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Automation of Fiscal Auditing in SMEs through a Sequential Algorithm for Extracting Tax Receipts: A Focus on the Digital Economy *Author(s) Name(s)*

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Abstract. The digital economy has revolutionised various sectors, including fiscal management. In Mexico, the mandatory use of electronic invoices, known as Comprobantes Fiscales Digitales por Internet (CFDI), has posed significant challenges for both small and medium-sized enterprises (SMEs) and the fiscal authorities. With the increasing volume of digital invoices, traditional manual processes are no longer efficient, prompting the need for automated solutions. This study explores the development and implementation of a sequential algorithm designed to optimise fiscal audits by automating the extraction of key data from CFDIs. The algorithm was tested on a representative sample of invoices, demonstrating its ability to significantly reduce processing time while maintaining high levels of accuracy. Results indicate that the automated approach is not only faster but also more reliable than manual methods, offering substantial benefits to SMEs by reducing administrative costs and improving compliance with fiscal regulations. This paper highlights the importance of integrating advanced technologies such as artificial intelligence into fiscal processes, contributing to a more efficient and transparent fiscal system in line with global trends in the digital economy.
Keywords: Tax audit automation, Digital Tax Receipts, SMEs compliance, digital economy

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1 Introduction

The digital economy is characterised by the integration of information and communication technologies into all economic and social activities, transforming how data is managed and processed. In this context, Artificial Intelligence (AI) has emerged as a fundamental tool for optimising processes in various areas, including accounting and tax auditing. The application of AI in the digital economy allows for the automation of administrative and accounting processes, enabling machines not only to perform repetitive tasks but also to make data-driven decisions in a manner similar to humans.

Recent studies show that AI helps improve accounting and auditing practices in emerging countries, aiding businesses in efficiently leveraging technological advancements to optimise their operations (Abdullah & Almaqtari, 2024). However, adopting digital technologies in accounting faces challenges such as resistance to change, organisational culture, lack of trust, and high implementation costs (Vărzaru, 2022). These factors slow the transition of many companies, particularly small and medium-sized enterprises (SMEs), into the digital economy.

Despite these barriers, automation through AI in accounting has demonstrated numerous benefits. For example, logical programming is used to develop algorithms that enhance efficiency and accuracy in routine tasks, maximising the available time for accounting professionals to focus on strategic activities (Sánchez & García, 2023). In Latin America, investment in robotic accounting technologies has positively impacted operational efficiency in businesses, contributing to the development of the digital economy in countries like Argentina, Chile, Colombia, and Peru (Larios & Atoche, 2023).

In the case of SMEs, the challenges of financial management and technological innovation are evident, as many of these businesses rely heavily on manual processes that affect their financial and operational situation (Fjord & Schmidt, 2023). Traditional management models have attempted to address these issues but have neglected to incorporate key technological elements for continuous improvement. As a result, the productivity of SMEs continues to be affected by their lack of integration into the digital economy (Rizzo & Plaza, 2024). Burga (2023) highlights that the lack of financial and technological management is one of the main barriers these entities face, which are vital for the economy due to their production capacity and employability.

Tax auditing, as a fundamental part of accounting in the digital economy, has also benefited from AI use, facilitating strategic oversight by minimising human intervention in routine procedures. However, implementing these technologies requires appropriate regulation, particularly in financial market accounting, to ensure information transparency and privacy (Montagnani, Najjar & Davola, 2024). AI use in auditing can be particularly useful for SMEs, most of which are at different stages of digitalisation and automation (Fülöp et al., 2022).

On the international stage, the digital economy has transformed production factors, industrial organisation, business models, and the global context in which companies operate. Advanced countries like the United States and China have consolidated the digital economy as a fundamental driver of their growth, especially in sectors such as e-commerce, digital financial services, and software development (Xia et al., 2024). These nations lead the digital transformation by adopting and developing technologies that drive the economy. On the other hand, developing countries are focusing efforts on adopting these technologies to close existing economic and technological gaps.

In Latin America, while there has been an increase in the use of digital technologies, their penetration and adoption have not yet reached the same level as in developed countries. Limitations in digital infrastructure and socioeconomic challenges have slowed this process. However, the digital economy offers significant opportunities to improve efficiency and promote financial inclusion in the region (Rong, 2022).

In the case of Mexico, the transition towards the digital economy is reflected in the requirement to issue Digital Tax Receipts via the Internet (CFDI) for all operations carried out by taxpayers, as established by Article 29 of the Federal Tax Code. This shift has resulted in a significant increase in the number of CFDIs issued, which poses a challenge for both tax authorities and SMEs, which must manage and validate large volumes of data (INEGI, 2015). In this situation, automation through AI emerges as a viable solution to improve accounting management and reduce errors in the issuance and processing of tax receipts, thus facilitating the integration of SMEs into the digital economy.

However, despite technological advances, Mexico still faces significant challenges in the area of tax collection. This challenge is exacerbated by recent fiscal data from Latin America, which shows that Mexico is below the regional average in tax revenue. According to the 2024 Latin American and Caribbean Tax Statistics report, the average tax revenue in the region was 21.5% of GDP in 2022 (OECD et al., 2022). Mexico recorded a tax revenue of 16.9% of GDP, placing it below several Latin American countries, such as Brazil and Argentina, which reported tax rates of 33.3% and 29.6%, respectively. These figures highlight a significant challenge for Mexico in the context of the digital economy, as an efficient tax system is essential for the mobilisation of internal resources and sustainable development. Mexico's lower tax revenue underscores the need to adopt automation and digitalisation technologies in fiscal processes, which would improve efficiency and increase the tax base, thereby contributing to the strengthening of the digital economy in the country.

Given this scenario, the present work focuses on automation for auditing tax receipts through the use of a sequential algorithm as a practical solution to improve efficiency and accuracy in tax auditing. This proposal seeks to highlight the practical implications and benefits that the digital economy can offer to SMEs through the adoption of advanced technologies, optimising the management and processing of tax receipts.

2 Methodology

2.1 Sample Size Determination in Tax Receipt Analysis

For the selection of the sample for the analysis of tax receipts, the following parameters were used by applying the formula for the calculation of the sample size (Equation 1).

$$n = \frac{Z^2 \cdot N \cdot p \cdot q}{e^2 \cdot (N-1) + Z^2 \cdot p \cdot q} \quad (1)$$

Where:

Z is the confidence coefficient corresponding to 95%
p and q are the variance of the proportion (p=0.5 and $q = 1 - p$)
e is the allowable margin of error.

By applying these parameters, a sample size of n = 369 was obtained, which was rounded to 370 for ease of analysis.
Once the total sample size was determined, it was proportionally distributed among the strata using the stratified sampling formula. The sample sizes for each stratum were calculated as follows:

$$n_{\text{Legal Advisory}} = \frac{1454}{8960} \times 370 \approx 60$$

$$n_{\text{Technical Support}} = \frac{1356}{8960} \times 370 \approx 56$$

$$n_{\text{Professional Services}} = \frac{1284}{8960} \times 370 \approx 53$$

$$n_{\text{Marketing Services}} = \frac{1260}{8960} \times 370 \approx 52$$

$$n_{\text{Consulting Services}} = \frac{1236}{8960} \times 370 \approx 51$$

$$n_{\text{Software Development}} = \frac{1236}{8960} \times 370 \approx 51$$

$$n_{\text{Financial Auditing}} = \frac{1134}{8960} \times 370 \approx 47$$

These calculations allowed us to determine the number of tax receipts to be selected from each category, reflecting the proportion of each stratum in the total population.

2.2 Configuration and execution of the random selection algorithm

Once the sample size for each stratum was determined, a random selection algorithm was configured and executed using functions from the Python NumPy library. The process was carried out as follows:
The np.random.choice function from NumPy was used to randomly select tax receipts within each stratum, adhering to the previously calculated sample sizes. To ensure reproducibility, a seed was set (np.random.seed(42)), allowing the random selection of receipts to be the same each time the algorithm is executed. The selection was done without replacement, ensuring that each receipt could only be selected once within its respective stratum sample. This automated random selection process allowed for the creation of a representative sample of tax receipts, organised by categories according to stratified sampling.

2.3 Algorithm for Extracting Data from Tax Receipts

An algorithm was implemented to read the selected set of tax receipts. This algorithm extracts key attributes from each receipt, such as the taxpayer's Federal Taxpayer Register (Registro Federal de Contribuyentes, RFC) in Mexico, the tax folio, the service description, the subtotal, and the Value-Added Tax (VAT), and then exports this information into an Excel file, facilitating further analysis and enabling efficient and precise tax audits.

The development of the algorithm is described in the following pseudocode:

```
FIRST PROCESS
INITIALISE the necessary libraries and modules:
    - Import the library for file and directory management (os)
    - Import the library for working with PDF files (PyPDF2)
    - Import the library for handling files with patterns (glob)
    - Import the library for managing data in tables (pandas)
DEFINE the file extension to be searched as "*.pdf"
DEFINE the main directory where the files will be searched (PATH)
CREATE an empty list called 'files' to store the found files
BEGIN searching for files in the directory:
    FOR each directory (dirpath), subdirectories (dirnames), and files
(filenames) IN the specified path (PATH):
        - ADD all the files with the ".pdf" extension found in the
current directory to the 'files' list using glob and os.path.join
END of process
SECOND PROCESS
INITIALISE the time measurement module
STORE the start time in a variable 'start'
CREATE empty lists to store the extracted data:
    - 'rfc_emitter' for the RFCs of the emitters
    - 'desc' for the descriptions
    - 'sub' for the subtotals
    - 'vat' for the VAT
    - 'names' for the names of the files
FOR each file in the 'files' list, perform the following actions:
    - READ the PDF file using 'PyPDF2.PdfReader'
    - OBTAIN the first page of the file
    - EXTRACT the text from the page
    - SPLIT the text into lines
    - ADD the file name to the 'names' list
FOR each line of text in 'lines':
    - IF the line contains 'RFC emitter:':
        - EXTRACT the RFC from the line
        - CLEAN the RFC text by removing unnecessary spaces
        - ADD the RFC to the 'rfc_emitter' list
    - IF the line contains 'Description':
        - EXTRACT the description from the line
        - CLEAN the description text
        - ADD the description to the 'desc' list
    - IF the line contains 'Subtotal':
        - EXTRACT the subtotal from the line
        - CLEAN the subtotal text
        - ADD the subtotal to the 'sub' list
    - IF the line contains 'Transferred VAT 16.0000%':
        - EXTRACT the VAT from the line
        - CLEAN the VAT text
        - ADD the VAT to the 'vat' list
STORE the extracted data in a 'data' dictionary with the following keys:
    - 'File' contains the file names
    - 'RFC Emitter' contains the emitters' RFCs
    - 'Description' contains the descriptions
    - 'Subtotal' contains the subtotals
    - 'VAT' contains the VAT amounts
CREATE a pandas DataFrame with the data from the dictionary, row-oriented
TRANSPOSE the DataFrame so that each file is a row
DISPLAY the resulting DataFrame
```

```
CALCULATE the total execution time by subtracting the start time from the
current time
DISPLAY the execution time (124 SECONDS)

THIRD PROCESS
IMPORT the 'files' module from 'google.colab'
SAVE the DataFrame 'df' in a CSV file named 'receipts.csv' using the
'to_csv' method
DOWNLOAD the 'receipts.csv' file using the 'files.download' method
```

This pseudocode details the key stages of the automated process for reading, extracting, and exporting data from tax receipts. The execution of the algorithm enabled the automation of obtaining relevant fiscal information, facilitating subsequent auditing and analysis.

3. Results

For the selection of tax receipts, a random selection algorithm was used to determine the folios to be analysed. This process was based on stratified sampling, where each category of service invoiced (Legal Advisory, Technical Support, Professional Services, Marketing Services, Consulting Services, Software Development, and "Financial Auditing) was considered as a stratum within the total universe of 8,960 tax receipts.

The algorithm, configured with the parameters of stratified sampling, selected a total of 370 folios. The number of receipts selected in each category was determined proportionally, thus ensuring a representative sample of the total universe. Subsequently, the folios were randomly selected within each category using a vector that ensured an impartial distribution.
Figure 1 shows a scatter plot illustrating the selection order (x-axis) versus the folio number (y-axis) for each type of description. The points are coloured according to the service category, indicating how the selected receipts were distributed throughout the process. This graph reflects the diversity in the random selection, clearly visualising the representative distribution of folios according to their invoiced service type.

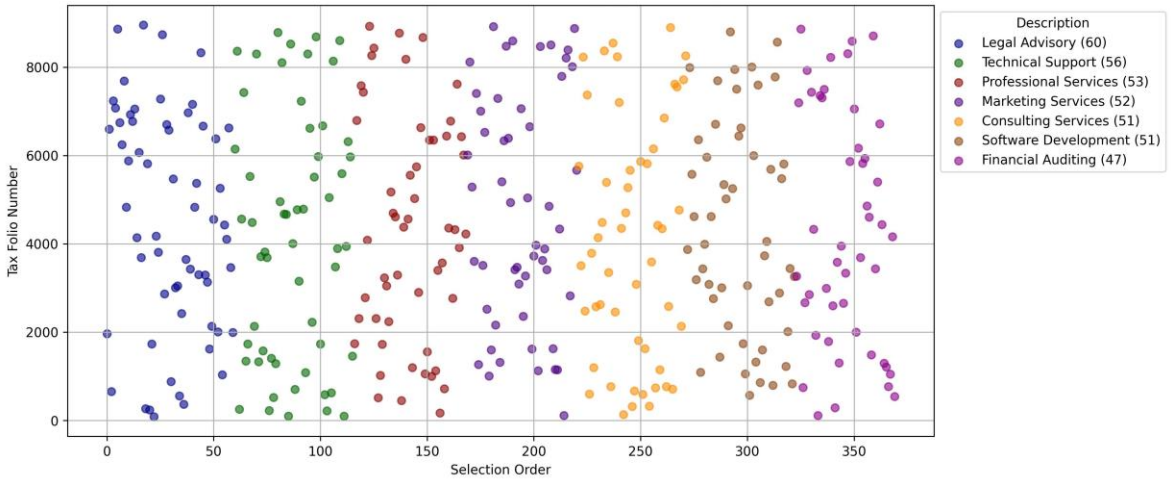

Figure 1. Random Distribution of 370 Selected Tax Folios by Service Type from a Universe of 8,960

The developed algorithm was implemented to read and extract key information from a total of 370 tax receipts, which were selected through a random process based on stratified sampling. Specifically programmed to identify and extract essential elements from each invoice, the algorithm was responsible for obtaining data such as the issuer's Federal Taxpayer Registry (RFC), the tax folio, the description of services or products, the subtotal, and the Value-Added Tax (VAT) in a time of 124 seconds.

As shown in Figure 1, the most commonly invoiced services in the sample include "Legal Advisory," "Technical Support," "Professional Services," "Marketing Services," "Consulting Services," "Software Development," and "Financial Auditing." The

"Legal Advisory" category has the largest number of invoices, reaching a total of 60 receipts, while "Financial Auditing" has the smallest number, with 47 receipts, although it remains relevant for analysis. This diversity in the selection of folios highlights the algorithm's ability to capture a representative sample of the various invoiced services, providing valuable insights for tax auditing.

In addition to data extraction, the algorithm facilitated the analysis of the information contained in the tax receipts, including the description of the invoiced services. This allowed the receipts to be categorized and counted according to the type of service provided. This categorization provides a greater understanding of the nature of the invoiced services, which is valuable for tax auditing as it helps to identify common patterns and key areas of focus. This result not only demonstrates the algorithm's ability to extract data from tax receipts but also to process and present this information in a clear and useful manner for decision-making in the auditing field.

During its execution, the algorithm demonstrated high precision in extracting the main fields from the tax receipts. Table 1 presents a representative sample of the first 20 randomly selected folios. In this table, examples of extracted RFCs can be observed, such as "TRYH711226XXX," "RLSV890702XXX," and "YWBX910911XXX." Additionally, the tax folios, unique identifiers for each invoice, were successfully captured, such as "0NQ5RSA3-H9Z9-S5XF-QB72-H07G05QTRSVE" and "61DUC7PR-EO0U-S5IO-SM79-3W0MQ1T5HMU5."

Table 1. Sample of the first 20 randomly selected tax receipts: RFC (with the last 3 digits anonymised as 'XXX'), Tax Folio, Description, Subtotal, and VAT.

RFC	Tax Folio	Description	Subtotal	VAT
TRYH711226XXX	0NQ5RSA3-H9Z9-S5XF-QB72-H07G05QTRSVE	Marketing Services	$ 2,505.69	$ 553.76
RLSV890702XXX	61DUC7PR-EO0U-S5IO-SM79-3W0MQ1T5HMU5	Financial Auditing	$ 7,025.63	$ 1,552.66
YWBX910911XXX	T8SHZC7Q-PB3Z-V2UV-ZZ17-ITKHC91VAVWO	Professional Services	$ 7,553.58	$ 1,669.34
ABNZ900214XXX	X6EX5XVU-6UGY-MVUX-ZIKZ-Q55WD5XV6XI5	Technical Support	$ 6,159.37	$ 1,361.22
DVYB711125XXX	DS8H8DLA-KLQQ-EQKZ-F1UX-W395ZQ1BYEWE	Consulting Services	$ 6,994.09	$ 1,545.69
JVPX630114XXX	VK757AMN-OV0V-UHJR-MVF2-Q5FTCQB3IM3K	Financial Auditing	$ 5,568.12	$ 1,230.55
RGXA740622XXX	PW6N3QDI-F53T-GMC3-MG29-TCVARDUHW7YS	Legal Advisory	$ 13,916.29	$ 3,075.50
NDZO720527XXX	J3Q9ALWF-70HK-9PUQ-NJLT-L3YATPBR7N7W	Legal Advisory	$ 3,356.45	$ 741.78
RWQS671024XXX	NB7UPIVU-VFLX-Q0M5-CU1N-TOGW5WKERVYR	Software Development	$ 4,871.26	$ 1,076.55
AKMN880301XXX	KG3DWVU3-CU8F-CD1E-QQXP-6HUETUHUWPKF	Software Development	$ 17,438.20	$ 3,853.84
AAMG810218XXX	PWD55P4E-YGGP-626G-A4ZU-8YH532E389LC	Financial Auditing	$ 10,496.98	$ 2,319.83
MUED850401XXX	IED9S5GU-V5VR-YVUB-9P7J-WRDBJTFUCRRT	Legal Advisory	$ 6,028.01	$ 1,332.19
JERH790104XXX	4MQ34O9J-EJIO-PKL4-B1UE-BLEITTN99SK9	Marketing Services	$ 4,279.90	$ 945.86
BWTQ880404XXX	V93095SZ-8HY1-GNKI-RM53-7KBZLEGD5QOX	Professional Services	$ 6,050.63	$ 1,337.19
PWNF721119XXX	CD6729YR-WBP3-FKNT-XF03-MS4JVORGZ7FV	Legal Advisory	$ 5,877.09	$ 1,298.84
GBTQ831206XXX	G4RW3JXT-1L68-83E5-3IRZ-Z5BZKYNXOSAM	Software Development	$ 8,530.34	$ 1,885.21
KYCA971001XXX	8XN35BO0-N7T6-G80D-6H7K-NWB5SQOAKZ0M	Professional Services	$ 14,049.36	$ 3,104.91
CYYB700427XXX	JSNHATB6-6G2B-Y85G-58ZK-LLMWRXYW66GV	Software Development	$ 10,329.92	$ 2,282.91
YDIU860220XXX	JAS5SU3C-FN2Y-2AIJ-5UCH-SGFVS8C3XD5U	Legal Advisory	$ 3,244.70	$ 717.08

Source: Own elaboration based on the results of the selection algorithm

The algorithm also correctly captured the descriptions of the invoiced products or services, such as "Marketing Services," "Financial Auditing," and "Consulting Services." Additionally, the numerical values for the "Subtotal" and "VAT" fields were extracted for each receipt. For example, for "Marketing Services," a subtotal of 2,505.69 MXN and a corresponding VAT of 553.76 MXN were recorded, while other services, such as "Professional Services," showed subtotals of 7,025.63 MXN and 7,553.58 MXN, with respective VATs of 1,552.66 MXN and 1,669.34 MXN.

The results presented in Table 1 demonstrate the algorithm's effectiveness and precision in extracting key information from the tax receipts. The speed and accuracy of the automated process, compared to the manual method, suggest that the implementation of this algorithm could significantly optimise fiscal audit processes in SMEs, contributing to the development of the digital economy.

In addition to extracting data, the algorithm allowed for the analysis of information contained in the receipts, including the descriptions of the services provided. This facilitated the categorisation and accounting of receipts according to the type of service provided.

This analysis offers a deeper understanding of the nature of the invoiced services, which is valuable for fiscal audits as it enables the identification of patterns and key areas. Thus, the algorithm not only demonstrates its capability to extract data from tax receipts but also to process and present this information in a clear and useful way for audit decision-making.
In the context of the digital economy, the algorithm aligns with the needs of SMEs, as the reading and extraction of fiscal data proved to be an effective and efficient tool in managing large volumes of tax receipts. During the execution of the algorithm, key data such as the issuer's RFC, the tax folio, the description of invoiced services, the subtotal, and the VAT were accurately extracted from a total of 370 randomly selected tax receipts. These results highlight the potential of automation to optimise fiscal processes and minimise human errors.

3.1 Discussion

The process of digitalisation and automation not only facilitates the massive processing of data but also has a significant impact on reducing tax evasion. Tiantian et al. (2023) highlight that digital transformation can improve internal company controls, increasing transparency and decreasing the likelihood of tax evasion. In this sense, the algorithm developed in this study not only optimises time and accuracy in tax audits but can also foster an environment of greater tax compliance and corporate control, which is crucial for the continuous oversight of fiscal activities.

The results obtained in this study align with the global trend towards the digitalisation and automation of fiscal processes, as mentioned by Wahab & Bakar (2021) and Chen & Chen (2024) who argue that the implementation of predictive and descriptive analysis models based on machine learning techniques can enhance the efficiency of tax compliance. By reducing processing time and costs, automation promotes more effective tax compliance, which is consistent with the findings of this study in optimising the processing of large volumes of tax data.

In terms of efficiency and time savings, the automation of tax audits, as shown in the results of this work, allows for a significant reduction in fiscal validation times. The algorithm's ability to automatically process tax data not only speeds up the process but also reduces the operational costs associated with manual audits. Gulkova and Tipalina (2019) mention that, in countries like Russia, the automation of fiscal processes has significantly improved audit efficiency, enabling real-time, automatic analysis of tax returns. In this study, the proposed sequential algorithm aligns with these global trends by offering a technological solution that facilitates the review and validation of tax receipts in SMEs.

The benefits of digitalisation in the fiscal sphere go beyond simply reducing operational times and costs. Currently, it is clear that the digital economy is driving a global transformation across various industries, including the fiscal sector, through the adoption of technologies such as AI and blockchain (Xia et al., 2024; Cheng et al., 2024). In this study, automation through the sequential algorithm not only allowed for faster analysis of tax receipts but also provided a level of precision and reliability that would be difficult to achieve through manual methods. This reinforces the importance of digitalisation in improving fiscal auditing, promoting more efficient and accurate accounting management.

However, the digital economy also presents challenges, especially in developing countries like Mexico. Bukht & Heeks (2017) underscore that the adoption of digital technologies faces barriers such as a lack of adequate infrastructure and technological skills, which may limit the impact of digitalisation on fiscal processes. Despite these challenges, the results obtained in this study show that the implementation of automated solutions, such as the developed algorithm, can help close the technology gap and improve the efficiency of fiscal processes in Mexico. The adoption of digital technologies in tax auditing not only promotes greater transparency but also facilitates the integration of SMEs into the digital economy.

While automation can improve efficiency and productivity, it also poses challenges related to tax equity (Merola, 2022). Digitalisation, as observed in this study, enables better management of fiscal resources and can contribute to greater equity in wealth distribution by reducing tax evasion. In this regard, the algorithm proposed in this work represents a step forward in automated auditing, promoting a more equitable and efficient tax system in the context of the digital economy.

4. Conclusion

The automation of tax receipts through a sequential algorithm represents a significant innovation in financial and tax management, as aligned with the results obtained in this study. The development and implementation of the sequential algorithm for SME tax audits have proven to be an effective tool for optimising the extraction and processing of large volumes of tax data, improving accuracy, and reducing validation times. This automation capability minimises human errors and enhances the operational efficiency of SMEs, resulting in significant time and cost savings.

The algorithm allows for the automatic classification of documents, the precise extraction of key data, and its validation according to local tax requirements. This approach reduces discrepancies that could lead to penalties or audits, while also enabling the detection of irregularities. Although it is not an advanced artificial intelligence system, the sequential algorithm provides a robust solution for tax compliance within the context of the digital economy, contributing to the digital transformation that drives efficiency and transparency in tax processes.

Additionally, automation frees up human resources from routine tasks and redirects them to more strategic, value-added activities, generating a positive return on investment in the long term. The reduction of administrative costs is one of the main benefits of automating tax processes, allowing SMEs to optimise their operational resources. However, to maximise these benefits, it is crucial that companies have the appropriate technological infrastructure and continuous training for the personnel managing these systems.

In the context of the digital economy, this work aligns with the need for companies to adopt technological solutions that facilitate integration into an increasingly digitalised environment. The automation of tax processes not only improves efficiency and accuracy but also promotes the adaptation of SMEs to the demands of the digital economy, where the ability to manage large volumes of information and conduct efficient audits is key to competitiveness. This study has demonstrated that the adoption of automated solutions for processing tax receipts is an effective strategy that better positions SMEs to face the challenges and opportunities of the digital economy, optimising their operations and strengthening their tax transparency.

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