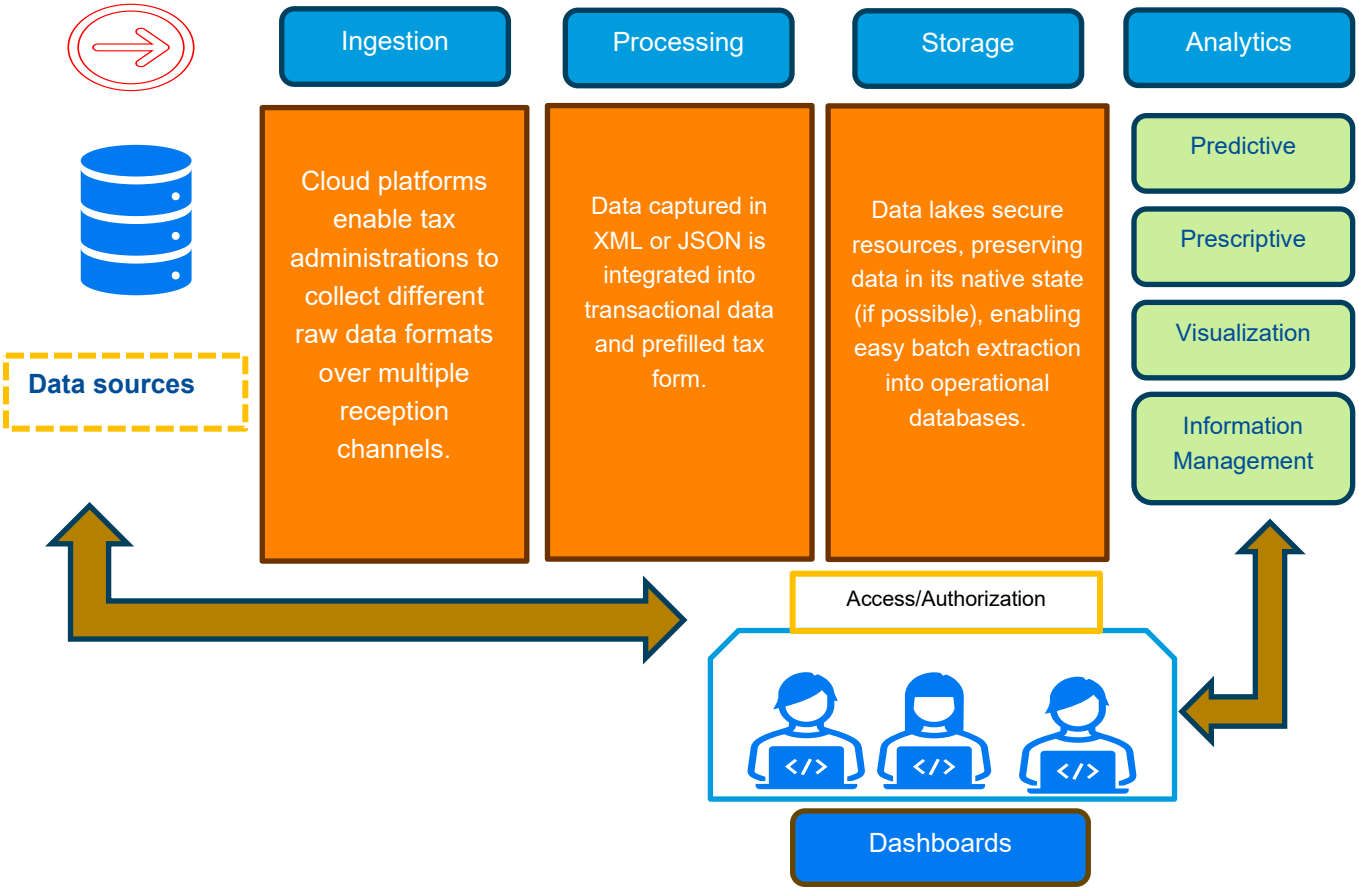
31. Large taxpayer offices (LTO)s process data from numerous data streams who must meet multiple reporting requirements in different jurisdictions. A unique data format, generally JSON[14] or XML[15], helps ensure data harmonization and the structuration of data into a data warehouse. In turn, a uniform data format significantly improves the application of AI and analytical tools.

32. A data pipeline ensures a cohesive integration, processing, and storage of data into a data warehouse, to optimize the use of analytics and statistical learning systems. Figure 6 illustrates a standard model for data pipelines used by tax administrations in advanced economies. Initially, data is gathered from various sources, including tax returns, financial institutions, and external databases, ensuring comprehensive coverage of taxpayer information. This data is then cleaned and transformed to maintain accuracy and consistency before being stored in centralized databases or data warehouses. Advanced analytics tools and techniques, including data mining and machine learning algorithms, are applied to identify patterns, assess risks, and generate insights related to taxpayer behavior and compliance risks. Finally, the processed data is made accessible to tax officials through dashboards and reporting tools, enabling informed decision-making and targeted interventions.

[14] JSON (JavaScript Object Notation) is a lightweight data interchange format that is easy for humans to read and write, and easy for machines to parse and generate. It is primarily used to transmit data between a server and a web application as an alternative to XML.

[15] XML (eXtensible Markup Language) is a markup language designed to store and transport data in a structured, human-readable format. It was developed to provide a flexible way to create information formats and share structured data across different systems, particularly over the internet.

Figure 6. Standard Model for Data Pipelines in Tax Administrations in Advanced Economies



Artificial intelligence

33. Currently, AI systems in advanced economies serve six primary functions within tax administrations, which are essential to the CRM process[16][17]. These functions include e-service, data collection, risk detection, risk management, nudging, and internal assistance, as illustrated in Figure 7. Additionally, Figure 8 provides a quantitative analysis of AI system usage in these economies, with functions that are not currently employed by the STA indicated.

- e-service: systems meant to aid taxpayers at their volition.
- data collection: systems meant to collect taxpayer online data.
- risk detection: systems meant to collect non-compliance signals.

[16] For a complete and sourced breakdown of the AI systems used by EU tax administrations, per Member State of the EU see: D. Hadwick, 'Overview of AI systems for revenue services – Country Reports' https://taxadmin.ai/country-reports

[17] For an aggregated report of the AI systems used by OECD tax administrations, see: OECD et al. (2022), Inventory of Tax Technology Initiatives, Table DM 5.

- risk management: systems meant to segment taxpayers in risk categories (predictive) and systems meant to suggests follow-up actions (prescriptive)
- nudging: systems meant to aid taxpayers, at the administrations' volition.
- internal assistance: systems meant to aid tax officials, at their own volition.

Figure 7. Functional Taxonomy of AI Systems Leveraged by Tax Administrations in Advanced Economies

Pre-assessment	Assessment			Post-assessment	
E-Service	Data Collection	Risk Detection	Risk Management	Nudging	Internal Assistance
Chatbot	Webscraping	Visualization	Predictive Analytics	Adaptive Communication	Information Management
	Crawling	Outlier Detection	Prescriptive Analysis	'Friendly Alert'	Generative AI
	Machine Vision	Data Matching (Real-time)		Systems integrated by the STA	
				Systems not integrated by the STA	

Figure 8. Quantitative Taxonomy of AI Systems Used by Tax Administrations.

Source: OECD, taxadmin.ai

34. Currently, tax administrations primarily utilize AI systems for assessment functions, which include data collection (20 percent), risk detection (25 percent), and risk management (20 percent). In addition to these assessment activities, tax administrations also leverage AI systems for internal and external assistance functions during the pre- and post-assessment phases. This includes the use of chatbots (10 percent), internal assistance (20 percent), and nudging techniques (5 percent). This multifaceted approach underscores the increasing role of AI in enhancing the efficiency and effectiveness of revenue administration.

35. The functional breakdown of AI systems used at the STA highlights that the STA has extensive e-service capabilities. These findings are on par or exceeding the current state of use of AI systems by tax administrations in advanced economies. In parallel, LETD exhibits a lower degree of integration of AI systems for clearance purposes.

36. When comparing the current state of integration of AI systems nation-wide, the STA has not yet integrated AI systems performing key functions of a standard CRM process. The most notable mentions are web crawling, prescriptive analysis tools, machine vision and real-time data matching. Such findings contrast with state of integration of AI systems in the OECD and advanced economies, where a number of these functions have been underpinned by the use of AI for almost a decade.

37. STA officials noted a lower utilization of supervised learning classifiers compared to advanced economies. These classifiers are essential for predictive analytics, to segment large taxpayer populations into distinct risk categories. A machine learning classifier can be trained on large sets of historical data to predict the likelihood of non-compliance. A classifier processes a larger variety of features to better identify taxpayers more likely to engage in non-compliance.[18] They play a crucial role in the CRM process by helping to devise risk profiles, inform the annual planning process, and develop diversified treatment strategies. In the European Union (EU), supervised learning classifiers account for nearly 20 percent of all observed AI systems.[19] Among OECD members, over 90 percent report using these classifiers and business intelligence tools to categorize taxpayers by risk.[20]

38. Additionally, the STA has chosen to outsource web scraping to an external service provider, a practice that sets it apart from other tax administrations in advanced economies. These economies typically use open access systems and employ adaptable scraping and crawling frameworks, such as those developed with Python[21] (e.g., Django, Scrapy), due to their versatility. This allows them to customize scripts for the strategic and targeted collection of structured data that meets the specific needs of their risk management departments.

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[18] See for instance, Baghdasaryan, V., Davtyan, H., Sarikyan, A., & Navasardyan, Z. (2022). Improving Tax Audit Efficiency Using Machine Learning: The Role of Taxpayer's Network Data in Fraud Detection. *Applied Artificial Intelligence*, *36*(1). https://doi.org/10.1080/08839514.2021.2012002;

For a review of different classification methods, see Qinghua Zheng, Yiming Xu, Huixiang Liu, Bin Shi, Jiaxiang Wang, Bo Dong (2024) 'A Survey of Tax Risk Detection Using Data Mining Techniques' *Engineering*, Vol. 34 doi.org/10.1016/j.eng.2023.07.014

[19] D. Hadwick, 'Overview of AI systems for revenue services – Country Reports' https://taxadmin.ai/country-reports

[20] OECD et al. (2022), Inventory of Tax Technology Initiatives, Table DM 5.https://github.com/scrapy-plugins/scrapy-djangoitem

[21] Python is a high-level, interpreted programming language known for its simplicity and readability.

C. Recommendations

- The STA should shift from an entity-by-entity approach to risk assessment to a more comprehensive, aggregate perspective that targets the highest risk cases within the large taxpayer population.
- Establish a framework using ITAS and CRM principles that anticipates the data and technology needs necessary for effective risk management. This framework should incorporate strategies for identifying emerging data sources, leveraging advanced analytical tools and innovative technologies.

III. Governance and Accountability

39. In the context of transitioning to a digital journey, governance and accountability become even more critical for tax administrations. As the STA moves towards implementing digital CRM systems, the complexity of operations increases, necessitating a robust governance framework to guide decision-making and ensure compliance with regulatory standards. Coordinated action across functional departments at the STA headquarters is essential to establish clear roles, responsibilities, and processes, which helps mitigate risks associated with the integration of new technologies.

40. Effective governance ensures that the digital transformation aligns with the overall strategic objectives of the STA, allowing for transparent oversight of the implementation process. This is particularly important in managing large businesses, as the stakes are higher, and the implications of errors or oversights can lead to significant revenue losses or compliance failures. Additionally, a strong governance framework fosters accountability, ensuring that all stakeholders are answerable for their actions and decisions throughout the transition. This not only builds trust within the organization but also enhances credibility with external stakeholders, including taxpayers and the public.

41. Moreover, as digital tools and data analytics become integral to the CRM agenda, maintaining high standards of data integrity and security is paramount. Governance structures must be in place to monitor data usage and protect sensitive taxpayer information, which is essential for upholding public confidence in the tax system. Thus, as the STA embarks on its digital journey, reinforcing governance and accountability mechanisms will be vital to ensuring successful management of large businesses and effective execution of its emerging CRM strategies.

A. The Importance of the Headquarters (HQ) Function

42. Strong governance in tax administration relies on the right organization structure and a clear articulation of roles and responsibilities. This includes not only core tax administration functions (i.e. registration, filing, correct reporting, and payment) but also significant tax administration programs such as CRM. Good practice in organization design is underpinned by the functional model that embodies certain key principles. These principles include: (i) a strong HQ; (ii) a function-based organization design—meaning a structure based on key tax administration functions and not tax types; (iii) minimal management layers; (iv) streamlined field offices; and (v) an organization that reflects key taxpayer segments.

43. A high-performance HQ is critical to a tax administration's success. HQ acts as the vital center of the tax administration. This means that HQ has responsibility for the functional direction of all aspects of tax administration while operations follow this direction. In this role, HQ develops procedures and policies and mechanisms to properly report and monitor results. It sets strategies, develops business cases, oversees planning and reporting, ensures consistency in administration and enforcement, determines resource allocations for the tax administration, develops KPIs and ensures they are tracked. The HQ is responsible for major decisions about the main tax administration functions and is the link to IT to ensure that the needs of each function are met – HQ embodies business ownership of each function. Box 2 sets out the high-level role of HQ.

Box 2. Typical Headquarters Role in Tax Administration

- Developing procedures and methodology.
- Preparing manuals and instructions.
- Determining business processes and IT requirements.
- Developing risk management strategies.
- Providing technical advice to operational units.
- Allocating resources and distribution in operational offices.
- Developing operational plans and national programs.
- Distributing revenue targets.
- Setting performance measures
- Establishing reporting requirements.
- Monitoring operational performance.

44. There is no single example of a best-practice tax administration organization structure. A multitude of factors e.g. scope, scale, geography impact a country's decisions on how to best structure its administration for success. However, consideration of the five principles set out above has been shown to lead to better results. In fact, these principles can underpin the structure of any organization in the public sector or any private sector enterprise. The STA structure embodies these principles.

45. The STA does not have a single locus for HQ functions, and this can create unique challenges. The STA's structure groups 17 functional departments that are described as HQ and these departments are a hybrid of tax-type and function-based. Some operations are also delivered from these departments. The TBDRM department is not in this grouping yet handles the important work of risk management and data analytics. How these departments work together to determine the STA's overall priorities as they relate to large business management (and especially CRM) needs to be carefully considered.

46. Large business management could be mandated to the LETD. This department could be named as the lead functional department, working in close collaboration with other key functional departments e.g. VAT, income tax, audit, taxpayer service. Further, the large business population should be a key segment for TBDRM and how their priorities are set and managed should be reviewed (some advice is provided later in this section). In the absence of assigning clear roles and responsibilities in this way, large business management risks being less effective because of lack of coordination, program development and priority setting. Large business should determine the service and audit approaches that will be delivered in any office that has some responsibly for large business management.

47. Field offices deliver operations in conformity with the policies, procedures and programs set out by HQ. A symbiotic working relationship between HQ and field offices is critical for effective delivery of tax administration programs. The credibility of the tax administration with taxpayers relies on

consistent treatment and trust. A clear distinction between HQ and operational roles supports consistency as all field offices should be managing daily operations using national policies and procedures as determined by HQ. Most importantly, field offices then plan and coordinate workload, oversee operations, prepare operational reports as determined by HQ, manage staff and collaborate with HQ to build centers of excellence in core business areas. Regular and open communication between field offices and HQ is essential to ensure that HQ understands the challenges and constraints faced by field offices and can adjust policies as needed.

48. China's sheer scale drives the need for a large office network and the importance of HQ direction and oversight. The STA's mandate is delivered in close to 4000 locations (600 manage large taxpayers) as well as 41,000 township level divisions. This presents clear challenges to the delivery of consistent and equitable tax administration across this entire network and makes a strong HQ function of more paramount importance. Each office in this network must operate from the same set of HQ guidance and procedure, report against clear expectations set out by HQ and communicate to HQ any emerging needs for new programs or adjustments to existing programs.

49. Taxpayer relationship management is a good example of an essential working dynamic between HQ departments and the field offices is needed. Given the breadth of the STA office network and the number of STA offices providing advice, guidance and dealing with taxpayer, the need for clear procedures that are carried out in the same manner and with the same quality service no matter where the service is delivered is critical. STA HQ must determine methodologies and ensure their implementation, review, and analyze reports from field offices, address poor performance and consider changes to methodologies in the event of unexpected outcomes. This is especially true in the large business program, where large businesses are not managed by the STA through one office but rather through several locations. One aspect of taxpayer relationship management, a rulings program, is an example of a program that is best delivered centrally, given the complexities of cases involved, the skill sets required and the need to ensure consistency in decisions. Taxpayer trust and STA credibility are buttressed when a taxpayer can have confidence in the accuracy and consistency of STA decision-making.

B. Accountability

50. Accountability works together with the structure of a tax administration. In its simplest sense, accountability is who—or what division—is responsible for delivering what part of the STA's mandate. The STA structure includes shared working relationships and shared accountabilities across the functional departments and branch offices. CRM is an emerging example where success will rely on a clear understanding of roles across all departments, well- coordinated action involving multiple offices and executive direction and oversight.

51. Leadership and accountability are interwoven concepts, and STA senior managers are the vanguard of their implementation. The administration and enforcement of the revenue laws requires senior leaders to assure the government that revenue collection is optimized by managing a wide network of operations, personnel, and assets. Relationships with government departments, especially the Ministry of Finance (MOF), and with civil society must be effectively managed. Leaders drive accountability so that

all the various STA departments work together towards agreed results. They define collective action, execute strategic plans, and continually look to renew the organization.

52. Accountability is closely linked to performance management. The 2023 FAD report[22] on the administration of corporate income tax provided advice on enhancing performance management. A performance management framework that identifies key indicators and links them to the strategic and operational plans is an integral part of any strategic management framework. Appendix 1 contains the large business components of strategic plans for the Canada Revenue Agency (CRA), His Majesty's Revenue and Customs (HMRC) in the United Kingdom, the Australian Taxation Office (ATO), and the Internal Revenue Service (IRS) in the United States.

53. Performance management also allows managers and members of staff to understand their own roles, accountabilities and the expectations that have been set for their performance. Individual efforts taken together make up the overall performance result for the STA, so clarity is essential.

54. The STA's functional model means some positions have two lines of accountability. Field offices take direction from two sources: (1) their direct management hierarchy and (2) from HQ functional departments as it relates to core tax administration functions. For example, an audit team works within the field office and has resources assigned, its time managed and general oversight from local management. Its audit caseload and results though are directed and overseen by the HQ functional department for audit. This underlines the need for effective communication and collaboration between the HQ functional departments and field office as the functional model relies on open lines of communication.

C. Leveraging CRM Across the State

55. To be effective, CRM needs an organizational focus. The CRM framework is driven and informed by the STA's strategic goals and objectives as set out in the strategic plan. It involves every key tax administration function and is focused on the administration and enforcement of tax laws. Most STA departments will have a CRM role of some magnitude and as a result, the STA needs a dedicated organizational focus. This could be assigned to an existing department e.g. TBDRM or involve the creation of a new department or division for CRM coordination.

56. The mandate of a CRM department will be one of leadership and coordination. Typically, it would be an HQ function and could be located in a planning/programming or a risk management division. Key activities include: (1) analyzing internal and external environments; (2) analyzing the current tax administration data for indications of non-compliance; (3) collaborating closely with risk owners, who are the business leaders for the various tax functions e.g. audit; (4) working collaboratively with risk owners to develop treatment strategies for identified risks; and (5) developing CRM management methodologies and practices and documenting them for future reference. CRM will require new skillsets related to data analytics, pattern recognition and early identification of outliers.

[22] Cindy Negus, David Carr, Toshiyuki Kemmochi, and Sunita Lough. Selected Issues in Administering Corporate Income Tax. January 2024.

57. CRM focal points should be named in all key departments. As described earlier, HQ functions are found in many STA functional departments and in the TBDRM. As the CRM framework develops and gains traction, all of these departments will make some contribution to CRM. This involvement needs to be formalized and coordinated to ensure not only that CRM has all needed inputs, but that CRM products and direction are properly integrated into daily operational work across the STA. Business knowledge about existing compliance risks is also important. For example, staff with experience in auditing will likely be aware of patterns of non-compliance and service officers will know trends in questions that could direct CRM treatments in education and awareness.

58. CRM can with time become a center of excellence. Naming focal points, beginning with key departments such as audit and eventually extending to any department with some CRM interest, will also help to create a culture of CRM and centers of CRM excellence across the STA. Given the size of the STA and its office network, this would be an especially important achievement.

59. Resources devoted to CRM should be reviewed with a view to possible reallocation. Some CRM is under development across the STA, and this should be reviewed and assessed to understand what new work will be needed to properly undertake CRM. Building an awareness of risk and identifying priorities and treatments will in many cases go beyond the current working methods in place in STA and this will need a resource response. Resource reallocation may be possible if some areas of work are no longer needed but there may be many cases where additional resources are critical to success. This analysis should be undertaken in the short term.

60. A senior CRM committee should be established to support management awareness and decision-making. This would bring all intelligence into one place and would mean that senior leadership is the STA's authority over CRM direction and resources. This committee would also ensure close linkage to the STA's overarching strategic priorities and goals. Such a committee would usually be chaired by the most senior executive and its membership would include the senior leadership i.e. risk owners from across the STA who are responsible for key tax administration functions. The work of the committee would be staffed by the CRM department with support from CRM focal points.

61. The CRM committee would meet regularly and have a clear mandate. The committee would usually meet annually (and perhaps more frequently in the early months after its creation). Its mandate would include: (1) evaluate progress in addressing existing risks: (2) confirm whether existing risks are still the highest priority risks for treatment; (3) identify any emerging risks to the tax system; (4) approve – on an annual basis – the CIPs for the upcoming year, including resource allocations aligned to the treatments identified; (5) provide guidance to the CRM department as needed; and (6) review the performance results of the various treatment strategies and adjust as required. The committee would oversee the compliance risk register (CRR) that is a historical record of the risks and approved strategies to address the risks.

D. Recommendations

- Designate LETD as the primary functional department at headquarters responsible for coordinating all large business programs and supporting functions[23] from a central focal point.
- Establish a dedicated CRM unit with a senior level committee to lead the STA's CRM strategy and governance framework.

[23] Large business programs and supporting units include VAT, CIT, TBDRM, and the Auditing Department.

Appendix I. STA Organizational Chart

STA Headquarters[24]

Discipline Inspection Office Designated Within the STA by the Commission of Discipline Inspection of the Central Committee of the CPC and the National Supervisory.

Functional Departments	Institutions Directly Under the STA	Branch Offices	Tax Associations
General Office (Office of the Party Committee)	Education Center	Tax Big Data and Risk Management Bureau	China Tax Society
Tax Policy and Legislation Department	Logistics Center	Beijing Special Commissioner's Office of the STA (Beijing Investigation Bureau of the STA)	China International Taxation Research Society
Goods and Services Tax Department	E-Tax Management Center	Shenyang Special Commissioner's Office of the STA (Shenyang Investigation Bureau of the STA)	China Certified Tax Agents Association
Income Tax Department	Procurement Center	Shanghai Special Commissioner's Office of the STA (Shanghai Investigation Bureau of the STA)	
Property and Behavior Tax Department	Tax Science and Research Institute	Guangzhou Special Commissioner's Office of the STA (Guangzhou Investigation Bureau of the STA)	
International Taxation Department (Hong Kong, Macao and Taiwan Office)	Tax Publicity Center	Chongqing Special Commissioner's Office of the STA (Chongqing Investigation Bureau of the STA)	
Social Security Contributions Department (Non-tax Revenue Department)	Tax Academy of STA (STA Party School of the CPC)	Xi'an Special Commissioner's Office of the STA (Xi'an Investigation Bureau of the STA)	
Revenue Planning and Accounting Department	China Tax Journal Office		
Taxpayer Service Department	China Tax Newspaper Office		
Tax and Information Technology Administration Department	China Tax Press		
Large Enterprise Tax Administration Department			
Tax Investigation Bureau			
Financial Management Department			
Supervision and Internal Audit Department			

[24] STA Annual Report, 2023

Personnel Department (Organization Department of the Party Committee) CPC Party Building Bureau (Publicity Department of the Party Committee, Inspection Office) STA Headquarter Committee of CPC Retired Staff Bureau	

Appendix II. Selected Strategic Plan Summaries for Large Taxpayers

Internal Revenue Service, United States

Vision

To be the premier resource for large corporations in complying with their tax obligations.

Key Goals

Enhance Compliance

- Increase audit coverage for high-risk large taxpayers.
- Develop compliance risk assessment tools.

Improve Service Delivery

- Establish dedicated account managers for major corporations.
- Implement a feedback system to enhance taxpayer services.

Leverage Data Analytics

- Utilize data analytics to identify trends and compliance issues.
- Integrate data from various sources for comprehensive analysis.

Initiatives

- Quarterly compliance workshops for large taxpayers.
- Regular updates on tax law changes and implications.

His Majesty's Revenue and Customs, United Kingdom

Vision

To facilitate compliance among large businesses while promoting a fair tax system.

Key Goals

- Strengthen Compliance Efforts
- Focus on high-risk large taxpayers through enhanced scrutiny.
- Develop industry-specific compliance strategies.
- Improve Service Delivery

- Provide a dedicated helpline for large businesses.
- Offer tailored guidance and support.
- Utilize Technology Effectively
- Implement advanced analytics for risk assessment.
- Enhance online services for large taxpayers.

Initiatives

- Regular tax compliance workshops and updates.
- Establishment of a feedback mechanism for service improvement.

Canada Revenue Agency

Vision

To support large corporations in meeting their tax obligations while ensuring fairness and compliance.

Key Goals

Strengthen Compliance Programs

- Focus on high-risk sectors and industries.
- Enhance audit techniques and methodologies.

Customer Relationship Management

- Assign dedicated tax advisors to large corporate clients.
- Offer personalized services and consultations.

Technology Implementation

- Upgrade IT systems for better data management.
- Utilize analytics to identify non-compliance trends.

Initiatives

- Annual compliance seminars for corporate clients.
- Development of an online portal for streamlined communication.

Australian Taxation Office

Vision

To provide tailored services and support to large businesses, ensuring compliance and facilitating economic growth.

Key Goals

Improve Engagement

- Establish regular communication channels with large businesses.
- Create advisory panels for policy feedback.

Increase Compliance Rates

- Implement targeted audits based on risk assessments.
- Provide educational resources specific to large corporations.

Enhance Operational Efficiency

- Automate reporting processes for large taxpayers.
- Streamline the audit process through technology.

Initiatives

- Bi-annual forums for large business stakeholders.
- Development of compliance checklists tailored for large enterprises.

Appendix III. Typical Large Taxpayer Risks

Risk topic - description	Summary
Income recognition	Derivation of income; unbilled income; asset sales; intra-group sales; discounts, rebates, and refunds; grants and subsidies.
Accounting Differences	Long term construction contracts; profit recognition; timing issues.
Work in Progress	Values; inventory numbers; classifications; methodologies; concessions; governance and controls.
Characterizations	Capital-revenue issues; grants and subsidies; warranties; private equity disposals; disposals – capital gains tax if regime exists; losses.
Major expenses	Research and Development; depreciation; cost of goods; repairs and maintenance; labor costs; input prices; transportation costs; incentives; government charges; intragroup transactions
Financing Costs	Leases; products; hybrids; stapled groups; foreign exchange; forward contracts.
Book to tax adjustments	Tax adjustments; low tax performance; exempt Income; concessions in tax law; non-tax items, e.g., fines or penalties; prepayments; Research and Development; capital allowances; provisions.
Losses	Origin of losses, capital/revenue and recoupments, misapplication of rules.
Key business events – requiring tax planning	Reorganizations; start-ups; end of business; major acquisitions, mergers, takeovers, projects, disposals.
Assets - capital expenditure & Infrastructure	Distinction between capital and revenue expenditure - write-offs, depreciation claims, valuation issues, expansion or improvement of network assets, unitization of plant and equipment, effective lives (depreciation rates), Exits and disposals

Valuations	Considerable law involves valuations – capital gains, stock, assets, related party dealings (pricing)
Related Party Dealings	Intra group transactions; cross-border interactions; structure - entity / vehicles used; locations; key individuals' interactions.
International	Profit Shifting - transfer pricing, thin capitalization, alienation of intellectual property; use of foreign experts, residency, source; permanent establishments (PEs); disposals offshore e.g. 'exits'; withholding tax, sovereign immunity, reorganizations, and business restructures – shift of functions e.g. marketing hubs; equity transfers; financing debt levels.
Other Taxes - VAT/Business Taxes	Governance and decision making on tax; Ensure taxpayers internal recording systems are appropriate so as to ensure that their VAT and Business Tax obligations are complied with, VAT Credits; Exemptions; PAYG withholding, Excise, Fuel Levies.

Appendix IV. Technical Guidance on Enhancing Data and Predictive Accuracy

Enhancing data quality and managing real-time data processing are concurrent goals, which necessitate similar technological solutions. In machine learning literature, data quality is generally broken down into three dimensions with high relevance for tax administrations, presented below:

- ***Data accuracy*** is "the degree to which information is correct, unambiguous, meaningful, believable, and consistent**".**[25] Data accuracy is expressed in terms of error rates, hence the ratio between the number of erred fields and the number of total fields, where a field is a given data-feature, as shown below:

  error_rates = (number_of _erred_fields)/(number_of _total_fields)

- ***Data representativity*** is "the degree to which the sample accurately corresponds to the phenomenon studied or the target population measured". It includes all possible states relevant to the user population that are represented in the stored [data]. For LTO officials, data representativity can be measured negatively, by assessing the presence of biases within a data sample. In particular, two biases are highly relevant for LTO officials and for revenue authorities at large: representation bias[26]; and training-deployment skew or 'data drift'[27].

- ***Data currency*** "the degree to which information is up to date, or the degree to which the information precisely reflects the current state of the world that it represents"[28]. This requires data to be up-to-date and outdated data to be purged. Data currency is inversely correlated to data drift and training-deployment skew, as it characterizes and measures the extent to which training data and predictions reflect real-world environment.

Numerous techniques have been proposed in scientific literature, but some of these solutions are highly impractical for tax administration officials. CRM dictates that field audit should be reserved to a selected sample of taxpayers. In turn, tax officials do not have the capacity to verify reference values for each taxpayer or for their entire data lakes. Certain open-source AI solutions have been proposed in

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[25] Nelson, R. Ryan, Peter A. Todd, and Barbara H. Wixom. "Antecedents of information and system quality: an empirical examination within the context of data warehousing." Journal of management information systems 21.4 (2005): 199-235.

Cai, Li, and Yangyong Zhu. "The challenges of data quality and data quality assessment in the big data era." Data science journal 14 (2015); Redman, Thomas C. "The impact of poor data quality on the typical enterprise." Communications of the ACM 41.2 (1998): 79-82.

[26] Representation bias is when there is no sufficient data on certain businesses or sectors of activity for the model to learn a correct probability distribution .

[27] Data drift is when the distribution of the training data differs significantly from that of deployment resulting from a lack of standardized data collection and recording methods.

[28] Nelson, R. Ryan, Peter A. Todd, and Barbara H. Wixom. "Antecedents of information and system quality: an empirical examination within the context of data warehousing." Journal of management information systems 21.4 (2005): 199-235.

machine learning to monitor data quality within a data pipeline, such as EvidentlyAI[29]. These solutions perform recurrent audit of data quality within a data pipeline.

Recurrent monitoring of data quality is of crucial importance for tax officials. It improves the accuracy of predictive and prescriptive AI systems, but also signals when a statistical model should be updated. Tax officials can include different solutions in their standard statistical procedural requirements to monitor data quality and verify the accuracy of predictive models or individual features.

When ground truth labels[30] are unavailable or when there is a delay in receiving feedback the most effective solution is to use proxy values. These proxy values can help assess the accuracy, representativeness, and currency of the data. Common proxy values include the following:

- ***Feature range compliance*** is a statistical summary technique that tracks whether the value of a label remains within a minimum-maximum range. This technique is highly scalable and can be augmented through the addition of logical inferences and expert knowledge. Data matching, whether retrospective or real-time, will inevitably require the implementation of feature range compliance as one of the assessment steps within the clearinghouse of revenue authorities. As an example, suppose that a taxpayer reports the sale of a low-value goods generating exceptionally high revenue, or a car as weighing one kilogram, feature range compliance and logical inferences can detect anomalous reported values in real-time during or prior to reporting data.

- ***Characteristic stability index*** (CSI) is a metric used to assess the consistency and reliability of an independent predictor over time, particularly in changing environments. When calculation is operated over an entire model's performance, it is generally referred as Population Stability Index (PSI). PSI was developed in risk scorecards, a process that is central to tax CRM, to monitor the changes of a scoring distribution between a modelling sample and validation sample.[31] Changes in PSI and CSI can be prompted by changes in the business environments, for instance inflation, changes in interest rates, inclusion of new business lines etc. CSI can be used to assess data drift, while PSI is generally used to quantify model drift and deployment-skew. These two indexes provide insights into potential shifts in data distribution that may impact predictive accuracy. Understanding these two indexes is crucial for ongoing model performance monitoring, as it allows for timely adjustments to maintain accuracy and robustness.

  PSI can be formulated as follows:
  Σ (Actual% – Expected%) *Ln (Actual%/Expected%) [32]

  CSI is formulated as follows:
  Σ (Actual% – Expected%) *feature predictive score

[29] Evidently AI is an open-source data science platform that focuses on improving the transparency and interpretability of machine learning models. https://github.com/evidentlyai/evidently

[30] A ground truth label refers to the accurate and authoritative information used as a benchmark to evaluate the performance of machine learning models or algorithms. In the context of supervised learning, ground truth labels are the correct outputs or classifications assigned to data points in a dataset, which serve as the reference for training and testing the model.

[31] Zhixiao Lin et al., 'Examining Distribution Shifts by using Population Stability Index (PSI) for Model Validation and Diagnosis' : https://www.lexjansen.com/wuss/2017/47_Final_Paper_PDF.pdf

[32] https://github.com/crpavia/ks_psi_stuff; see also Ackerman et al.: https://arxiv.org/abs/2111.05672

A PSI and/or CSI value below 0.1 or ranging from 0.1 to 0.2 indicates no major changes or moderate changes in the datasets. If the value obtained is above 0.2, statistical model supervisors or process owners should be alerted of the presence of data or model drift, as the predictive value of an individual feature (CSI) or of an entire model has shifted. In turn, the value obtained provides a robust indication that the model should be retrained, and the quality of the dataset should be assessed.

- ***Monitoring predictive value***: of features and assessing accuracy of statistical models is generally performed by tax administrations through two well-known measurements in machine-learning literature, so-called Receiver Operating Characteristic (ROC)[33] and Area Under the Curve (AUC)[34]. To assess predictive accuracy of classifier models, i.e. models generally used by revenue authorities to score taxpayers into risk categories, and how the model fits with a dataset, two metrics are commonly used:

    - **Sensitivity**: The probability that the model predicts a positive outcome for an observation when the outcome is positive.

    - **Specificity:** The probability that the model predicts a negative outcome for an observation when the outcome is negative

Sensitivity and specificity can be visualized with a ROC curve.[35] This provides an indication of model accuracy by comparing diagnostic tests, i.e. the ratio between true positive and false positive, as illustrated in Figure 9 The green diagonal indicates a prediction accuracy of 50 percent equal to accuracy of random prediction. Accordingly, the closer the curve is to the top left corner, the higher the accuracy of the predictive model. This can be quantitatively determined by calculating the AUC.

When using machine learning to predict the likelihood of tax non-compliance for a given set of large taxpayers, the model assigns a score to each taxpayer. Higher scores are indicative of a higher probability of fraud. The LTO sets a threshold score to determine which taxpayers will be selected for audit. A ROC curve plots the true positive rate (TP) against the false positive rate (FP) for various threshold values. The ROC curve helps choosing an appropriate threshold based on the risk tolerance and resource constraints of the LTO in the circumstances. If the priority is to minimize the likelihood of missing potential fraud cases, a lower threshold should be opted for. Conversely, if the priority is to minimize the likelihood of auditing compliant taxpayers, a higher threshold should be opted for.

The LTO can use the ROC curve to determine the optimal threshold score for audit selection. In turn, given specific risk tolerance and resource constraints, The ROC curve enables a visualization of the appropriate balance between sensitivity and specificity. A threshold set at 1 minimizes false positives, but

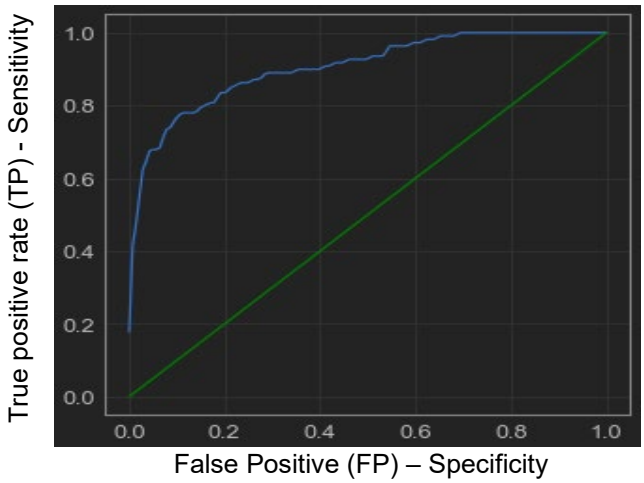
[33] ROC measurement is a statistical tool used to evaluate the performance of binary classification models. It is particularly useful in determining how well a model can distinguish between two classes, such as positive and negative outcomes.

[34] AUC is a performance metric used to evaluate the effectiveness of binary classification models, particularly in conjunction with the Receiver Operating Characteristic (ROC) curve. As the sensitivity of the receiver increased, the number of false positives increased, hence specificity went down. See, T. Fawcett (2006), 'An Introduction to ROC Analysis' Elsevier Pattern Recognition Letters 27, p. 861-874.

[35] Murorunkwere, B. F., Haughton, D., Nzabanita, J., Kipkogei, F., & Kabano, I. (2023). Predicting tax fraud using supervised machine learning approach. *African Journal of Science, Technology, Innovation and Development*, *15*(6), 731–742. https://doi.org/10.1080/20421338.2023.2187930

the model selects taxpayers whose likelihood of non-compliance is 100%. A threshold set at 0.6 generates more false positives, increasing the number of taxpayers selected for audit, potentially resulting in a higher administrative burden.

Figure 9. ROC Curve



AUC can be calculated through several methods, for instance with a Rule Numerical Integration method:

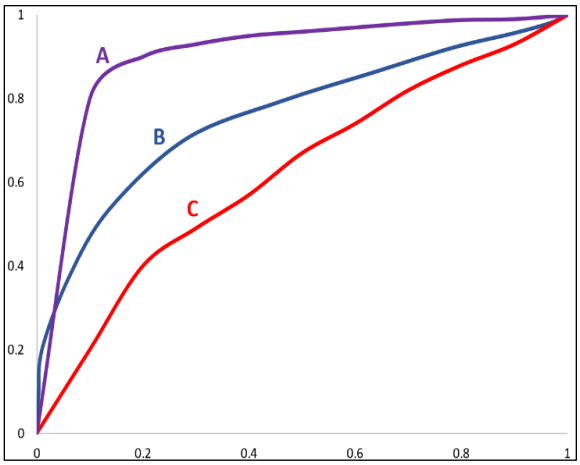
$(x_{i+1} - x_i) * (y_i + y_{i+1}) / 2$

Results obtained are Model A[36]= 0.91, Model B= 0.794, Model C= 0.59 with the optimal AUC = 1. Figure x illustrates each of these models.

A high-performing model helps prioritizing treatments, allocating resources efficiently, and maximizing the detection of non-compliance. The AUC is a common metric to evaluate the overall performance of a classification model. The AUC corresponds to the probability that a model can correctly classify positive instances as positive and negative instances as negative. In the context of tax compliance, the AUC measures how accurately the model can distinguish between compliant and non-compliant taxpayers across a range of thresholds.

[36] Model A is the best model at correctly classifying observations into categories.

Figure 10. ROC Curve, and AUC



Managing Real-Time Data Matching

Certain non-compliance and fraud schemes rely on the retrospective nature of CRM that permit the submission of erroneous data to obtain a tax benefit prior to detection. In advanced economies, the most well-known instance of such scheme is VAT refund fraud, which accounts for an estimated 80 to 120 billion in revenue losses every year in the EU.

These schemes exhibit a high degree of sophistication, requiring sophisticated solutions to detect and prevent. In 2019, EU revenue authorities implemented 'Transaction Network Analysis' (TNA) a real-time data matching tool that connects tax IT platforms of all EU Member States to instantly process transactional data and detect anomalies when VAT returns are filed by a taxpayer. The following year, the EU Fiscalis [37]network reported a €12 to 15 billion increase in revenue collected annually. The only use case where real-time data would be of relevance to tax administrations is for improved VAT refund fraud.

Real-time machine learning, sometimes also referred as 'online machine learning', is the approach of using machine learning systems to process data as soon as it becomes available.[38] In turn, real-time machine learning permits AI systems to operate instantaneous predictions. TNA leverages real-time data matching to verify the correspondence of transactional data in real-time, enabling an instantaneous reaction from tax officials. Similar solutions have been implemented by tax administrations in Belgium and Poland to verify correspondence of financial transactions.[39]

In machine learning literature, there are generally three maturity steps to attain real-time data-matching or predictions.[40]

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[37] EU Fiscalis is a program established by the EU aimed at enhancing cooperation and collaboration among EU member states in the field of taxation.

[38] Vajda, D.L., Do, T.V., Bérczes, T. et al. Machine learning-based real-time anomaly detection using data pre-processing in the telemetry of server farms. Sci Rep 14, 23288 (2024). https://doi.org/10.1038/s41598-024-72982-z

[39] For Poland STIR real-time detection system, see: https://www.vertexinc.com/resources/resource-library/poland-wields-ai-battle-against-vat-fraud ; For Belgium and EU real-time detection see: https://taxation-customs.ec.europa.eu/taxation/vat/vat-and-administrative-cooperation/eurofisc_en

[40] Chip Huyen (2022) 'Real-time machine learning: challenges and solutions': https://huyenchip.com/2022/01/02/real-time-machine-learning-challenges-and-solutions.html

Batch Prediction

Revenue authorities without real-time matching capability generally compute predictions in batch, with a certain time interval. To devise annual plans, diversified treatment strategies and segment taxpayer populations, batch prediction suffices as these exercises are by nature retrospective and rest on the submission of retrospective tax returns.

Session-based predictions

The second stage is generally referred as 'online prediction with batch features' or 'session-based predictions.[41] At this stage, revenue authorities collect online data in real-time through connected data streams, for instance through e-invoicing models or direct data models. However, features are computed after receipt of the data, with a certain time interval. For instance, recommender systems for streaming services, generally recommend new content following a 'session-based prediction' approach. The user data generated on the application is collected in real-time but new inferences are learned with a certain interval, generally a few seconds. With pre-computer algorithms, data can be matched instantly.

Session-based predictions already require a thorough annotation system, to ensure that the system understands the correspondence between different value and tax items. In turn, by embedding pre-computed algorithms, the system can identify anomalies within the self-reported taxpayer data, with a substantially shorter interval, so-called 'near real-time'. 'Session-based predictions' already enables the detection of a substantially higher degree of anomalies within reported data, as it reduces inference latency. [42]

Session-based predictions rely on a data infrastructure which enables a real-time data streaming transport to transfer data. It also includes a streaming computation engine, such as Structured Query Language (SQL)[43] to track user data and remit it in real-time. 'Session-based prediction' presents one challenge: it rests on high-quality embeddings of pre-computed algorithms to ensure matching rate between self-reported data and data within data warehouses of the administration.

Online predictions

Utilizing batch prediction and session-based prediction, features are extracted from historical data through batch processing, which automatically results in inference latency. Online predictions refer to feature computation using newly generated data, the instant a prediction request is generated by the report of new taxpayer data. In turn, this requires a continual self-learning capability using a combination of pre-computed algorithms and self-learning AI systems. Online predictions are only useful if an organization necessitates to infer new features or risk-indicators in real-time, such as with autonomous vehicle.

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[41] The term 'session-based predictions' derives from the fact that the user data is generated during the session where the user makes use of a specific application.

[42] Inference latency refers to the time taken to process one unit of data provided only one unit of data is processed at a time. The unit of latency is seconds.

[43] SQL is a standardized programming language specifically designed for managing and manipulating relational databases

It is important to note that continual self-learning generates a substantially higher risk of feedback loop, which can introduce a bias within the statistical model. Currently, very few if any CRM use cases requires online prediction, as any fraud scheme inevitably also requires a certain time interval and cannot be operated instantly.

Despite claims of 'real-time data matching', currently no tax administration has implemented an online prediction model. The data is matched at an interval rate of seconds, which for CRM purposes is sufficient to detect non-compliance and anomalies within reported data.

Appendix V. Virtual Training to Advance Tax Administration (VITARA)

The following online courses are available for tax administration professionals that may provide helpful additional guidance on risk management principles and practices, and information technology and data management.

- Compliance Risk Management[44]
- Information Technology and Data Management[45]

[44] Full website address: https://www.imf.org/en/Capacity-Development/Training/ICDTC/Schedule/OL/2024/VITARA-CRMOL24-188

[45] Full website address: https://www.imf.org/en/Capacity-Development/Training/ICDTC/Schedule/OL/2025/VITARA-ITDOL25-121