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FROM ACCOUNT MANAGEMENT TO RISK-TRIGGERED AUDIT: A CONTINUOUS MONITORING FRAMEWORK FOR LARGE TAXPAYERS IN E-INVOICING ENVIRONMENTS

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Abstract

This study develops SIGNAL (Sources, Indicators, Graduated response, Narrowed scope, Audit trail, Learning loop), a framework that converts the continuous monitoring of large taxpayers by an assigned account manager into risk-triggered audit selection in jurisdictions that have adopted electronic invoicing. It addresses a paradox observable in Ukraine and increasingly relevant to countries implementing mandatory e-invoicing: tax administrations now receive transaction-level data in near real time, yet the decision to audit a large taxpayer is still driven largely by annual plans, while the richest structured accounting data are requested only after an audit has begun.

Methods. A design-science approach was combined with documentary analysis, structured practitioner reflection and simulation. Phase one analysed a corpus of twenty-eight Ukrainian legal instruments, oversight reports, official publications, foreign regime documents and international guidance covering 2015–2026, together with five foreign e-invoicing and reporting regimes. Phase two constructed the framework, drawing on the author's practice as the assigned account manager for about ten large taxpayers in the Large Taxpayers Office of the State Tax Service of Ukraine and subsequent work in tax debt collection and in an anti-corruption unit. Phase three evaluated alternative trigger rules through a Monte Carlo simulation of a synthetic portfolio of 1,000 large taxpayers observed over 24 months, with sensitivity analysis across six scenarios.

Scientific novelty. The study identifies a gate–insight gap: in Ukraine, e-invoice data are used intensively at the gate, to suspend the registration of individual invoices (7.7 million invoices carrying UAH 144.1 billion of VAT were suspended in 2021 – H1 2024, while 49.4% of complaints against regional suspension decisions were upheld), but only weakly for insight, that is, for the selection and scoping of audits. Since 1 January 2026 the standard audit file SAF-T UA has been requested from large taxpayers only during a documentary audit. In the simulation, a trigger that requires a weighted signal score to persist for two consecutive months raised the precision of audit selection from 10.0% for a single-signal rule to 90.5%, while retaining 99.7% of non-compliant taxpayers, at the cost of a mean detection delay of about three months; the advantage held, with reduced magnitude, under correlated signals, gradual onset of non-compliance and lower prevalence.

Contributions. The study extends the compliance risk management literature by specifying how monitoring signals should be converted into audit decisions, rather than assuming that better data automatically produce better selection, and links that literature to research on continuous auditing, where

alert overload is a recognised failure mode. It contributes to the literature on corruption in tax administration by showing that a formal signal log reduces the discretion of the account manager, the officer with the longest and closest relationship with a large taxpayer.

For countries introducing mandatory e-invoicing, including Poland since February 2026 and the European Union under the VAT in the Digital Age package, the study offers transferable design rules for linking real-time data to proportionate, documented enforcement. It is, to the author's knowledge, the first framework that treats the account manager's monitoring and the audit selection decision as a single, auditable process rather than as separate administrative functions.

Keywords

Large Taxpayers, Account Management, Continuous Monitoring, Risk-Based Audit, Electronic Invoicing, SAF-T, Audit Selection, Responsive Regulation, Integrity, Tax Administration, Ukraine

Introduction

Large taxpayer administration rests on a simple operating model. A small number of enterprises, which account for a disproportionate share of revenue, are assigned to a specialised office in which an account manager follows each company continuously, answers its questions, monitors its filings and payments, and serves as the principal point of contact with the tax authority (Baer, 2002). In Ukraine the segment is defined by revenue above the equivalent of EUR 50 million or taxes paid above EUR 1.5 million over four consecutive quarters (Tax Code of Ukraine, 2010, art. 14.1.24). The 2024 register contained 1,315 taxpayers (State Tax Service of Ukraine, 2023), administered by five interregional large taxpayer offices (State Tax Service of Ukraine, 2025), and these taxpayers paid 40.6% of the general fund revenue of the State Budget in the first half of 2024 (Forbes Ukraine, 2024). Across OECD and other advanced administrations the pattern is similar: a few hundred or thousand enterprises carry a large part of the revenue base, which is why most administrations operate dedicated large taxpayer units (OECD, 2013).

The second pillar of the model is the audit. The account manager monitors, the auditor examines, and the link between the two determines whether scarce audit capacity is directed at genuine risk. Historically that link was weak by necessity: monitoring relied on periodic returns, and audit selection relied on annual plans built from those returns and from the elapsed time since the previous audit. Electronic invoicing changes the information environment fundamentally. When every VAT invoice is registered electronically in a central system, the tax authority observes the transaction network of each large taxpayer almost in real time. The question is no longer whether data are available, but how monitoring signals are converted into audit decisions.

Ukraine offers an instructive case because it adopted transaction-level control early and under pressure. Electronic registration of VAT invoices in a unified register and an electronic VAT administration system have operated since 2015, and since 2017 the registration of individual invoices can be suspended on the basis of automated risk criteria, now governed by Resolution No. 1165 of the Cabinet of Ministers (2019). The Accounting Chamber of Ukraine (2024) found that in 2021 – H1 2024 the system registered 99.3% of submitted invoices covering UAH 7,834.9 billion of VAT, but suspended the registration of 7.7 million invoices carrying UAH 144.1 billion of VAT. The central commission upheld 49.4% of taxpayers' complaints against regional decisions, and the Chamber observed that broad criteria such as "available tax information" confer discretion that may be accompanied by corruption risk.

The audit end of the chain shows a different picture. Between 2017 and 2023, assessments from tax audits totalled UAH 346.2 billion, but the share agreed by taxpayers ranged from 23% to 64%, and the share actually collected fell from 16% in 2017 to 4% in 2023 (Business Ombudsman Council, 2024). Courts decided 74.7% of tax cases against the tax authority in 2021 – H1 2024 (Accounting Chamber of Ukraine, 2024). The electronic audit system launched on 1 January 2026 is built on the standard audit file SAF-T UA, which large taxpayers must provide only upon request during a documentary audit, within two working days (Debet-Kredyt, 2026; Crowe, 2026). The data most suited to targeting therefore arrive after the target has been chosen.

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This configuration produces what this study terms a gate–insight gap: transaction data are used intensively to block individual transactions at the point of registration, a high-friction and high-dispute form of control, and only weakly to decide which taxpayers to audit, on which issues and when. The gap is not peculiar to Ukraine. Every administration that introduces clearance e-invoicing acquires the technical capacity to stop transactions before it acquires the institutional capacity to interpret them, and the temptation to use the former as a substitute for the latter is strong, because blocking produces immediate and visible results.

The central research question is accordingly: how can the continuous monitoring performed by an account manager be converted into risk-triggered audit selection that is precise, proportionate and documented? Three subsidiary questions follow. Which monitoring signals are available to an account manager in an e-invoicing environment, and how should they be combined? What trigger rule balances precision against detection delay, and how robust is that balance to realistic departures from ideal conditions? How can the conversion be designed so that it reduces, rather than enlarges, the discretion of the officer closest to the taxpayer?

Main Body

The economic case for third-party and transaction-level information is well established. Kleven, Knudsen, Kreiner, Pedersen and Saez (2011) showed in a Danish audit experiment that evasion is close to zero for third-party reported income and substantial for self-reported income. Pomeranz (2015) demonstrated that the VAT paper trail produces self-enforcement: firms respond to an increased perceived probability of detection more strongly where transactions are documented by counterparties. Naritomi (2019) found that giving consumers incentives to request receipts in São Paulo increased reported retail revenue, and Bellon, Dabla-Norris, Khalid and Lima (2022) found that the introduction of electronic invoicing in Peru increased the sales, purchases and VAT liabilities reported by adopting firms. Slemrod (2019) summarises the implication: enforcement increasingly works through information rather than through audits alone.

The same literature also documents the limits of information. Carrillo, Pomeranz and Singhal (2017) showed that when the Ecuadorian tax authority confronted firms with third-party revenue data, firms raised reported revenue but offset most of the increase by raising reported costs, an item the authority could not verify. Almunia and Lopez-Rodriguez (2018) found that Spanish firms bunch just below the turnover threshold at which they enter the large taxpayers unit, because closer monitoring above the threshold changes behaviour. Two lessons follow for the design of monitoring systems. Taxpayers adapt to what is observed, so signals must cover several dimensions of a business rather than a single ratio; and monitoring itself is a deterrent, so its value cannot be measured solely by the assessments it produces.

A second strand concerns how tax administrations organise risk-based work. The OECD compliance risk management model describes a cycle of identifying, assessing, prioritising and treating risks, and evaluating the outcome (OECD, 2004). Baer (2002) documented how large taxpayer units combine service and enforcement for a concentrated segment, and the co-operative compliance model added a relational layer of continuous engagement, disclosure and early resolution of uncertain positions (OECD, 2013). The OECD later described the trajectory towards Tax Administration 3.0, in which compliance is built into the systems through which taxpayers transact (OECD, 2020), and earlier codified the standard audit file as a format for exchanging accounting data (OECD, 2010).

Analytics is now routine: the OECD (2016) documented predictive case selection, Gupta, Keen, Shah and Verdier (2017) the wider digital transformation of public finance, and by 2026, 69% of tax administrations used artificial intelligence for risk assessment (OECD, 2026). This literature, however, concentrates on ranking taxpayers at a point in time rather than on how evidence accumulates month by month for a taxpayer already under continuous observation.

A third strand, developed outside tax administration, addresses exactly this dynamic. Continuous auditing research, beginning with Vasarhelyi and Halper (1991), studied how internal and external auditors can monitor transaction systems in near real time. Pilot implementations showed that the main practical obstacle is not data access but the volume of exceptions generated by rule-based monitoring, which overwhelms the capacity of auditors to investigate (Alles, Kogan, & Vasarhelyi, 2008). Kogan, Alles, Vasarhelyi and Wu (2014) proposed prioritising exceptions by their estimated likelihood of reflecting genuine errors. Tax administrations that move to real-time data face the same problem at scale, and the solutions developed for continuous auditing, namely prioritisation, aggregation of weak signals and escalation rules, transfer directly.

A fourth strand concerns integrity. Klitgaard (1988) located corruption risk in monopoly and discretion unaccompanied by accountability, and Hindriks, Keen and Muthoo (1999) distinguished collusion between inspector and taxpayer from extortion. Khan, Khwaja and Olken (2016) showed experimentally that the design of incentives for tax officials changes both collection results and the character of interaction with taxpayers, and Okunogbe and Pouliquen (2022) found that electronic filing in Tajikistan reduced compliance costs and bribe payments by reducing face-to-face contact. The account manager model concentrates the features Klitgaard identified: one officer, a long relationship, privileged information and influence over whether a case is escalated. Continuous monitoring therefore cuts both ways. It can make audit selection more precise, and it can create a channel through which signals are quietly ignored or selectively escalated.

Finally, the responsive regulation tradition (Ayres & Braithwaite, 1992) provides the logic for graduated intervention: regulators should begin with persuasion and escalate only when cooperation fails, and the existence of credible escalation makes cooperation more likely. Braithwaite (2003) applied this logic to taxation, and the slippery slope framework (Kirchler, Hoelzl, & Wahl, 2008) explains why the legitimacy of intervention matters, since trust in the authority sustains voluntary compliance while power alone sustains only enforced compliance. Alm (2019) adds that compliance responds to perceived fairness and quality of administration as well as to deterrence. None of these strands, however, specifies the conversion step: the rule by which an accumulation of monitoring signals for a particular large taxpayer becomes a decision to intervene, at what intensity, on which issues and with what record. This is the design objective of the present study.

The institutional setting determines what such a rule can use. In Ukraine, large taxpayers are administered by interregional offices of the State Tax Service, in which account managers in tax support units monitor assigned companies, while audit units conduct desk and documentary audits. The Tax Code distinguishes desk audits, conducted on the basis of filed returns without a site visit (art. 76), planned documentary audits included in an annual risk-based plan (art. 77) and unscheduled documentary audits, which require one of the grounds listed in the Code (art. 78). One of these grounds is the failure of a taxpayer to respond within the prescribed period to a written request of the tax authority for information about identified discrepancies (art. 73.3 and art. 78.1.1). Large taxpayers are also obliged to provide documents in electronic form on request (art. 85.2).

Two developments have changed the data environment of this setting. First, the e-invoice infrastructure accumulated a decade of transaction data on every VAT-registered large taxpayer. Second, the e-audit system based on SAF-T UA moved from pilot to production: version 2.0 of the file format was published on 6 November 2024 (Crowe, 2026); by November 2025, 38 taxpayers were participating in testing and 692 SAF-T files had been transmitted (LIGA, 2025); and from 1 January 2026 the system entered use, with the file provided by large taxpayers on request during a documentary audit (Debet-Kredyt, 2026). The National Revenue Strategy to 2030 sets the broader objective of risk-based control and reduced administrative pressure on compliant business (Cabinet of Ministers of Ukraine, 2023).

These developments have not been accompanied by a rule linking monitoring to audit. Planned documentary audits are selected annually; unscheduled audits are initiated on legal grounds that are reactive by design; and SAF-T is used to examine rather than to select. Meanwhile the strongest real-time instrument, the suspension of invoice registration, operates at the level of individual transactions and has generated a large volume of disputes. The Ukrainian setting therefore combines rich data with a weak conversion layer, which makes it a suitable case for design.

The study follows a design-science approach (Hevner, March, Park, & Ram, 2004), which seeks to construct and evaluate an artefact that solves a practical problem while contributing design knowledge. Evaluation followed the logic of the FEDS framework (Venable, Pries-Heje, & Baskerville, 2016): because the artefact could not ethically or legally be tested on live taxpayer data by an individual researcher, an artificial ex ante evaluation through simulation was chosen, to be followed in further work by naturalistic evaluation in an administrative pilot.

The first phase assembled a documentary corpus of twenty-eight items in five groups: seven Ukrainian legislative and regulatory instruments, namely the Tax Code, Cabinet Resolution No. 1165 on invoice suspension, the Ministry of Finance order on electronic documents of large taxpayers, the Register of Large Taxpayers for 2024, the National Revenue Strategy to 2030 and the state and State Tax Service anti-corruption programmes; two oversight reports, the 2024 performance audit of the Accounting Chamber and the 2024 investigation of the Business Ombudsman Council; five official publications on the State Tax Service public report for 2024, the e-audit launch, version 2.0 of the SAF-T UA format, the e-

audit pilot and large taxpayer revenue; six documents on the regimes of Italy, Poland, Hungary, Spain and Portugal and on Council Directive (EU) 2025/516; and eight items of OECD and IMF guidance published between 2002 and 2026. Documents were included where they defined the legal powers of the tax authority with respect to large taxpayers, governed the use of e-invoice or accounting data, reported on the performance of audit and invoice control, or described the design of comparable foreign regimes. Each document was coded for the data sources it creates or uses, the decision points it governs and the discretion it confers on officials.

The second phase constructed the framework. Its design drew on structured reflection on professional practice in the sense of Schön (1983): the author served as the assigned account manager for about ten large taxpayers in the Large Taxpayers Office, subsequently worked in tax debt collection and then in the anti-corruption unit of an interregional large taxpayer office. These positions span the full chain examined here: monitoring, audit follow-up, collection and integrity control. Practitioner knowledge informed the choice of signals, the steps of the escalation ladder and the integrity checks. No confidential taxpayer information is used or disclosed, and the illustrative case presented below is a stylised composite rather than an account of any actual taxpayer.

The third phase evaluated trigger rules through a Monte Carlo simulation, described in detail with the results. The simulation is intended to demonstrate the comparative behaviour of alternative rules under stated assumptions, not to estimate Ukrainian parameters, which would require access to historical signal and audit data.

The framework has six components, which correspond to the letters of its name. The first component is an inventory of sources. In Ukraine in 2026 an account manager has access to six principal sources. The unified register of tax invoices, updated daily, reveals the transaction network of the taxpayer, the structure of its sales and purchases by product code and the risk status of its counterparties. The electronic VAT administration system, also daily, shows registration limits, the VAT balance and sudden changes in VAT flows. Monthly, quarterly and annual returns and financial statements allow the effective tax burden and margins to be compared with sector peers. Daily payment and debt records show payment discipline, arrears and instalment requests. Transfer pricing reports and customs declarations reveal related-party flows and export and import pricing. The standard audit file SAF-T UA, which provides ledger-level data, is available only on request during a documentary audit and therefore cannot currently be used for monitoring. The striking feature is the asymmetry of timing: invoice-level data arrive daily, whereas the most complete accounting data arrive only once an audit has been ordered.

The second component is a catalogue of indicators. Signals were selected on three criteria: they can be computed from data already held by the administration, they relate to a recognisable compliance risk, and they can be explained to the taxpayer in a compliance dialogue. The third criterion is deliberate. A signal that cannot be explained cannot be discussed with the taxpayer, and a framework that relies on unexplainable signals forfeits the graduated, cooperative steps that make it proportionate. The breadth of the catalogue responds to the finding of Carrillo, Pomeranz and Singhal (2017) that taxpayers adjust unobserved items when one item becomes observable; signals therefore cover income, input VAT, goods flows, refunds, related-party payments and payment discipline. The core catalogue contains six signals, each with an indicative weight that reflects its evidential strength and is to be recalibrated against outcomes.

The first signal (S1, weight 1.0) is an effective tax burden below sector peers for consecutive periods, which points to understated income or overstated deductions. The second (S2, weight 1.0) is a growing share of purchases from counterparties flagged as high-risk or recently registered, the typical footprint of fictitious input VAT and intermediary schemes. The third (S3, weight 0.8) arises when sales of a product code exceed purchases and imports of the same code, suggesting invoices not backed by goods. The fourth (S4, weight 0.8) is a sharp growth of VAT refund claims without matching exports or investment. The fifth (S5, weight 0.6) is a growth of payments to related parties or non-residents, which may indicate profit shifting or asset stripping. The sixth (S6, weight 0.6) is a deterioration of payment discipline or the appearance of new arrears, which signals liquidity stress and a future collectability risk.

The indicators are combined through a trigger rule. For each taxpayer and month, a weighted score is calculated as the sum of the weights of the signals active in that month. An intervention is triggered only when three conditions hold together: the score reaches a set threshold in the current month, it also reached that threshold in the previous month, and the estimated tax at stake exceeds a materiality threshold.

Persistence filters transient anomalies such as a single unusual transaction, a reporting error or a seasonal spike; materiality aligns audit effort with fiscal significance. The rule has a simple interpretation for the account manager: a single bad month is a question, two bad months are a case.

The third component is a graduated escalation ladder, derived from the responsive regulation pyramid (Ayres & Braithwaite, 1992) and mapped to the procedural instruments available under Ukrainian law. Each level has an entry condition, a legal basis and a documented output, and the scope of every intervention is narrowed to the signals that triggered it. The mapping matters: an analytical query under article 73.3 of the Tax Code is not merely a courtesy, because an unanswered query is itself a ground for an unscheduled documentary audit under article 78.1.1. The ladder therefore gives the cooperative steps legal consequences.

The ladder has six levels. At level L0, continuous monitoring, all assigned taxpayers are observed and every signal is recorded in the log with its date, source and value. Level L1 is a preliminary analytical review when one or more signals are active. The officer records the anomaly and checks alternative explanations. A formal written request under article 73.3 is issued only when its statutory prerequisites are independently satisfied; the request, legal grounds, required information and response deadline are recorded. An isolated signal does not automatically justify such a request. Level L2, a compliance dialogue, follows when the trigger condition is met: the taxpayer is invited to a meeting and offered the opportunity to correct its returns voluntarily. Level L3 is a referral for a targeted desk-audit review, limited to matters that may lawfully be examined under article 76; SIGNAL does not itself create a new type of desk audit or enlarge its statutory scope. Level L4 is a recommendation for a documentary audit only where an independent legal ground exists under article 77 or article 78; non-response to a legally valid request can support article 78.1.1 only if all applicable statutory conditions are met. A SAF-T UA request follows the legally authorised documentary-audit procedure, not the risk score alone. Level L5, a comprehensive audit across tax types, is used only where several risks are confirmed or there is evidence of deliberate evasion.

The fourth component, the narrowed scope, follows from the ladder. Under the conventional model, the programme of a documentary audit is drafted when the audit is ordered and often covers all taxes for several years. Under SIGNAL, the programme is drafted from the signal log: the issues to be examined are those supported by persistent signals and not resolved at L1–L3. Narrow scope shortens audits, reduces the burden on compliant parts of the business and, most importantly in the Ukrainian context, concentrates audit effort on issues that are already supported by data, which should improve the survival of assessments on appeal.

A stylised composite case illustrates the sequence. A manufacturer in the register shows, from month one, a rising share of purchases from recently registered counterparties (S2); the account manager records the signal and, as it is isolated, does not issue a formal statutory request. In month two the effective tax burden falls below the sector median (S1) while S2 persists; the score exceeds the threshold for the first time, and a documented preliminary review is conducted and, if statutory grounds are verified, a formal information request is sent. In month three both signals persist, the trigger condition is met, and the taxpayer is invited to a compliance dialogue, at which it attributes the change to a new supplier network. The taxpayer amends its VAT returns for part of the purchases but disputes the remainder. Because the signals persist and the amount at stake is material, a targeted desk audit is opened on input VAT only, followed by a documentary audit limited to transactions with the flagged counterparties, for which a SAF-T extract is requested. After nine months the outcome of the audit, the status of any appeal and the amount collected are recorded, and the weights are reviewed. At no point does the account manager decide alone or without a record, and at every point the taxpayer knows what concern is being addressed.

The fifth component, the audit trail, is described below together with its integrity function, and the sixth, the learning loop, together with the performance indicators.

To evaluate trigger rules, a synthetic portfolio of 1,000 large taxpayers was simulated over 24 months. In the baseline scenario, 10% of taxpayers become non-compliant from month seven. Each of the six signals fires monthly with a probability of 4–8% for compliant taxpayers and 30–45% for non-compliant ones, independently across signals and months. Tax at stake follows a log-normal distribution with a median of UAH 20 million, and the materiality threshold is UAH 5 million. Four rules were compared over months 7–24 and averaged across 300 runs: a rule reacting to any single signal, a weighted score threshold, the score with a two-month persistence requirement, and the latter with materiality. The parameters are assumptions chosen to be plausible, not estimates.

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The rule reacting to any single signal selected on average 998.6 of the 1,000 taxpayers, with a precision of 10.0%, full recall and a mean detection delay of 0.1 months. The weighted score rule selected 436.5 taxpayers, with a precision of 22.9%, full recall and a delay of 0.6 months. The score with two-month persistence selected 110.0 taxpayers, with a precision of 90.5%, recall of 99.7% and a delay of 3.1 months. Adding materiality reduced the selection to 100.8 taxpayers, with a precision of 90.6% and recall of 91.5%, while still capturing 98.9% of the tax at stake, at the same delay of 3.1 months.

The results illustrate a trade-off that is easy to state and frequently ignored in practice. A rule that reacts to any single signal detects every non-compliant taxpayer almost immediately but selects nearly the entire portfolio, so that nine of ten interventions fall on compliant companies. This is the tax-administration analogue of the alert overload documented in continuous auditing (Alles, Kogan, & Vasarhelyi, 2008). Weighting signals reduces the volume by more than half, yet precision remains below one quarter. Requiring persistence over two months is the decisive step: precision rises to about 90% while recall is virtually unchanged, at the price of a delay of roughly three months. Adding materiality reduces the number of interventions further and excludes some small cases, while retaining almost 99% of the tax at stake.

Because the baseline rests on favourable assumptions, the two score-based rules were re-estimated under five departures from it. Correlated shocks represent months in which several signals fire together for reasons unrelated to compliance, such as a change in accounting systems or a corporate reorganisation; gradual onset represents non-compliance that builds over six months rather than starting abruptly; lower prevalence represents a better-behaved portfolio; and two variants tighten the rule itself.

With correlated shocks in 10% of months, the persistence rule selected 126.2 taxpayers, with a precision of 79.0%, recall of 99.9% and a delay of 2.7 months. With gradual onset over six months, precision stayed at 90.5% and recall at 99.3%, but the delay rose to 6.1 months. With prevalence reduced to 5%, the rule selected 60.7 taxpayers, with a precision of 81.8% and recall of 99.8%. Requiring persistence over three months raised precision to 99.7% but reduced recall to 92.8% and doubled the delay to 6.0 months, and raising the score threshold to 2.2 produced a precision of 99.9%, recall of 83.8% and a delay of 6.4 months.

Three findings stand out. First, the advantage of the persistence rule is robust: under every scenario its precision remains between about 79% and 100%, against 12–23% for the score-only rule (17% with correlated shocks and 12% at 5% prevalence). Correlated shocks are the most damaging departure, because they mimic persistence; this is why the framework separates signal sources and requires that the account manager record a known non-compliance explanation, such as a reorganisation, in the log so that the affected months can be excluded. Second, lower prevalence reduces precision for every rule, as the base-rate effect predicts, but the persistence rule degrades far less. Third, tightening the rule, either by requiring three months or by raising the threshold, buys near-perfect precision at the cost of recall and of doubling the delay. The appropriate setting is therefore a policy choice about the relative cost of a missed case and an unnecessary intervention, and should be made explicitly rather than by default.

The choice can be framed as minimising the total expected cost of three kinds of error. The first is the cost of unnecessary interventions, comprising administrative effort, the compliance burden imposed on compliant taxpayers and the erosion of trust. The second is the cost of missed cases, comprising tax at stake not recovered and the weakened deterrent effect on other taxpayers. The third is the cost of delay, which captures the risk that assets move or the limitation period runs while a signal is being confirmed.

For large taxpayers the cost of unnecessary interventions is unusually high, because they damage a relationship on which the account manager model depends, while the cost of delay is moderate, because the limitation period for documentary audits is measured in years rather than months. Under these conditions the two-month persistence rule is preferable both to the score-only rule and to the more conservative three-month rule; where collectability risk is high, as signalled by S6, the cost of delay rises and a shorter persistence window or an immediate L1 query is justified.

The fifth component addresses integrity. The account manager is the officer with the longest and most informal relationship with a large taxpayer, and the combination of monopoly over information and discretion over escalation is the configuration Klitgaard (1988) identified as corruption-prone. Under the conventional model, an account manager who observes a warning sign and does nothing leaves no trace. Under SIGNAL, every signal is recorded automatically and every level change, or its absence when the trigger condition is met, requires a reasoned entry. This transforms the account manager's discretion from invisible to reviewable.

The log enables integrity checks that are otherwise impossible. Persistent triggers without escalation may indicate collusion; escalation without recorded signals may indicate pressure or extortion in the sense of Hindriks, Keen and Muthoo (1999); repeated closure of triggers at L1 on the basis of explanations that are not documented may indicate relationship capture. These checks can be run by the anti-corruption unit as part of routine monitoring rather than in response to complaints, which matters because neither party to a collusive arrangement has an incentive to complain. Combined with periodic rotation of account managers, the log addresses the risk of capture without sacrificing the knowledge of the taxpayer that continuous monitoring requires. It also protects honest officers, who can demonstrate from the record why they escalated or did not escalate a case.

The sixth component is a learning loop. Each escalation ends in an outcome: an explanation accepted at L1, a voluntary correction at L2, an assessment at L3–L5, and eventually the result of any appeal and the amount collected. Feeding these outcomes back into the weights and thresholds turns the framework into a self-correcting system, in line with the evaluation stage of the compliance risk management cycle (OECD, 2004). Linking the loop to collection outcomes matters in Ukraine, where the gap between assessed and collected amounts is extreme (Business Ombudsman Council, 2024); signals of deteriorating payment discipline (S6) therefore also serve as an early warning for the collectability of future assessments.

A related safeguard concerns the learning loop itself. If audits are selected only from triggers, the administration observes outcomes only for triggered taxpayers, and the weights cannot be tested against non-compliance that the signals fail to capture. Random audit programmes address this problem by examining a small sample selected independently of risk scores, which both calibrates selection models and preserves a general deterrent (Kleven et al., 2011; Slemrod, 2019). For a segment of about 1,300 taxpayers, a random component of a few dozen audits per year would suffice to test whether the signal catalogue is missing systematic risks, and would also limit the ability of taxpayers to infer the catalogue from the pattern of interventions.

The framework itself should be evaluated through seven indicators: selection precision, the share of L3–L5 interventions that confirm a discrepancy; the early resolution rate, the share of triggers resolved at L1–L2 by explanation or voluntary correction; scope efficiency, measured in audit days per confirmed issue; assessment survival, the share of assessed amounts upheld after appeal; conversion to revenue, collected amounts as a share of assessed amounts; integrity exceptions, the number of persistent triggers without escalation and of escalations without signals per account manager; and taxpayer burden, the number of interventions per compliant taxpayer per year. The first five should rise over time and the last two should fall.

The framework is designed to be transferable, because many jurisdictions are now building the infrastructure Ukraine already has. Poland made e-invoicing through its national system mandatory for taxpayers with turnover above PLN 200 million from 1 February 2026 and for most other businesses from 1 April 2026 (EY, 2025), and the European Union adopted the VAT in the Digital Age package, which introduces digital reporting requirements for intra-EU transactions from 2030 (Council of the European Union, 2025). The Ukrainian experience suggests specific lessons for each type of regime.

Jurisdictions with clearance e-invoicing, such as Italy since 2019, Poland since 2026 and Ukraine with its invoice registration since 2015, should avoid relying on transaction blocking as the main control and use invoice data primarily to target and scope audits. Jurisdictions with real-time invoice reporting, such as Hungary since 2018 and Spain since 2017, should build persistence and materiality into their triggers to prevent alert overload. Where SAF-T files are reported periodically, as in Portugal and Poland, they should be used for monitoring and not only during audits, at least for large taxpayers. Where SAF-T is available only on request, as in Ukraine since 2026, a targeted extract can be requested at levels L3–L4 to confirm signals before a full audit is ordered. Finally, any administration that uses account managers should record signals and escalation decisions in a reviewable log and rotate account managers periodically.

Two established large taxpayer programmes outside Europe point in the same direction. The Compliance Assurance Process of the United States Internal Revenue Service works with large corporations to identify and resolve issues before a return is filed, replacing much of the post-filing examination with contemporaneous review (Internal Revenue Service, n.d.). The Justified Trust programme of the Australian Taxation Office seeks objective evidence that the largest corporate groups pay the right amount of tax, through continuous engagement and assessment of tax governance rather than periodic audits (Australian Taxation Office, n.d.). Both rely on mature compliance cultures and extensive

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voluntary disclosure; SIGNAL is designed for an administration with abundant data but limited trust, where cooperative steps must be backed by data and legal consequences.

Implementation can proceed in three stages without legislative change. In the first stage, the signal catalogue and log are introduced in one interregional large taxpayer office as a decision-support tool, with weights set by expert judgement and all escalation decisions remaining with officials. In the second stage, after twelve to eighteen months, weights and thresholds are calibrated on the outcomes recorded in the log, and the anti-corruption unit begins routine integrity checks. In the third stage, the framework is extended to all offices and linked to the annual audit plan, so that planned audits are selected predominantly from persistent triggers. One step would require regulatory change: making SAF-T data available for monitoring of large taxpayers outside an audit, which would close the timing asymmetry between invoice data and accounting data.

The framework is also designed to function under disruption. Ukrainian tax administration operated through the COVID-19 period and then under martial law, during which procedural time limits for reviewing taxpayer complaints were suspended from 29 May 2020 to 1 August 2023 and the work of tax offices was partly interrupted in 2022 (Accounting Chamber of Ukraine, 2024). Periods in which audits are restricted are precisely the periods in which continuous monitoring retains its value: signals continue to accumulate, analytical queries and compliance dialogues remain possible, and when audit powers are restored the log provides a ready, documented basis for prioritisation, instead of a backlog selected by elapsed time.

Data governance is a condition of legitimacy, and three safeguards are proposed. First, signals are inputs to human decisions: no intervention above L1 is initiated without a reasoned entry by an identifiable official. Second, every signal used to justify an intervention must be explainable to the taxpayer in the terms of the signal catalogue, which keeps opaque model scores out of the formal record. Third, integrity checks based on the log are restricted to the anti-corruption unit and internal audit, and their results are grounds for review, not evidence of misconduct. This reflects the concern that automated enforcement tools must remain explainable and supported by audit trails that withstand judicial scrutiny (OECD, 2026).

The prevailing framing of digital tax administration treats data as the scarce resource. The Ukrainian case suggests that, at least for large taxpayers, data have ceased to be scarce and the scarce resource is a defensible decision rule. Where data are abundant but the rule is weak, administrations default either to control at the gate, which generates volume, disputes and discretion, or to audit plans detached from the data, which produce assessments that are frequently cancelled or never collected. The gate–insight gap is therefore not a technological gap but a governance gap.

For the compliance risk management literature, the study adds an explicit conversion layer between risk detection and intervention, and shows that the structure of that layer can change the precision of selection by an order of magnitude without any change in the underlying data. It also connects the tax administration literature to continuous auditing research, where the problem of exception overload and its solutions have been studied for three decades. For the literature on corruption in tax administration, it identifies the account manager as an under-examined locus of integrity risk and proposes a mechanism that reduces discretion while preserving relational knowledge, consistent with evidence that digitalisation reduces opportunities for bribery when it removes unrecorded discretion (Okunogbe & Pouliquen, 2022).

For practitioners, the framework reframes a familiar tension. Large taxpayers value predictability and dislike unexpected audits; administrations value flexibility and dislike committing to rules that taxpayers can anticipate. SIGNAL resolves part of this tension by making the process predictable while keeping the parameters partly confidential: taxpayers know that persistent, material anomalies will be raised with them first and audited only if unresolved, but they do not know the exact weights and thresholds. This is consistent with the co-operative compliance model (OECD, 2013) and with the trust dimension of the slippery slope framework (Kirchler, Hoelzl, & Wahl, 2008).

The study has clear limitations. The framework has not yet been tested in a live administrative setting, and the simulation relies on assumed parameters; although the sensitivity analysis shows that the main result is robust to correlated signals, gradual onset and lower prevalence, it cannot substitute for calibration on historical data. Taxpayers may adapt to the signals, as Carrillo, Pomeranz and Singhal (2017) and Almunia and Lopez-Rodriguez (2018) show, which requires periodic revision of the catalogue. The signal catalogue reflects the Ukrainian VAT and corporate tax environment and would require adaptation elsewhere. Practitioner knowledge, while grounded in direct experience across monitoring, collection and integrity functions, is that of a single author.

This study asked how the continuous monitoring performed by an account manager can be converted into risk-triggered audit selection that is precise, proportionate and documented. The answer developed here is that the conversion must be designed as explicitly as the data collection that precedes it. SIGNAL specifies six elements: an inventory of sources, a catalogue of explainable indicators combined through a trigger rule with score, persistence and materiality, a graduated escalation ladder mapped to existing legal powers, scope narrowed to the triggering signals, a reviewable audit trail and a learning loop linked to collection. The simulation shows that a persistence requirement alone can raise the precision of selection from about 10% to about 90% while retaining nearly all non-compliant taxpayers, and that this advantage survives realistic departures from ideal conditions.

The urgency is practical. Ukraine has operated transaction-level invoice control for a decade and launched e-audit in 2026, while Poland and the European Union are entering the same terrain. Each jurisdiction faces the same choice: to treat real-time data as a gate that blocks transactions, or as insight that directs a limited audit capacity to the right taxpayers, issues and moments. For large taxpayers, where both revenue and integrity stakes are highest, the second path is more effective, more defensible and more consistent with the co-operative relationship on which the account manager model was built.

Further research should calibrate signal weights and thresholds on historical monitoring and audit data, evaluate the ladder and the proposed indicators in a pilot interregional large taxpayer office, and test whether recorded discretion reduces collusion and extortion in large taxpayer administration.

Additional Methods, Results and Implementation Specification

The following specifications make explicit the operational assumptions and reporting conventions underlying SIGNAL. Numerical values reproduced below are those reported in the original study; no new simulation has been executed. Where the original experiment does not disclose a parameter or outcome, replication requires access to the original simulation code or a fresh rerun.

1. Formal trigger specification and reproducibility

For taxpayer i in month t, define binary signal $X(i,t,k) \in \{0,1\}$, with k=1,…,6 and weights w=(1.0,1.0,0.8,0.8,0.6,0.6). The monthly score is $R(i,t)=\Sigma[k=1..6]\ w(k)X(i,t,k)$. Let θ denote the score threshold, M(i,t) the estimated tax at stake and m=UAH 5 million the materiality cutoff. The proposed baseline decision indicator is $T(i,t)=1\{R(i,t)\geq\theta\}\cdot 1\{R(i,t-1)\geq\theta\}\cdot 1\{M(i,t)\geq m\}$. This is a selection rule, not a statutory basis for a tax audit. The original text reports a sensitivity threshold of 2.2 but does not state the baseline θ explicitly; θ must be disclosed and verified against the original simulation before results can be independently reproduced.

2. Reported Monte Carlo outcomes

Baseline rule	Selected / 1,000	Precision	Recall	Delay (months)
Any signal	998.6	10.0%	100%	0.1
Weighted score	436.5	22.9%	100%	0.6
Score + 2-month persistence	110.0	90.5%	99.7%	3.1
Score + persistence + materiality	100.8	90.6%	91.5%	3.1

For the baseline materiality rule, the reported share of tax at stake captured is 98.9%. This is a simulated coverage measure, not a measured collection or enforcement yield.

Scenario (persistence rule)	Selected / 1,000	Precision	Recall	Delay (months)
Baseline	110.0	90.5%	99.7%	3.1
Correlated shocks (10% of months)	126.2	79.0%	99.9%	2.7
Gradual onset (six months)	Not reported	90.5%	99.3%	6.1
Lower prevalence (5%)	60.7	81.8%	99.8%	Not reported
Three-month persistence	Not reported	99.7%	92.8%	6.0
Higher score threshold (2.2)	Not reported	99.9%	83.8%	6.4

These tables compile reported point estimates. The source does not provide run-level variability, standard deviations, confidence intervals or all corresponding score-only scenario outcomes. Such cells are

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deliberately not imputed. Before submission, regenerate the experiment and provide a machine-readable results table and code appendix; uncertainty intervals are especially important because strong precision under independent synthetic signals may be sensitive to the assumed data-generating process.

3. SIGNAL architecture and decision rights

SOURCES (e-invoices, VAT, returns, payments, customs) → INDICATORS (S1–S6 and weighted score) → GRADUATED RESPONSE (L0–L5 subject to legal gateways) → NARROWED SCOPE (issues supported by recorded signals) → AUDIT TRAIL (evidence, decision-maker, justification, timestamps) → LEARNING LOOP (appeals, collections, corrections and model review) ↺ feeds back to INDICATORS and thresholds. Audit-trail recording applies across all stages, not only after escalation.

At L0, record and validate signals without formal taxpayer intervention. At L1, conduct internal triage; issue an article 73.3 request only when statutory grounds exist. At L2, offer voluntary clarification or compliance dialogue, without treating an analytical trigger as a compulsory audit power. At L3, refer only issues legally examinable through desk-audit powers. At L4, recommend a documentary audit only if the independent statutory conditions for a planned or unscheduled audit are satisfied; SAF-T requests must comply with applicable procedure. At L5, recommend broader examination only where scope and legal authorisation independently permit it. An authorised official, not the account manager alone, records each decision.

4. Distinct contribution and practical test

SIGNAL's proposed contribution is the integration of sequential evidence accumulation, proportionate legally gated escalation, issue-specific audit scope and a reviewable record of both action and inaction within the large-taxpayer account-management function. Unlike a static risk-ranking score, the unit of design is a documented conversion decision over time. Unlike generic continuous auditing, SIGNAL explicitly maps the conversion to public-law powers and integrity oversight. This is a proposed synthesis; any claim of being the first such framework requires a systematic search of competing models and should be framed cautiously.

The synthetic experiment supports comparative plausibility under assumed probabilities, not real-world accuracy, causality, improved tax collections or reduced corruption. A prospective pilot should pre-register thresholds and outcomes, compare SIGNAL with business-as-usual selection, include independent review of unselected cases, and measure taxpayer burden, appeal survival, audit effort, collected revenue and integrity exceptions. Strong precision in the simulated portfolio does not establish deployment readiness without calibration and external validation.

5. International comparison (functional, not legal equivalence)

Jurisdiction	Illustrative system	Relevant design lesson
Ukraine	Invoice registration, risk-based suspension; SAF-T UA audit use	Separate invoice-level gate decisions from taxpayer-level audit selection
United States	IRS Compliance Assurance Process	Early engagement and issue resolution; distinct voluntary/legal setting
Poland	KSeF e-invoicing and JPK reporting	Combine structured data with proportional escalation
Italy	Sistema di Interscambio e-invoicing	Use transaction visibility for targeted risk review
Australia	ATO Justified Trust	Document governance, evidence and assurance decisions
Hungary / Spain	Online invoice reporting / SII	Control alert volume and consider persistence

This comparison is conceptual rather than a verified statement of each jurisdiction's current legal obligations. Effective dates, coverage and permitted data uses require confirmation against primary official sources as of the submission date, including Ukraine's Tax Code and SAF-T UA rules, Poland's KSeF schedule and EU VAT in the Digital Age instruments.

6. Deployment and anti-corruption safeguards

Pilot governance: a central tax-risk methodology team owns the signal dictionary, version control and model validation; information-technology and data-protection teams maintain feeds, access control and retention; account managers review anomalies but cannot silently suppress automatically recorded signals; legally authorised audit officials make statutory decisions; internal audit and anti-corruption staff review

exception reports. A 0–3 month preparation phase should map lawful data access, establish baselines and document controls; months 4–12 should run a shadow-mode pilot without automated enforcement; months 13–18 should assess outcomes, taxpayer burden and legal compliance before any wider rollout. Required resources include a secure data pipeline, case-management log, analytical staff, legal review and independent evaluation capacity.

Integrity controls should flag persistent material triggers closed without supporting evidence, escalation without recorded rationale, repeated overrides by the same official, unusual case reassignment, and unexplained divergence between comparable cases. Each exception must prompt a documented supervisory review rather than a presumption of corruption. Maintain role-based access, tamper-evident event history, periodic independent sampling, conflict-of-interest declarations, proportionate officer rotation and a process for correcting erroneous records.

7. Limitations and research agenda

Key limitations include synthetic rather than observed compliance labels; unspecified baseline score threshold and distributional dispersion; dependence between signals, seasonality and corporate restructurings; strategic taxpayer adaptation; selection bias when only escalated cases are audited; and variation in the legal permissibility of requests, desk audits and documentary audits. A pilot should test subgroup calibration, false-positive burden, drift and alternative explanations, and preserve a legally authorised independent validation sample. The theoretical contribution is an auditable conversion architecture; the practical value is a testable workflow; empirical effectiveness remains a question for administrative evaluation.

LEGAL AND EMPIRICAL VERIFICATION NOTE: Statutory provisions, SAF-T UA availability, cross-border implementation dates and the source’s 2026 references have not been independently verified in this editorial revision. They should be checked against authoritative primary sources before journal submission. No new Monte Carlo runs or real-data validation are represented here.

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