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Article

Intellectual Automation of the Digital Transformation of Treasury Payments and 24/7 Digital Currency Operations

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Abstract: *This article examines the organizational, economic, and methodological foundations of the digital transformation of treasury payment processes. The author proposes an integrated mechanism that combines the automatic verification of electronic documents; intelligent control of budget limits and contractual obligations; risk assessment based on artificial intelligence (AI) and machine learning (ML); straight-through processing (STP) of low-risk payments without human intervention; and the handling of exceptional transactions through human oversight and decision-making. To assess changes in human intervention resulting from digital transformation, the article develops the concept of the Human Intervention Reduction Index (HIRI) and proposes a reduction of at least 30% in human intervention as a target performance indicator. Furthermore, a digital treasury model is developed for the continuous, 24/7 acceptance of foreign currency transactions through digital channels, automatic verification, risk monitoring, and payment status tracking, based on integration with SWIFT infrastructure and compliance with the ISO 20022 standard. A key performance indicator (KPI) framework is established to evaluate the proposed solutions in terms of operational efficiency, the degree of automation, the reliability of controls, and accountability.*

Keywords: *treasury, public financial management, digital transformation, electronic documents, artificial intelligence, machine learning, budgetary control, contractual obligations, straight-through processing (STP), human-in-the-loop, Human Intervention Reduction Index (HIRI), SWIFT, ISO 20022, foreign currency transactions, risk management.*

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1. Introduction

The effectiveness of the public financial management system depends on the coordination of processes related to budget planning, commitment registration, payment execution, and the recording of financial results. Treasury payments constitute a central component of these processes and play a significant role in ensuring budgetary discipline, the targeted use of public funds, and the monitoring of financial commitments. In recent years, the introduction of digital technologies into public financial management systems has involved a transition from merely converting traditional operations into electronic formats towards data-driven, automated, and risk-oriented management models [1]. The International Monetary Fund's methodological guidance on digital solutions for public financial management considers process automation, the interoperability of information systems, and digital risk management as interrelated areas. At the same time, alongside the opportunities offered by artificial intelligence and machine learning in public payments, challenges remain concerning algorithmic errors, data quality, information security, and accountability for control decisions [2].

This situation requires two objectives to be addressed simultaneously in the digital transformation of treasury payments. The first is to reduce repetitive manual work and accelerate payment processing. The second is to preserve budgetary discipline, financial control, and accountability under conditions of increased automation.

In the context of Uzbekistan's treasury system, a particularly important consideration is the existence of an established legal framework for electronic document circulation and electronic approval [3]. Accordingly, the proposed model should not duplicate existing arrangements but should complement them through intelligent automation of existing controls, enhanced monitoring of international currency transactions, and mechanisms for measuring human intervention. In particular, the Treasury Execution Rules registered under No. 2850 establish procedures for submitting electronic documents through the UzASBO system, electronic approval within the O'RIMV information system, and the electronic transmission of certain transactions to servicing banks [4]. The rules also regulate payment processing through UzASBO, O'RIMV, and electronic documents, contract registration, the submission of documents relating to import contracts, and certain procedures associated with currency conversion. Specifically, Clauses 116 and 120 are relevant to import contracts and currency conversion processes. Amendments introduced in 2025 clarified provisions relating to these processes. Therefore, the proposed model of a "24/7 Digital Treasury for Currency Operations" should be developed not as a replacement for existing systems but as an additional digital layer integrated with them [5].

International research on the use of digital technologies in public financial management demonstrates the importance of digitalization in enhancing fiscal transparency, budget execution, and the efficiency of public fund management. The digital transformation of treasury payments is closely associated with improving budget execution, automating financial operations, strengthening budgetary discipline, and enhancing oversight of public expenditure. The introduction of digital technologies into treasury processes involves more than converting paper documents into electronic formats. It also requires the redesign of payment processes, the integration of data, and the implementation of new approaches to risk identification.

The study by Rivero del Paso, Pattanayak, Uña, and Tourpe examines the implementation of digital solutions in public financial management through the interaction of functional processes, information technology architecture, and governance and institutional oversight [6]. The authors view digital transformation as a comprehensive process encompassing budget execution, treasury operations, data exchange, and risk management rather than as the introduction of an individual software product. An important implication of this approach is that the technical capabilities of an information system do not, by themselves, guarantee improvements in public financial management. Achieving such improvements requires business process optimization, enhanced data quality, clearly defined control responsibilities, and effective information security. From this perspective, improving the speed of electronic document processing while preserving the reliability of payment authorization and budgetary controls constitutes a fundamental objective of treasury digital transformation [7].

A handbook on government financial management information systems prepared by Hashim for the World Bank examines the automation of financial operations, timely access to budget data, report generation, and improvements in financial control. This study provides an important methodological foundation for defining the functional requirements of treasury systems.

Analytical materials published by the World Bank on the digitalization of government payments also emphasize that the effectiveness of digital payment mechanisms depends not only on technology but also on legal regulation, institutional cooperation, and payment infrastructure. Consequently, digitalizing treasury payments requires more than the

introduction of electronic document circulation; it also requires uninterrupted data exchange among all participants in the payment process.

In Uzbekistan, the relevance of this approach is also linked to the conditions for executing cash expenditures established under Article 124 of the Budget Code. Treasury payments must comply with budget appropriations, legal and financial commitments, and other requirements stipulated by legislation [8]. Accordingly, automation mechanisms should not bypass budgetary controls but should facilitate the rapid execution of certain checks within a digital environment.

An analysis of Georgia's treasury experience published by the International Monetary Fund in 2024 describes the use of machine learning models to detect anomalies in payment transactions and manage associated risks [9]. This experience demonstrates the potential to classify treasury transactions according to their risk levels and allocate greater control resources to high-risk payments. Such risk classification relies on anomaly detection techniques that are well established in machine learning [10].

The IMF study Transforming Public Finance Through GovTech analyzes the impact of public-sector digitalization on budget resource management, public expenditure efficiency, and the oversight of financial transactions. Its methodological contribution lies in emphasizing that digital transformation in public finance should be evaluated in terms of the overall performance of financial processes rather than the introduction of individual software products.

In the field of international payments, the capabilities of SWIFT gpi (Global Payments Innovation) are proposed as a means of improving the transparency of treasury transactions conducted in foreign currencies. This approach facilitates the tracking of international payment flows, provides timely information on transaction status, and enhances the monitoring of payment processes [11]. The ISO 20022 standard supports the exchange of structured and detailed information in payment messages. These international approaches therefore provide an important methodological foundation for digital treasury systems. However, the integration of electronic document verification, budgetary and contractual controls, AI/ML-based risk scoring, STP, human oversight, HIRI, and 24/7 monitoring of foreign currency transactions within a single conceptual model constitutes the principal focus of this study.

The purpose of this research is to develop a comprehensive methodology for the intelligent automation of treasury payment processes and to propose a model for the continuous acceptance and monitoring of foreign currency transactions through digital channels. The research objectives are as follows:

- to systematize the principal stages of the digital transformation of treasury payments;

- to substantiate mechanisms for the automatic verification of electronic documents and the control of budgetary commitments;

- to propose an AI/ML-based risk assessment and automatic processing algorithm for low-risk transactions;

To develop the Human Intervention Reduction Index (HIRI);
- to design a "24/7 Digital Treasury for Currency Operations" model based on SWIFT integration;

- to establish criteria for evaluating the outcomes of digital transformation [12].

2. Materials And Methods

The study employs several complementary methodological approaches. Normative and legal analysis. The Budget Code, treasury execution rules, payment system regulations, and legal instruments governing foreign exchange operations are examined. This method identifies which control functions can be automated within existing legal

authorities and which functions require additional regulatory provisions. Systems analysis. The payment process is divided into stages, beginning with the receipt of an electronic document and continuing through verification, budgetary and contractual controls, risk assessment, transmission of messages to banks, and recording of the final settlement status. The relationships between data flows and control functions at each stage are examined. Comparative analysis. Existing processes are compared with the proposed digital model in functional terms. The comparison considers indicators such as processing time, the number of manually performed actions, the frequency of documents returned for reprocessing, and the coverage of automated controls. Process modeling. An algorithmic sequence for payment operations is developed. The model specifies the conditions under which low-risk transactions can be processed automatically through STP without human intervention, transactions that fail mandatory checks must be suspended, and exceptional cases must be referred to a human-in-the-loop (HITL) mechanism for review and decision-making where necessary. Statistical analysis. Where pilot data are available, baseline and post-pilot indicators are calculated for transaction volumes, processing times, human intervention, and verification outcomes. Scenario-based evaluation. Where actual transaction data are unavailable, the potential outcomes of digital transformation are estimated using hypothetical scenarios. The results of such scenarios are explicitly distinguished from actual empirical findings.

3. Results

streams Treasury payments are one of the principal operational mechanisms through which the public financial management system ensures the targeted, efficient, and lawful use of budgetary resources. Their effectiveness is determined not only by the speed of executing payment orders but also by the validity of budgetary commitments, the authenticity of financial documents, compliance with budget limits, fulfillment of contractual obligations, and the reliability of internal controls over transactions [13].

The methodological guidance developed by the International Monetary Fund on the application of digital solutions in public financial management emphasizes the need to coordinate the functional capabilities of digitalization with information technology architecture, governance, and control mechanisms. In accordance with this approach, the digital transformation of treasury payments requires more than converting paper documents into electronic formats. It involves reorganizing all stages of the payment process within a unified data environment.

Traditional payment processes may require staff to manually verify documents, enter the same information into multiple information systems, reconcile budget limits, check contractual obligations, and determine payment status. These activities can extend processing times, increase the likelihood of human error, raise control costs, and delay the identification of financial risks. At the same time, full automation alone is not a sufficient solution. If automation is not aligned with budget legislation, the distribution of institutional authority, data reliability, and risk management requirements, existing errors may be reproduced on a larger scale within a digital system. Consequently, digital transformation must maintain a balance between the degree of automation and the reliability of internal controls [14].

An IMF study published in 2023 identifies artificial intelligence, machine learning, and robotic process automation as promising tools for data verification, strengthening budgetary controls, identifying unusual treasury payment transactions, and monitoring contractual obligations. However, the implementation of these technologies must also account for data quality, algorithmic errors, information security, and personal data protection requirements [15].

Against this background, the principal objective of the digital transformation of treasury payments should be to increase payment speed while simultaneously ensuring

legality, budgetary discipline, financial control, and accountability through a unified intelligent mechanism.

This study proposes an integrated mechanism for the digital transformation of treasury payments. It combines the automatic verification of electronic documents, intelligent control of budget limits and contractual obligations, AI/ML-based risk assessment, automated processing of low-risk payments without human intervention, and human-supervised review of exceptional transactions. The conceptual model comprises the following interconnected stages: Electronic Document → Automatic Verification → Budgetary and Contractual Controls → Risk Scoring → STP or Human Review → Payment Execution → Real-Time Monitoring. In this model, each stage transfers data to the next only when the specified control conditions have been satisfied. This approach improves the payment process not only in terms of operational speed but also in terms of legal validity and financial security [16].

Stage 1: Automatic Verification of Electronic Documents. Electronic document verification involves checking mandatory payment document fields, the validity of electronic signatures, whether a document has been submitted previously, the consistency of payer and beneficiary information, contract details, and the relationship between the payment document and supporting documents, including invoices. Rule-based checks determine whether a document complies with formal and legal requirements. AI-based document processing tools can recognize information in different formats, extract relevant fields, and identify logical inconsistencies among the extracted data. The verification process may produce one of three outcomes:

1. The document is fully compliant.
2. Corrections are required.
3. Additional verification is necessary.

If mandatory requirements concerning an electronic signature, authorization, or document authenticity are not satisfied, even a high confidence score generated by an algorithm cannot independently justify automatic payment approval.

Stage 2: Intelligent Control of Budget Limits and Contractual Obligations. At this stage, the payment amount is reconciled against the relevant budget program, expenditure classification, approved appropriations, available financial resources, and registered contractual obligations. Previous payments under the contract, outstanding commitments, and specified payment deadlines are also taken into account. If a budget limit or legal restriction is violated, the transaction is automatically suspended. Machine learning models serve as supplementary tools for identifying unusual changes in payment flows, related transactions, potential duplicate payments, and anomalies in expenditure patterns. However, AI/ML models must not independently determine budget limits, reallocate funds, or alter powers established by legislation. Such decisions must be made exclusively by authorized bodies in accordance with the applicable legal framework.

Stage 3: AI/ML-Based Risk Assessment. The proposed approach combines rule-based controls with machine learning models to assess the risk associated with payment transactions. Rule-based mechanisms verify mandatory legal and financial requirements, while machine learning models identify unusual transactions and potential risk indicators based on historical data. Risk assessment may consider the following indicators:

- payment amount;
- counterparty history;
- inconsistencies between contract and account information;
- indicators of potential duplicate payments;
- transaction frequency; and
- results of previous control procedures.

The use of data must comply with legal requirements, confidentiality obligations, and access control restrictions [17].

The results of risk scoring are provisionally divided into three categories:

- Low-risk transactions: automatic processing.
- Medium-risk transactions: additional automated verification or targeted review.
- High-risk transactions: mandatory review by an authorized employee.

Risk thresholds should not be established solely on the basis of arbitrary or assumed numerical values. Instead, they should be determined using historical data, erroneous approval rates, false rejection rates, operational risks, and pilot testing results.

Stage 4: Processing Low-Risk Payments through Straight-Through Processing. Straight-through processing (STP) refers to the automatic processing of payment transactions according to predefined rules, without repeated manual data entry or the need for manual approval at every stage.

Under the proposed model, STP is activated only when all the following conditions are satisfied simultaneously:

1. The electronic document has passed verification.
2. The available budget limit is sufficient.
3. The transaction is confirmed to be associated with the relevant contractual obligation.
4. Mandatory compliance and security checks have been successfully completed.
5. The assessed risk does not exceed the predefined low-risk threshold.
6. All applicable authorization and approval requirements have been fulfilled.

This approach is not intended to reduce human involvement indiscriminately. Rather, it aims to eliminate repetitive technical checks and enable employees to focus more effectively on high-risk transactions.

Stage 5: Processing Exceptional Transactions under the Human-in-the-Loop Principle. Human-in-the-loop (HITL) is a governance mechanism in which risks, data inconsistencies, and exceptional cases identified by an automated information system or artificial intelligence are reviewed and assessed by authorized specialists, who participate in the decision-making process. In the digital transformation of treasury payments, HITL reconciles the automatic processing of low-risk transactions with human oversight of high-risk transactions. When making a decision, the responsible employee is provided with information about the reasons for the transaction's risk classification and the results of the relevant checks. The decision and its justification are recorded in an electronic audit log. This mechanism enables the timely identification of algorithmic errors, reduces false positives and false negatives, and preserves human accountability and oversight in the use of public funds.

Integrating these components allows human resources to be redirected from repetitive technical checks towards the assessment of high-risk transactions and the adoption of control decisions.

Introducing the Human Intervention Reduction Index (HIRI). To evaluate the effectiveness of the proposed digital transformation mechanism, this study proposes the introduction of the Human Intervention Reduction Index (HIRI). The primary purpose of this index is to quantitatively measure the reduction in human intervention in payment processing compared with the baseline situation.

HIRI is calculated using the following formula:

$$HIRI=\frac{H0-H1}{H0}\times100\%$$

Where:

- (H0) is the number of human intervention instances recorded during a defined period before digital transformation.
- (H1) is the number of human intervention instances recorded after digital transformation under comparable conditions and for a comparable volume of transactions.

Human intervention is defined as a set of predefined actions performed by an employee during payment processing. These actions may include manual data entry, repeated verification, manual reconciliation, or manual reprocessing of a transaction.

The methodology must establish consistent rules for counting individual actions and recording multiple instances of intervention within a single transaction. For example, if the number of human intervention instances decreases from 10,000 to 7,000 during comparable periods, the index is calculated as follows: [HIRI=\frac{10000-7000}{10000}\times100%=30%]

Thus, in this hypothetical example, human intervention instances have decreased by 30%. The study proposes a reduction of at least 30% in HIRI as a target KPI. This figure represents a preliminary research and implementation target; its confirmation as an actual result requires evidence from pilot project data.

When calculating HIRI, differences in transaction volumes, transaction complexity, the composition of budgetary commitments, and reporting periods must be controlled for. Otherwise, changes in payment volumes may artificially affect the index. Accordingly, alongside HIRI, it is advisable to monitor the number of human intervention instances per payment and the proportion of payments processed automatically. Reliable calculation of the index also requires consistent criteria for transaction volume and complexity, rules for recording human intervention, and transaction composition across the periods being compared.

Developing the "24/7 Digital Treasury for Currency Operations" Model.

The digital transformation of public payments in foreign currencies requires the integration of several mechanisms: electronic submission of transactions, automatic document verification, sanctions and compliance screening, monitoring of foreign currency transaction status, and recording of payment outcomes.

SWIFT is an international financial messaging infrastructure. Its Global Payments Innovation (gpi) services provide capabilities for tracking payment flows, obtaining information about transaction status, and confirming the delivery of payments to beneficiaries. The SWIFT ISO 20022 standard supports the exchange of more structured and detailed information in payment messages, thereby facilitating automated data processing and improving compliance screening.

On this basis, the study proposes a «24/7» Digital Treasury for Currency Operations" model.The model is designed to accept foreign currency payment instructions through digital channels around the clock, perform preliminary checks automatically, monitor transaction risks, and track payment status.

The model's principal architecture consists of the following modules: 1. Digital Payment Gateway — accepts and identifies foreign currency payment instructions submitted through electronic channels.

2. Document Verification Engine — verifies electronic documents, signatures, and document fields.

3. Budget and Contract Control — monitors budgetary commitments, contractual conditions, and relevant financial limits.

4. AI/ML Risk Engine — detects unusual transactions and calculates risk scores.

5. Compliance and Sanctions Screening — conducts checks in accordance with applicable legislation and financial compliance requirements.

6. SWIFT Connectivity Layer — facilitates international messaging with relevant banks and financial infrastructure.

7. Payment Tracking and Reconciliation — tracks payment status, receives confirmations, and reconciles payment information with account records.

8. Human-in-the-Loop Control — enables authorized employees to review exceptional transactions.

9. Audit and Monitoring Dashboard — displays transaction histories, risk alerts, and control outcomes.

Within this model, the 24/7 operating mode encompasses three distinct functions:

- accepting payment instructions throughout the day and night;

- continuously performing authorized automated verification and monitoring procedures; and

- forwarding transactions to the next stage whenever the external payment infrastructure permits.

However, sending or receiving a SWIFT message does not, in itself, mean that funds have completed interbank settlement. The final execution of a foreign currency payment depends on correspondent banks, the beneficiary's bank, the payment system, foreign exchange market operating hours, liquidity, compliance checks, and the availability of the relevant settlement infrastructure.

Therefore, the term "24/7" in the proposed model primarily refers to the uninterrupted acceptance of electronic instructions, automatic preliminary verification, risk monitoring, and payment status tracking. Achieving final settlement on a 24/7 basis should be treated as a separate objective dependent on the fulfillment of specific technical, contractual, and institutional conditions. The effectiveness of the proposed mechanism cannot be adequately assessed solely by payment processing time or the proportion of automated transactions. The evaluation framework should incorporate a system of KPIs that jointly reflects operational speed, reliability, financial control, and operational risks.

Table 1. Key Performance Indicators for Evaluating the Proposed Model

Indicator	Assessment objective
HIRI	Reduction in instances of human intervention
STP Rate	Proportion of transactions processed automatically
First-pass Validation Rate	Proportion of documents successfully verified on the first attempt
Payment Processing Time	Time required to process a payment
Exception Rate	Proportion of transactions referred for human review
False Positive Rate	Proportion of transactions incorrectly classified as high-risk
False Negative Rate	Proportion of high-risk transactions not detected by the control system
Reconciliation Rate	Proportion of transactions successfully reconciled automatically
Availability	Degree to which digital services are available for use

These indicators should be evaluated jointly. The specific target values for the KPIs should be established on the basis of baseline data, existing process performance, and pilot testing results. A 30% reduction is proposed as the target for HIRI, while targets for STP, error frequency, and service availability should be empirically justified. An increase in automation must not be achieved at the expense of weaker budgetary controls or reduced compliance quality. Therefore, alongside operational speed indicators, the evaluation should monitor erroneous approvals, unjustified rejections, and information security performance. During pilot testing, data from periods before and after digital transformation should be compared. Differences in transaction volumes and complexity must be taken into account, and the outcomes of automatic processing and the review of exceptional transactions should be analyzed separately.

The principal advantage of the proposed mechanism is that it treats the automation of treasury payments not merely as a technical process but as an institutional mechanism integrating budgetary control, risk management, and human accountability. HIRI provides a quantitative means of assessing changes in human intervention. However, its value depends on transaction volumes, transaction complexity, and the rules used to record human actions. Accordingly, HIRI should not be interpreted in isolation but alongside STP Rate, Payment Processing Time, and control error indicators.

AI/ML models may help identify unusual payment patterns. Nevertheless, model outputs cannot replace legally grounded decisions. Budget limits, electronic signature requirements, and mandatory compliance obligations must be satisfied regardless of algorithmic assessments. Furthermore, the "24/7 Digital Treasury for Currency

Operations" model must distinguish between message acceptance, automatic verification, payment status tracking, and final settlement. This distinction helps align technical capabilities with institutional and interbank requirements. At the current stage, the effectiveness of the proposed mechanism is substantiated at the conceptual and methodological levels [18]. Assessing its actual performance requires baseline data on treasury transactions, pilot testing, and comparative evaluation.

4. Conclusion

The study proposes an integrated mechanism for the digital transformation of treasury payments that combines electronic document verification, budgetary and contractual controls, AI/ML-based risk assessment, STP processing of low-risk transactions, and the review of exceptional transactions under the human-in-the-loop principle. The introduction of the Human Intervention Reduction Index (HIRI) establishes a methodological basis for evaluating changes in the volume of operations performed by employees as a result of digitalization. A reduction of at least 30% is proposed as a target KPI, and the need to validate its actual performance through pilot testing is established. In addition, a model has been developed for the acceptance of foreign currency payments through digital channels on a 24/7 basis, automatic verification, and risk monitoring through integration with SWIFT infrastructure and alignment with the ISO 20022 standard. The model explicitly accounts for the distinctions between message exchange, payment tracking, and final settlement. The proposed approach provides a methodological foundation for organizing treasury payments in a fast, transparent, and risk-oriented manner. Future research should focus on evaluating the mechanism using actual transaction data, empirically validating HIRI and other KPIs, and specifying the legal and technical requirements of the digital infrastructure. As the final outcome of the research, the following proposal has been developed:
"The methodology for the digital transformation of treasury payment processes has been improved through the integration of automatic electronic document verification, intelligent control of budget limits and contractual obligations, AI/ML-based risk assessment, straight-through processing of low-risk transactions without human intervention, and the review of exceptional cases under the human-in-the-loop principle. The proposal also предусматривает the application of the Human Intervention Reduction Index (HIRI), with a target reduction of at least 30%, as well as a treasury model designed for the acceptance of foreign currency transactions through 24/7 digital channels, automatic verification, and risk monitoring based on integration with SWIFT infrastructure and compliance with the ISO 20022 standard.

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