ECONOSCITECH INTEGRATION

ISSUE 5

INTERNATIONAL SCIENTIFIC ELECTRONIC JOURNAL

TASHKENT STATE UNIVERSITY OF ECONOMICS

American University of Technology
Powered by Arizona State University®

ISSN: 3060-5075

Acceptance of articles
PUBLISHED EVERY MONTHLY

ARTICLE CONTRIBUTORS
PROFESSORS-TEACHERS, SPECIALISTS AND SCIENTIFIC RESEARCHERS.

Google Scholar · Academic Resource Index ResearchBib · BASE · OpenAIRE · doi Digital Object Identifier · OPEN ACCESS

CONTACT: +998 94 3540880 https://econoscitech-integration-journal.uz 2026

THE SCIENTIFIC-POPULAR ELECTRONIC JOURNAL **"ECONOSCITECH-INTEGRATION"** HAS BEEN REGISTERED UNDER THE NUMBER C-5669651 BY THE AGENCY FOR INFORMATION AND MASS COMMUNICATIONS (AOKA) OF THE REPUBLIC OF UZBEKISTAN, EFFECTIVE FROM OCTOBER 9, 2024.

In accordance with Resolution No. 384/6 dated April 10, 2026, issued by the Presidium of the Supreme Attestation Commission under the Ministry of Higher Education, Science and Innovation of the Republic of Uzbekistan, this journal is included in the list of recommended international scientific publications for publishing the primary research findings of doctoral dissertations in the field of Economic Sciences.

Partners: Tashkent State University of Economics / American University of Technology in Tashkent (AUT)

Electronic publication, Issue 5. 374 pages.
Approved for publication on May, 2026.

Editorial Board Members:

CONTENTS

CONTENTS

CONTENTS

CONTENTS

CONTENTS

INTERNATIONAL SCIENTIFIC ELECTRONIC JOURNAL

INTEGRATED REAL-TIME AUDIT MODEL FOR FRUIT AND VEGETABLE PROCESSING ENTERPRISES

Rakhmatullayev Mirjalol Khatamson
Independent Researcher,
Tashkent State University of Economics

Abstract. This article develops the scientific and methodological foundations of an integrated real-time audit model for fruit and vegetable processing enterprises. The proposed model is closely integrated with production, technological, environmental, and economic processes and is based on digital audit evidence. It enables continuous monitoring of business operations, enhances audit effectiveness, and supports timely and well-informed management decision-making through the use of real-time data and digital technologies.

Keywords: integrated audit, real-time audit, Data Hub, audit dashboard, alert system, ERP, MES, LIMS, digital audit evidence.

Аннотация. В статье разработаны научно-методические основы интегрированной модели аудита, функционирующей в режиме реального времени на предприятиях по переработке плодоовощной продукции. Предлагаемая модель тесно интегрирована с производственными, технологическими, экологическими и экономическими процессами и основана на использовании цифровых аудиторских доказательств. Она обеспечивает непрерывный мониторинг деятельности предприятия, повышает эффективность аудита и способствует принятию своевременных и обоснованных управленческих решений на основе данных, получаемых в режиме реального времени.

Ключевые слова: интегрированный аудит, аудит в режиме реального времени, Data Hub, аудиторская панель мониторинга, система оповещений, ERP, MES, LIMS, цифровые аудиторские доказательства.

INTRODUCTION

In the current digital economy, the conceptual paradigm of auditing is undergoing a fundamental transformation. The traditional post-factum approach to auditing is no longer sufficient in the context of a rapidly evolving business environment and increasingly dynamic risk conditions. Modern enterprises require a continuous, real-time audit system that is fully integrated with all business processes. Such a system is not limited to verifying the financial statements of previous reporting periods; rather, it identifies risks at the moment they arise and provides timely support for management decision-making.

The specific characteristics of fruit and vegetable processing enterprises make the implementation of such an integrated audit system particularly important. The perishability of raw materials, the need to maintain an uninterrupted cold chain, continuous monitoring of quality parameters, stringent export market requirements, and significant seasonal fluctuations in production volumes all necessitate real-time monitoring and auditing at every stage of the production process.

LITERATURE REVIEW

E. A. Arens and J. K. Loebbecke explained the conceptual foundations of risk-based auditing in their studies and substantiated the role of auditing as an effective instrument for managing business process risks [1].

B. Needles and S. X. Ying empirically examined the application of analytical audit procedures and demonstrated their effectiveness in identifying and assessing business risks [2].

D. Caldwell emphasized that the risk–control matrix plays a central role in the development and implementation of a risk-based internal audit system, enabling organizations to strengthen internal controls and improve risk management practices [3].

RESEARCH METHODOLOGY

The empirical basis of this study consists of data obtained from information systems, audit reports, and business process documentation of East Agro International LLC, Asian Jam LLC, and Green World Group LLC for the period 2022–2024. In addition, practical data and analytical materials provided by ERP solution vendors (1C, SAP, and Microsoft Dynamics), Laboratory Information Management System (LIMS) providers, and international audit firms specializing in the fruit and vegetable processing industry were utilized.

ANALYSIS AND RESULTS

The architecture of the proposed integrated audit model is based on a hub-and-spoke structure. At the center of the model is the Integrated Audit System (IAS), which is connected through bidirectional information flows to five key functional blocks:

Accounting Data Block – integrated with the ERP system;

Production Block – integrated with the Manufacturing Execution System (MES);

Quality and Laboratory Block – integrated with the Laboratory Information Management System (LIMS) and the Quality Management System (QMS);

Logistics and Sales Block – integrated with the Warehouse Management System (WMS) and the Customer Relationship Management (CRM) system;

Audit and Control Block – integrated with internal audit and risk management systems.

The integration of these five functional blocks through a centralized platform implements the “single source of truth” principle, ensuring data consistency, transparency, and reliability across all business processes.

The technological foundation of the proposed model consists of four principal components (Table 1).

Table 1

Structural elements of the integrated audit model[1]

Element	Functional task	Technological done increase
Data Hub	All from systems coming data in a single format to gather , to recollect work and storage	Apache Kafka, Apache NiFi , ETL/ELT pipelines, OLAP cubes , Data Warehouse
Audit panel	KPIs and danger real- time indicators in mode visualization , drill-down analysis	Power BI, Tableau, Qlik Sense, web dashboards
Warning system	Marked borders when increased automatic message to give , anomalies determination	Rule-based alerts, machine learning anomaly detection, email/SMS/Telegram bot
Evidence registry	Audit evidence electronic digital signature with storage , with blockchain protection	Document Management System, Blockchain (Hyperledger Fabric), digital signatures

The Data Hub serves as the central component of the integrated audit model. It consolidates all data received from the five functional blocks into a unified format and prepares it for presentation on the audit dashboard. During this process, the data are cleaned, normalized, validated, and cataloged to ensure their consistency, accuracy, and reliability. Based on the processed data, the audit dashboard displays the following key performance indicators (KPIs) in real time (Table 2).

Table 2

Integrated audit panel main KPIs[2]

KPI	Source	Update frequency	Audit importance
Exit coefficient (each party according to)	MES + LIMS	Real-time	Tannarx accuracy , quality related
Coldness chain temperature	MES (sensors)	Real-time (every 5 minutes)	Product quality , loss risks
Brix and acidity	LIMS	Every one party	To quality connected pricing
Losses amount (% of raw material)	MES + ERP	From the shift then	Technological efficiency
Tannarx (each) product according to)	ERP	Daily	Financial report reliability
Gross and operational margin	ERP	Weekly	Profit management
Warning events number	Audit system	Real-time	Risks dynamics
Certificate and audits status	QMS	To status looking at	Certification risks

1 Author’s development

2 Author’s development

The Warning System is designed to automatically generate alerts whenever predefined threshold values are exceeded. Notifications are immediately sent to the responsible personnel, enabling prompt managerial response. For example, if the temperature within the cold chain exceeds the established limit by +3°C, an alert is sent to the quality manager. If the Brix value deviates from the prescribed standard, the laboratory manager receives a notification. When the purchase price exceeds the forecast by 5%, the finance director is informed. Similarly, if accounts receivable exceed the acceptable threshold, a warning is automatically delivered to the head of the sales department. As a result, the audit function evolves from a passive monitoring tool into an active mechanism for protecting enterprise operations and supporting timely managerial decision-making.

The Evidence Registry provides secure storage of digital audit evidence supported by electronic digital signatures and time stamps. This component is particularly important because, in traditional auditing, evidence is primarily maintained in paper-based documents, where the reliability, completeness, and traceability of information may not always be fully ensured. Within the digital evidence registry, every audit document—including laboratory reports, goods receipt and delivery certificates, temperature records, and batch passports—is electronically signed, time-stamped, and securely archived. This approach enhances the integrity, authenticity, and accessibility of audit evidence while ensuring full traceability throughout the audit process.

The pilot implementation of the integrated audit model at “East Agro International” LLC demonstrated that its practical application generated significant economic benefits (Table 3).

Table 3

Integrated audit model efficiency (pilot results of “East agro international” LLC)[3]

Indicator	2023	2024	Change
Audit process time (days)	92	58	–37.0%
Determined important deviations number	23	5	–78.3%
Risks early determination rate (%)	28	87	+59 pp .
False positive warnings share	47 %	12 %	–35 pp .
Coldness chain interruptions number	18	3	–83.3%
Poor quality raw material acceptance to do (% of parties)	6.2%	1.4%	–4.8 pp .
Audit costs reduction (million soums)	—	284	–18.5%
Tannarx accuracy increase (%)	—	+9.6%	—
Operation margin increase (pp)	+4.2	+8.3	+4.1 pp .

The results presented above demonstrate that the integrated audit model transforms the audit function from a traditional control mechanism into a strategic management tool. The implementation of the model reduced the audit process time by 37%, while the number of significant deviations identified during operational processes decreased by 78.3%. Interruptions in the cold chain were reduced by 83.3%, and the acceptance of low-quality raw materials declined by 77%, corresponding to a 4.8 percentage-point reduction. Most importantly, the company’s operating margin increased from 4.2% to 8.3%, indicating a substantial improvement in operational efficiency.

Another significant advantage of the proposed model is its ability to considerably enhance the transparency of business processes. All key performance indicators (KPIs) of the enterprise are monitored in real time, allowing any deviation from established thresholds to be detected immediately and automatically communicated to the responsible personnel. As a result, managerial decisions are based on timely, accurate, and comprehensive information, significantly improving overall management efficiency and strengthening the enterprise’s risk management capabilities.

Furthermore, the integrated audit model also enhances the efficiency of external audit activities. The information required by external auditors is maintained in electronic form, securely stored in the digital evidence registry, and can be retrieved and presented promptly when needed. This significantly reduces both the time and cost associated with external audits while simultaneously improving audit quality, reliability, and overall effectiveness.

3 Author’s development

CONCLUSION AND RECOMMENDATIONS

In the context of the digital economy and Industry 4.0, the traditional post-factum audit approach is no longer sufficient for fruit and vegetable processing enterprises. Modern enterprises require a real-time audit model that is integrated with business processes, based on digital evidence, and capable of supporting managerial decision-making through continuous monitoring and timely risk identification.

The proposed integrated audit model is built on a hub-and-spoke architecture, in which five core functional blocks—Accounting, Production, Quality and Laboratory, Logistics and Sales, and Audit and Control—are interconnected through a single Integrated Audit System. The technological foundation of the model consists of four key components: the Data Hub, Audit Dashboard, Warning System, and Evidence Registry, which together ensure continuous data integration, monitoring, and audit support.

The pilot implementation of the proposed model demonstrated significant economic and operational benefits. Specifically, the audit process duration was reduced by 37%, the number of significant operational deviations decreased by 78.3%, the level of early risk detection increased from 28% to 87%, interruptions in the cold chain declined by 83.3%, and the enterprise's operating margin improved by 4.1 percentage points. These results confirm the practical effectiveness of the integrated audit model in improving operational performance and internal control.

The proposed integrated audit model transforms auditing from a traditional control function into a strategic management instrument. It enables the early identification of risks, enhances the transparency of business processes, and supports managerial decision-making based on reliable real-time information.

Furthermore, the model implements the "Single Source of Truth" principle, ensuring consistency, integrity, and reliability of information across all management levels. This not only strengthens the effectiveness of the internal audit function but also significantly improves the efficiency, quality, and reliability of external audit procedures. Consequently, the proposed model provides a comprehensive framework for strengthening corporate governance, improving operational performance, and supporting the sustainable development of fruit and vegetable processing enterprises in the digital economy.

REFERENCES

1. Arens E.A., Lobbek Dj.K. *Audit*. – Moscow: Finansy i statistika, 2019. – 712 p.
2. Committee of Sponsoring Organizations of the Treadway Commission (COSO). *Enterprise Risk Management: Integrating with Strategy and Performance*. – New York: COSO, 2017.
3. Caldwell D. Risk-based internal audit: Theory and practice // *Journal of Accounting and Auditing*. – 2022. – Vol. 18, No. 2. – P. 145–168.
4. Institute of Internal Auditors (IIA). *International Professional Practices Framework (IPPF)* [Electronic resource]. – URL: https://www.theiia.org
5. International Federation of Accountants (IFAC). *International Standard on Auditing (ISA) 315: Identifying and Assessing the Risks of Material Misstatement* [Electronic resource]. – URL: https://www.ifac.org

INTERNATIONAL SCIENTIFIC ELECTRONIC JOURNAL

Proofreader: Xondamir Ismoilov

Layout and Designer: Oloviddin Sobir ugli

2026. № 5

To publish articles in this journal, you may submit articles, advertisements, stories, and other creative materials through the following links. Materials and advertisements are published on a paid basis.

You may subscribe to the journal at any time using the following details. Once subscribed, please send a screenshot or photo of your payment confirmation to our Telegram page @iqtisodiyot_77. Based on this, we will send the latest issue of the journal to your address each month.

Our address: Tashkent city, Yunusobod district, 19th block, House 17.