National College of Ireland

Modernizing Pensions: Blockchain's Potential to Revolutionize Retirement for Young Mexicans

MSc Research Project
Fintech

Fernando Garcia Garcia
Student ID: 23142448

School of Computing
National College of Ireland

Supervisor: Brian Byrne

National College of Ireland

MSc Project Submission Sheet

School of Computing

Student Name: Fernando Garcia……

Student ID: 23142448……..……

Programme: Fintech…… **Year:** 2023/2024……..

Module: MSC Research Project……..……

Supervisor: Brian Byrne……..……

Submission Due Date: August 12, 2024……..……

Project Title: Modernizing Pensions: Blockchain's Potential to Revolutionize Retirement for Young Mexicans……..…

Word Count: 5773 …… **Page Count** 19……..……..

I hereby certify that the information contained in this (my submission) is information pertaining to research I conducted for this project. All information other than my own contribution will be fully referenced and listed in the relevant bibliography section at the rear of the project.
ALL internet material must be referenced in the bibliography section. Students are required to use the Referencing Standard specified in the report template. To use other author's written or electronic work is illegal (plagiarism) and may result in disciplinary action.

Signature: ……

Date: ……

PLEASE READ THE FOLLOWING INSTRUCTIONS AND CHECKLIST

Attach a completed copy of this sheet to each project (including multiple copies)	□
Attach a Moodle submission receipt of the online project submission, to each project (including multiple copies).	□
You must ensure that you retain a HARD COPY of the project, both for your own reference and in case a project is lost or mislaid. It is not sufficient to keep a copy on computer.	□

Assignments that are submitted to the Programme Coordinator Office must be placed into the assignment box located outside the office.

Office Use Only	
Signature:	
Date:	
Penalty Applied (if applicable):	

Modernizing Pensions: Blockchain's Potential to Revolutionize Retirement for Young Mexicans

Fernando Garcia Garcia
23142448

Abstract

This study investigates the potential of blockchain technology to transform retirement planning among young adults in Mexico. Utilizing a range of advanced statistical models—including Ordinal Regression, Decision Tree, Random Forest, Ridge, and Lasso Regression—the research explores various factors that could influence the adoption of blockchain-based pension systems. The analysis examines the roles of demographic variables, financial literacy, and trust in technology in shaping young adults' attitudes towards innovative retirement solutions. By offering a detailed exploration of these aspects, the study provides valuable insights into how emerging technologies might be integrated into pension systems to enhance financial security and engagement in retirement planning. This research highlights the importance of considering new technological approaches to meet the evolving needs of a digitally-aware population, contributing to the broader discourse on modernizing financial systems for future generations.

1 Introduction

Retirement planning is a crucial component of financial security. However, it poses significant challenges, especially in developing countries like Mexico. With its diverse and dynamic population, Mexico faces several socio-economic issues that hinder its progress towards becoming a developed nation. These challenges include education, healthcare, security, and housing. A particularly pressing concern is the financial uncertainty faced by young adults aged 20 to 29, stemming from inadequate pension systems.

Countries like the Netherlands, Iceland, and Denmark have established robust pension systems that ensure financial stability for retirees (Mercer, 2023). In contrast, Mexico's pension system is damaged by limitations and inefficiencies (INEGI, 2020). Despite having a population of 126 million as of 2020, a significant proportion of which is young and economically active, the country struggles to provide a secure financial future for its citizens. The pension reforms enacted in 1997 under President Ernesto Zedillo were intended to improve the system but unknowingly introduced complexities that have left many without adequate retirement plans (Commission, 2023).

The financial landscape for young adults in Mexico is particularly precarious. A significant portion of the workforce, 56.9% as of 2019, is engaged in informal employment, which precludes them from participating in formal pension systems. The requirement to contribute for at least 24 years to qualify for a pension is unattainable for many who do not

have continuous formal employment. Consequently, approximately 70% of young adults may find themselves without a pension upon retirement (Gutiérrez & Esquivel, 2020)

The current pension contributions are also insufficient to ensure a comfortable retirement. The minimum wage in Mexico, reported to be 13.59 EUR per day in 2022, could result in a pension of approximately 409.37 EUR per month, considering a 6.5% contribution rate. This amount falls short when compared to the average monthly living costs of 239.02 EUR, leaving retirees with very little surplus for emergencies or leisure (INEGI, 2022). This situation underscores the urgent need for innovative solutions to rectify the flaws in the current pension system and ensure the financial security of the population.

Blockchain technology has been identified as a promising approach to address these issues. As an immutable, transparent, and decentralized system, blockchain could have the capability to innovate the operation of pension systems. By leveraging blockchain, it is possible to enhance accessibility, reduce administrative costs, and increase user trust Blockchain's key features, such as smart contracts, can automate and secure transactions, ensuring that pension contributions and payouts are handled transparently and efficiently (Sarker, 2022).

Smart contracts, which automatically enforce the terms written in their code, are key to this transformation. In the context of pensions, smart contracts can ensure that contributions are automatically deducted, and benefits are paid out according to set conditions, removing the necessity for intermediaries. This reduces the risk of errors and fraud while also lowering administrative costs. Blockchain's immutability ensures that recorded data is unalterable and undeletable, providing robust security and fostering trust.

For a generation that is highly familiar with digital technology, blockchain offers an appealing alternative to conventional pension plans. Given these circumstances, it is critical for young adults in Mexico, particularly those aged 20 to 29, to explore different retirement planning strategies. Blockchain technology provides an attractive option to engage this group in actively seeking and managing retirement plans. Blockchain facilitates easy access to private retirement plans and removes the need for intermediaries, which could significantly encourage young adults to engage in financial planning.

This study aims to explore how blockchain technology can encourage young adults in Mexico to actively plan for their retirement. It will examine the extent to which blockchain can address the current limitations of the pension system and its acceptance among young adults. A detailed survey will be conducted with young adults from various educational backgrounds, financial circumstances, long-term ambitions, and diverse histories to uncover their views and attitudes towards blockchain-based pension systems. The findings of this study will offer valuable insights into leveraging blockchain technology to improve pension systems in Mexico.

The questions directing this study are:

• How successful are blockchain technologies in motivating young adults, aged 20 to 29, to engage in retirement planning?

• How do variables such as sex, marital status, age, and employment status influence the likelihood of accepting blockchain as a pension plan option?

The importance of this study stems from its ability to add to the wider discussion on retirement planning in Mexico, highlighting how emerging technologies can be utilized to

boost financial security. The information gained from this study can inform policy and practice, ultimately leading to more secure and reliable retirement options for young adults in Mexico. Moreover, this research can lay the groundwork for future studies examining the application of blockchain technology in other areas of financial services, both within Mexico and internationally.

2 Related Work

Given the scarcity of research on blockchain's role in pension funds, this literature review will expand its scope to broader subjects. It will delve into the advantages of blockchain technology across various sectors, including insurance and national statistics. Additionally, it will examine the implementation of smart contracts to enhance and streamline processes and procedures, providing a comprehensive overview of blockchain's potential benefits.

2.1 National Statistics

A robust financial sector is essential for providing citizens with access to investment opportunities, banking systems, and secure pension funds. Despite reforms intended to enhance accessibility and stability, Mexico's pension system remains with issues that jeopardize the financial security of retirees. Recent data highlights the scope of these challenges: as of 2018, only 71.7 million Mexicans had social security coverage, representing just 57.3% of the population (CONEVAL, 2019). Additionally, Mexico's pension fund commissions are among the highest within OECD countries, further straining the system. Between 2000 and 2016, the pension system's coverage increased from 2.55% to 14%, yet this is significantly lower than other Latin American countries like Chile, which had a 69% coverage rate in 2016 (Gutiérrez & Esquivel, 2020).

Past research has primarily concentrated on correlational analysis, utilizing linear and non-linear regression models to investigate the interrelationships among various factors. This approach has provided valuable insights into how different variables interact and influence one another. One study, which included 500 college students, applied Likert scaling to measure their financial literacy and attitudes towards pension funds. While Likert Scaling offers benefits such as producing quantitative data that is easy to analyse, it also has limitations including a restricted response range and potential biases like social desirability. Survey findings indicated that men generally possess more knowledge about pensions, with 52% having a full understanding of how they operate and 73% possessing the knowledge of what procedures to follow upon a pensioner's death. However, there was no significant correlation between their overall knowledge and specific details about pension providers (Aguilar et al., 2023).

Additionally, the 1997 pension reform in Mexico intensified the problem by moving from a defined benefit system, where retirees received guaranteed payouts, to a defined contribution system, where benefits depend on individual contributions and investment performance. According to Colín (2024), this reform is predicted to significantly increase poverty among retirees by 2051, with the percentage of men without a pension rising from 38% to 59% and women from 44% to 66%. The reform's strict requirement of 1,250 weeks of

contributions makes it difficult for many to qualify for a pension, and the average replacement rate is expected to drop from 70% to 30%. These forecasts emphasize the pressing need for novel approaches to tackle the deficiencies of the existing pension system and prevent extensive poverty among senior citizens.

Lastly, the World Bank's study on pension contribution requirements in Mexico and Uruguay sheds light on the systemic difficulties in meeting eligibility conditions for contributory pensions. The research highlights that a substantial proportion of workers in Mexico face challenges in satisfying the minimum contribution period due to sporadic employment histories marked by informal work and unemployment. This leads to a lower effective coverage rate of contributory pensions, with only 27% of those aged 65 or more receiving benefits from the contributory system in 2018 (Apella & Zunino, 2023). These findings suggest that Mexico's rigid contributory requirements, combined with high levels of informal employment, significantly hinder the ability of many workers to secure a stable retirement income.

In response to these challenges, it is essential to devise innovative strategies to strengthen the financial security of young adults in Mexico. Exploring blockchain technology's potential, characterized by decentralization, transparency, and efficiency, could present a viable alternative to conventional pension schemes. Blockchain can provide an immutable record of contributions, which is particularly beneficial in environments with high levels of informal employment. Additionally, smart contracts could automate contributions and payouts, reducing administrative costs and increasing trust in the pension system. By leveraging these technologies, Mexico could improve pension accessibility and reliability, thereby addressing some of the critical issues among its current system.

2.2 Blockchain Technology

Due to its inherent features of transparency, decentralization, and immutability, blockchain technology has transformative potential for multiple industries. These features ensure that blockchain operates without a central authority, maintaining a transparent record of transactions that cannot be altered once added to the ledger. In the context of pension systems, this translates to enhanced security and trust, as all contributions and payouts would be recorded in an immutable ledger. The decentralized nature of blockchain reduces dependency on intermediaries, potentially lowering administrative costs and increasing efficiency (Gatteschi et al., 2018).

These technologies, while still considered disruptive and emerging, offer numerous benefits. Among these, the distributed ledger system stands out. In contrast to traditional banking systems that depend on a central authority, blockchain functions autonomously, storing data across a network of computers. Not only does the decentralized design improve security, but it also grants users full control over the network through protocols like Proof of Work (PoW) or Proof of Stake (PoS). Protocols as these guarantee the integrity of the network by rewarding participants for solving complex mathematical problems honestly and efficiently (Mlika, et al., 2024).

PoW and PoS consensus mechanisms guarantee that transactions cannot be modified or erased, thereby preserving data integrity and security. This immutable structure is essential

for fostering confidence and reliability in blockchain systems. In the context of pension systems, this immutability means that once contributions and payouts are recorded, they cannot be altered, ensuring the integrity of the pension fund. This feature is particularly beneficial in environments with high levels of corruption or administrative inefficiencies, as it ensures that all pension transactions are secure and trustworthy. Tamper-proof records can streamline dispute resolution processes by providing verifiable and unchangeable evidence of transactions, which can be particularly beneficial in cases where there are disputes over contribution records or benefit entitlements (Prasad, et al., 2021).

Regarding transaction visibility, blockchain often faces misconceptions due to its alleged ties to criminal activities and its perceived opacity. In reality, blockchain is built for transparency. Each block in the network is linked to its predecessors, creating an unbroken chain of transactions. These transactions are visible to all through their unique IDs or hashes. This structure not only allows for tracing the history of any asset or cryptocurrency but also enhances security. The transparency of blockchain ensures that all transactions related to contributions and payouts are visible and verifiable by all stakeholders. This system reliably tracks contributions over time, providing security regardless of changes in employment status or pension administrators, thereby building a trustworthy and resilient pension system.

While blockchain technology holds considerable promise, it faces several hurdles that must be overcome for its successful integration into pension systems. A significant challenge is scalability; the current infrastructure may not efficiently handle the large number of transactions seen in national pension systems. Furthermore, concerns about data privacy and security arise from the public nature of blockchain, which could lead to exposure of sensitive information if not adequately safeguarded.

The regulatory landscape for blockchain is still in development, presenting unresolved issues related to taxation and legal compliance. There's also a shortage of research and knowledge sharing among scholars, especially in developing and underdeveloped regions, pointing to a considerable research gap. Additionally, blockchain initiatives are still nascent, and the insurance sector has yet to fully exploit the potential of blockchain 3.0 (Apella & Zunino, 2023).

Blockchain technology offers significant potential for improving the efficiency, transparency, and security of pension systems, careful consideration of the associated challenges is crucial. By addressing these barriers, blockchain can provide a viable alternative to traditional pension systems, offering a more secure and reliable solution for managing retirement funds in Mexico and beyond. Further research and pilot projects are necessary to explore the full potential of blockchain technology and to develop best practices for its implementation in the pension industry.

2.3 Smart Contracts

Smart contracts are an essential aspect of blockchain technology, allowing for automated and self-executing agreements with terms coded directly into the software. This removes the need for intermediaries, minimizing the risk of fraud and errors. These contracts can be designed

to execute transactions automatically based on predetermined rules and conditions, making them highly flexible for a wide range of applications beyond just transferring value. In the context of pensions, smart contracts can streamline processes by ensuring that contributions are automatically deducted, and benefits are paid out based on predefined conditions. This enhances efficiency, transparency, and trust in the system (Samanta, Bisht, & Singh, 2024).

The application of smart contracts extends beyond the pension industry, finding significant use in healthcare and health insurance as well. For instance, integrating Ethereum smart contracts with zero-knowledge proofs in Zcash can ensure the privacy of patient data while verifying transactions and insurance claims. This innovative approach enables secure, privacy-preserving transactions that maintain the confidentiality of sensitive information. By leveraging these technologies, healthcare providers and insurers can reduce administrative costs, prevent fraud, and improve the overall efficiency of their operations. The immutability and automated execution of smart contracts make them an ideal solution for managing complex agreements and ensuring compliance with regulatory requirements (Samanta, Bisht, & Singh, 2024).

In the realm of cryptocurrency insurance, smart contracts also play a crucial role. The security of cryptocurrency transactions has been a significant concern, with numerous instances of security breaches in storage and exchange services. To address these vulnerabilities, a new framework for insuring cryptocurrencies using smart contracts and ‘multisignature’ protocols has been proposed. This framework aims to enhance the security of cryptocurrency insurance services by incorporating various security measures to protect private keys and ensure transaction integrity and confidentiality. The proposed framework's architecture prioritizes security through several layers of protection. A notable feature is the use of multisignature wallets, which necessitate multiple private keys to approve any transaction. This approach significantly reduces the risk of unauthorized access and theft.

The framework also leverages decentralized storage solutions to distribute and safeguard private keys, further enhancing security. In practical application, this framework can be implemented in different models, such as insurance for cryptocurrency exchanges, individual investors, or institutional holdings. Each model tailors the security protocols to the specific needs and risks associated with the insured assets. This comprehensive approach not only improves the security of cryptocurrency transactions but also contributes to the broader acceptance and reliability of digital currencies in financial systems (Andrew et al.,2023).

Ultimately, the integration of smart contracts into pension systems, healthcare, and cryptocurrency insurance demonstrates their potential to revolutionize traditional practices. By automating processes, reducing administrative overhead, and enhancing security and trust, smart contracts pave the way for more efficient, transparent, and reliable systems across various sectors. This technological advancement holds promise for significantly improving how financial and insurance operations are conducted, fostering greater confidence and participation from users.

3 Research Methodology

The research methodology for this study involves several key steps: data collection, data preparation, and statistical analysis. These steps are essential for gathering and analysing data

on young adults' attitudes and perceptions towards blockchain-based pension solutions in Mexico.

3.1 Data Collection and Preparation

This study adopts a mixed-methods approach, blending quantitative and qualitative research to collect detailed data. Surveys were the primary tool, targeting young adults aged 20 to 29 in various Mexican cities. To facilitate participation, 213 questionnaires were conducted using Google Forms. The survey questions were crafted to evaluate the participants' understanding of pension funds and their perceptions of blockchain technology.

A fully random sampling method was employed to select participants, maintaining age as the main parameter. Additionally, the surveys were sent to some universities to ensure a diverse range of respondents within the specified age range. This approach facilitated the collection of data from a diverse group of young adults without other specific demographic restrictions.

Data preparation involved several steps to ensure accuracy and readiness for analysis, performed using Python. Incomplete or inconsistent responses were removed. Binary questions with yes/no answers were transformed into 1/2. Variables such as income and age, which were strings and ranges, were mapped allowing its analysis. Some variables were transformed into ordinal numerical values. For the last open-ended question, a Python library was used to find the top relevant word counts, providing insights into common themes and sentiments expressed by respondents.

3.2 Statistical Analysis

The first step in the analysis was performing general statistical analysis to calculate the probability of each response for each question. This provided a better understanding of the demographic characteristics. Correlation matrixes were used to explore potential relationships between different variables. A general correlation matrix was performed to identify patterns within the data. Although the primary dependent variable was 'Would you consider switching your pension plan to a blockchain-based system?', additional correlation analyses were performed for each age category.

An ordinal logistic regression model was first utilized to forecast the likelihood of adopting blockchain for pensions. This model incorporated several independent variables, such as age, sex, highest level of education, and marital status. By focusing on an ordinal dependent variable, namely the likelihood of adoption, the model effectively manages multiple predictors to pinpoint significant factors influencing adoption (An, 2022).

Transitioning from this, a decision tree model was employed to determine the key factors affecting young adults' choices regarding blockchain-based pension solutions. Chosen for its capability to visualize the decision-making process, this model provides a clear and interpretable understanding of how different variables impact decisions (Kern, Klausch, & Kreuter, 2019).

Following this, an ordinal random forest model was introduced to enhance the prediction accuracy of the ordinal logistic regression model. This ensemble learning technique excels in

managing complex interactions between variables and mitigating overfitting through the aggregation of multiple decision trees, thereby boosting predictive performance (Buskirk & Kolenikov, 2015).

Subsequently, ordinal ridge regression was applied to tackle multicollinearity among the independent variables. This approach stabilizes regression estimates by incorporating a bias that reduces variance, thereby increasing the model's robustness. It is especially effective when predictors exhibit high correlation.

Finally, lasso regression was employed for variable selection and regularization. This technique refines the model's predictive accuracy by penalizing less significant variables, effectively shrinking their coefficients to zero. Consequently, the model becomes simpler and more interpretable. Each model was implemented in sequence to improve the accuracy and relevance of the calculations, ensuring a better fit for the data.

4 Results and Discussion

4.1 Survey Statistics

The survey results provide a comprehensive overview of the demographic distribution, financial circumstances, and attitudes towards blockchain technology among young adults in Mexico, and these findings can be effectively compared with the broader data discussed in this thesis.

The majority of respondents were young adults aged 20-23 (43.19%) and predominantly female (53.05%). Other significant age groups included those aged 27-29 (32.39%) and 24-26 (24.41%). Educationally, over half held a bachelor's degree (53.52%), with a substantial portion having completed high school (35.68%).

The survey revealed that 44.60% of respondents are employed full-time, while 19.25% are self-employed. This distribution mirrors the diverse employment landscape in Mexico, where informal and self-employed work is prevalent. As mentioned in the literature review, as of 2019, 56.9% of the workforce was engaged in informal employment, which likely overlaps with categories like self-employment and part-time work in the survey. The significant percentage of students (14.55%) also reflects the younger demographic reached by the survey.

Income levels among respondents also reflect the broader economic challenges discussed in this thesis. Nearly half of the participants (46.95%) reported earning less than $10,000 MXN per month, followed by 21.13% who earn between $20,001 and $30,000 MXN per month. This income distribution is consistent with the low wage environment previously discussed, where the minimum wage was reported to be 13.59 EUR per day in 2022, leading to insufficient pension contributions and inadequate retirement savings. The survey data supports the concern that a large portion of young adults may struggle to accumulate enough wealth to secure their retirement, emphasizing the need for innovative solutions like blockchain-based pension systems.

The survey results indicate that 61.97% of respondents currently have a pension plan, with the majority relying on the government's AFORE system (60.18%). This coverage is

somewhat higher than the general participation rates discussed earlier, particularly among those in informal employment who often do not qualify for pension plans due to insufficient contribution periods. The relatively higher coverage in this survey could be attributed to the younger, more educated demographic likely working in more formalized sectors.

However, despite this higher coverage, confidence in the current pension system remains low, with an average confidence rating of 2.06 out of 5. As shown in Figure 1, the distribution of confidence levels indicates that a significant number of respondents have low to moderate confidence in the pension system. This finding aligns with the broader scepticism expressed throughout this thesis, where current pension reforms are predicted to result in increased poverty rates among retirees. The significant percentage of respondents who are unsure (49.77%) or pessimistic (38.50%) about the sufficiency of their pensions for retirement underscores the inadequacies of the pension system, as previously discussed.

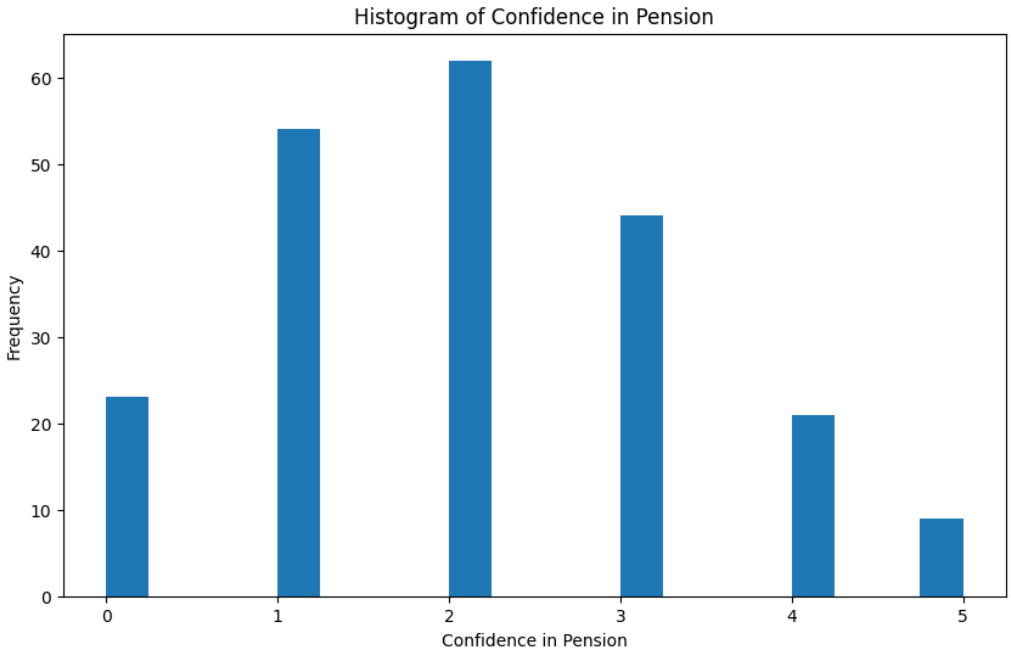

Figure 1

The survey also provides insight into respondents' cautious yet open attitudes towards blockchain technology, with over half (53.05%) having heard of it before the study. Trust in blockchain for financial transactions is moderate, with an average rating of 2.71 out of 5. This moderate level of trust and familiarity aligns with the potential of blockchain to improve transparency and efficiency in pension systems, particularly among a digitally literate younger population, as discussed in the literature review.

Nevertheless, significant concerns about blockchain, including trust issues (23.18%), lack of understanding (21.56%), and security concerns (20.75%), are consistent with the barriers identified earlier in this thesis. Additionally, from the open-ended responses, the most frequently mentioned words were "information" (18 mentions), "security" (16 mentions), and "transition" (11 mentions). These terms highlight the critical areas of concern for respondents, indicating a need for more comprehensive information about blockchain,

addressing security issues, and managing the transition to a blockchain-based system. Despite these concerns, the willingness of 64.79% of respondents to learn more about blockchain if it were implemented in pension systems suggests a potential for education and engagement strategies. This willingness can be seen as an opportunity to further explore how blockchain technology could be integrated into the pension system to address its current shortcomings.

4.2 Correlation Analysis

The correlation matrix (see Figure 2) provides insights into the relationships between key variables related to financial behavior, confidence in pension systems, and attitudes towards blockchain technology among young adults in Mexico. A moderate positive correlation between age and monthly income (r = 0.48) indicates that older respondents generally have higher income levels, which aligns with career progression. Interestingly, the correlation between monthly income and confidence in the current pension system is relatively weak (r = 0.12), suggesting that income alone doesn't strongly influence confidence levels.

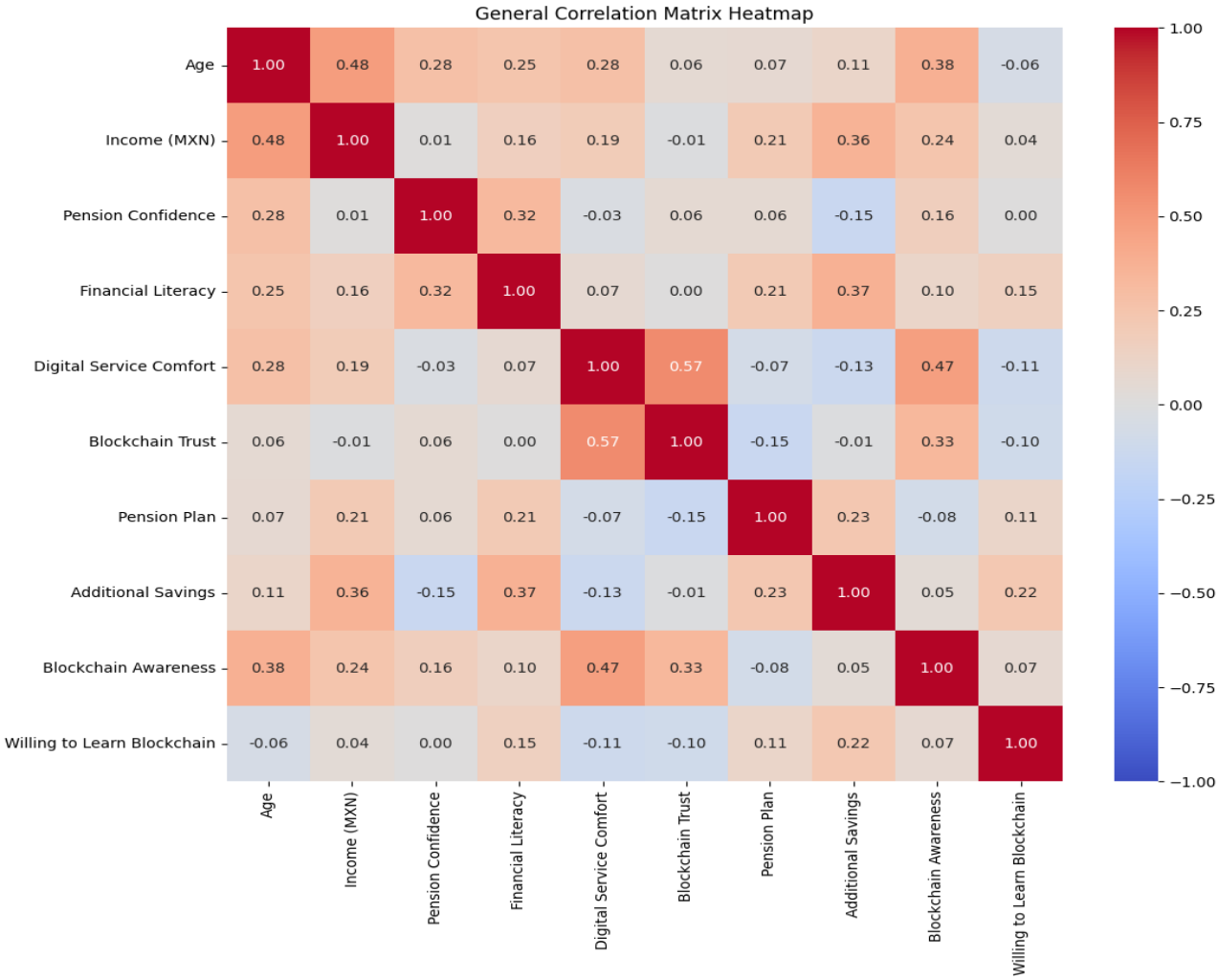

Figure 2

Additionally, there is a positive correlation between financial literacy and comfort with using digital financial services (r = 0.37), showing that individuals with higher financial

literacy are more comfortable using digital platforms. However, age shows a weak correlation with trust in blockchain technology for financial transactions (r = -0.06), and willingness to learn more about blockchain technology shows negligible correlations with most other variables. This suggests that trust in and openness to blockchain technology may be influenced by factors beyond traditional financial metrics.

Since the values in this correlation matrix do not portray any significant correlations, more tests were performed to explore other potential relationships and factors that might better explain the variability in attitudes towards blockchain and confidence in the pension system. These additional analyses aim to uncover deeper insights that could be masked by the surface-level correlations presented here.

4.3 Ordinal Regression Model Analysis

The Ordinal Regression Model was applied to explore the relationships between several independent variables—such as age, sex, marital status, education level, and income—and the dependent variable. The model demonstrated a log-likelihood of -307.94, with an AIC of 651.9 and a BIC of 712.4, based on 213 observations. While these fit statistics provide a baseline for model adequacy, the significance of individual predictors was mixed. The detailed results of this model are presented in Figure 3.

OrderedModel Results

Log-Likelihood:	-307.94
AIC:	651.9
BIC:	712.4

	coef	std err	z	P>|z|	[0.025	0.975]
Age_24-26	-0.5199	0.413	-1.258	0.209	-1.330	0.290
Age_27-29	0.6258	0.461	1.359	0.174	-0.277	1.528
Sex_Male	0.0134	0.278	0.048	0.962	-0.532	0.559
Sex_Other	1.0507	0.802	1.311	0.190	-0.520	2.622
Status_Married	-0.7399	0.465	-1.592	0.111	-1.651	0.171
Status_Single	-0.4546	0.443	-1.027	0.304	-1.322	0.413
Status_Widowed	-2.1006	1.340	-1.567	0.117	-4.727	0.526
Highest Level of Education Completed_Doctorate	-1.6512	0.850	-1.943	0.052	-3.317	0.014
Highest Level of Education Completed_High school	0.1307	0.320	0.409	0.683	-0.496	0.757
Highest Level of Education Completed_Master□s Degree	0.0814	0.540	0.151	0.880	-0.977	1.140
Monthly Income (In MXN)_$20,001 □ $30,000	-0.3688	0.504	-0.732	0.464	-1.356	0.619
Monthly Income (In MXN)_$30,001 □ $40,000	0.0684	0.535	0.128	0.898	-0.980	1.117
Monthly Income (In MXN)_Less than $10,000	-0.4582	0.379	-1.208	0.227	-1.202	0.285
Monthly Income (In MXN)_More than $40,000	-0.7804	0.637	-1.226	0.220	-2.028	0.467
0/1	-3.2973	0.657	-5.022	0.000	-4.584	-2.011
1/2	-0.0544	0.213	-0.255	0.799	-0.473	0.364
2/3	0.2002	0.133	1.507	0.132	-0.060	0.461
3/4	0.1226	0.122	1.002	0.316	-0.117	0.362

Figure 3

Age groups 24-26 and 27-29 showed coefficients of -0.5199 and 0.6258, respectively, yet neither was statistically significant, suggesting that age may not be a decisive factor in this context. Similarly, gender did not emerge as a significant predictor, with the coefficient

for males being nearly zero (0.0134, p = 0.962). Marital status also lacked strong predictive power, although the "Widowed" category exhibited a more negative coefficient (-2.1006), it still failed to reach significance (p = 0.117).

The analysis of education level and income provided further evidence that these variables might not be the most critical determinants in this model. For example, the coefficient for individuals with a Doctorate was -1.6512, approaching statistical significance (p = 0.052), suggesting a potential but weak inverse relationship with the dependent variable. Income levels across the board did not significantly impact the outcome. This is further illustrated in Figure 4, where the likelihood to switch is fairly evenly distributed across income categories, reinforcing the idea that income, as defined in this study, does not have a strong influence on the likelihood to switch. Given that many of the model's predictors did not yield significant correlations, additional tests and models were performed to uncover potential relationships that might provide more robust insights into the factors influencing the dependent variable. The results of these further analyses will also be explored in subsequent sections.

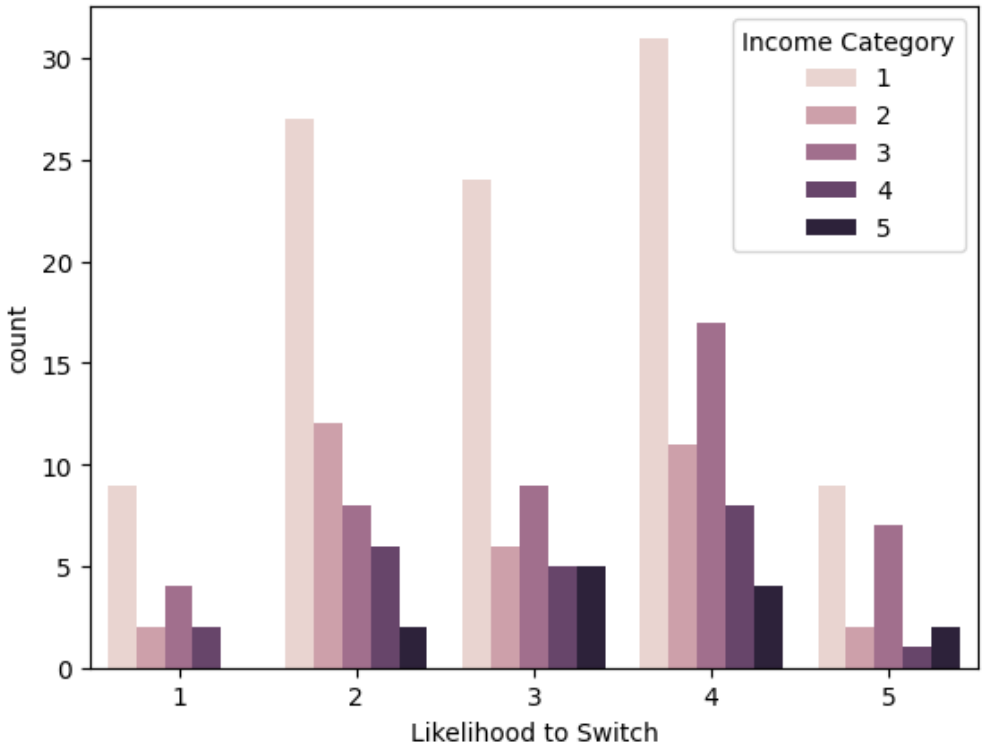

Figure 4

4.4 Decision Tree Analysis

To further explore the factors influencing the likelihood to switch to a blockchain-based pension system, a decision tree model was employed. The analysis identified the highest level of education completed and gender as key factors, with specific splits indicating how these variables interact to predict the likelihood to switch. Notably, the decision tree suggests that those with higher levels of education, particularly those who have completed a Doctorate or master's degree, are more likely to fall into higher categories of likelihood to switch.

However, the model's performance, as indicated by the precision, recall, and F1-scores, suggests that the decision tree's predictive power is limited. The overall accuracy of the model is 28%, with the precision and recall values showing considerable variability across different categories. For example, the model's ability to predict category 4 (likely to switch) is somewhat stronger (recall of 0.56) compared to other categories, but the performance for categories 1, 3, and 5 is notably poor, with several F1-scores indicating weak predictive accuracy.

These results suggest that while the decision tree model identifies certain educational and demographic variables as important, it may not be capturing all the complexities influencing the decision to switch. The relatively low accuracy and performance metrics indicate the need for more sophisticated modelling techniques or the inclusion of additional variables to better understand the factors driving individuals' likelihood to switch to a blockchain-based pension system.

4.5 Decision Tree Analysis

To further investigate the factors influencing the likelihood to switch to a blockchain-based pension system, a Random Forest model was employed. The feature importance analysis revealed that "Income Category" is by far the most significant predictor, with a much higher importance score compared to other variables such as "Sex" and "Highest Level of Education Completed" (see Figure 5). This indicates that income plays a critical role in determining individuals' likelihood to switch, overshadowing other demographic and educational factors.

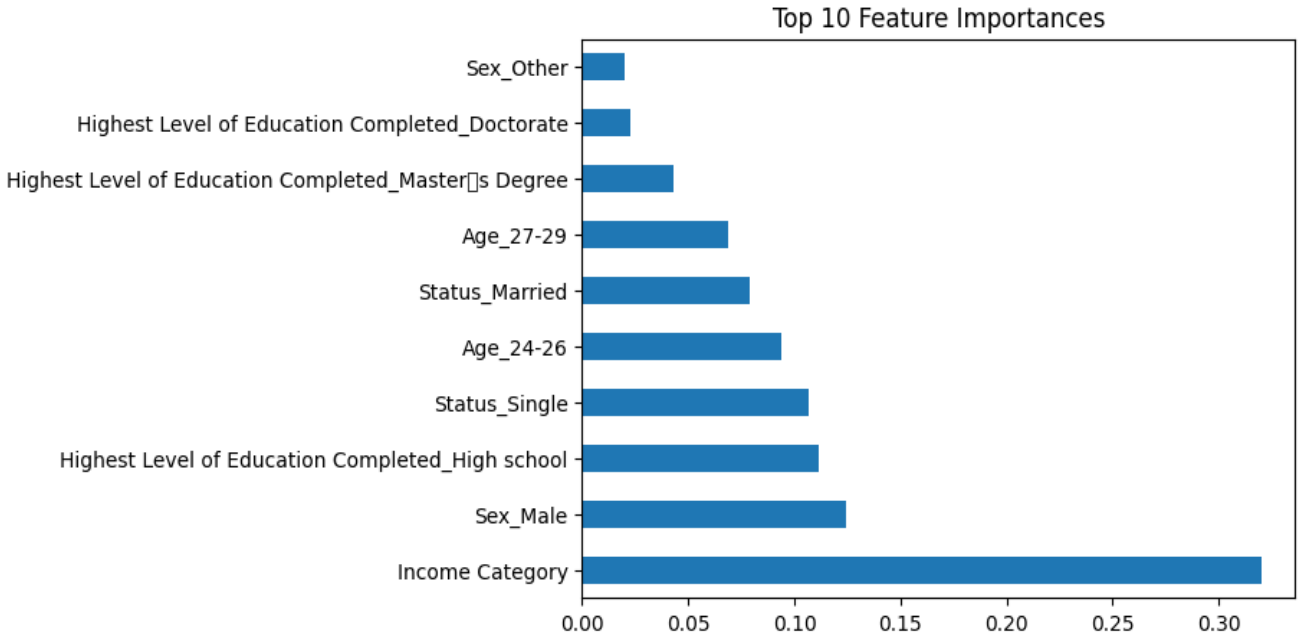

Figure 5

However, the overall performance of the Random Forest model, as indicated by the precision, recall, and F1-scores, was relatively modest. The model achieved an accuracy of 30%, with varying performance across different categories. For instance, while the model had

some success in predicting categories 3 (F1-score of 0.33) and 4 (F1-score of 0.38), it struggled with categories 1 and 5, where the F1-scores were notably low, indicating poor predictive accuracy.

Given the limitations observed in the previous models it is evident that additional approaches are necessary to uncover any underlying patterns that may not have been captured. The Random Forest analysis, while highlighting income as a dominant factor, still showed limitations in predicting the likelihood of switching to a blockchain-based pension system. To address these gaps and further explore potential relationships, a Ridge Regression model was employed, aiming to identify any significant predictors that might have been overlooked and to enhance the robustness of the analysis.

4.6 Ridge Regression Analysis

The Ridge Regression model exhibited challenges similar to those observed in previous analyses, with an overall accuracy of 27%. The model's performance was uneven across different categories, with a notable recall of 0.72 for category 4, indicating a higher likelihood of correctly identifying respondents inclined to switch. However, the precision and F1-scores for other categories, particularly 1, 3, and 5, were close to zero, reflecting the model's struggles in those areas. The macro F1-score of 0.13 and weighted F1-score of 0.18 further highlight the limited effectiveness of this model in capturing the complexity of the decision to switch.

Despite the application of Ridge Regression, the model faced similar challenges to those encountered in earlier analyses, falling short of fully capturing the complexity of factors that influence the decision to switch. Given these limitations, the Ridge Regression results suggested that additional approaches were needed. Therefore, Lasso Regression was employed as the final step to refine the analysis and potentially uncover more significant predictors.

4.7 Lasso Regression Analysis

As the final model in this analysis, Lasso Regression was employed to further refine the identification of significant predictors influencing the likelihood to switch to a blockchain-based pension system. The Lasso Regression model produced a Mean Squared Error (MSE) of 1.18 and an R^2 score of 0.0005, indicating that the model has limited explanatory power for the variance in the data.

The analysis of feature importance, as shown in Figure 6, revealed that three variables—Sex (Male), Income Category, and Age (24-26)—were the only predictors with non-zero coefficients. Among these, the "Sex (Male)" variable had the highest positive coefficient, followed by "Income Category," while "Age (24-26)" had a negative coefficient. These results suggest that being male and having a higher income are associated with a greater likelihood of switching, while being in the 24-26 age group might decrease this likelihood.

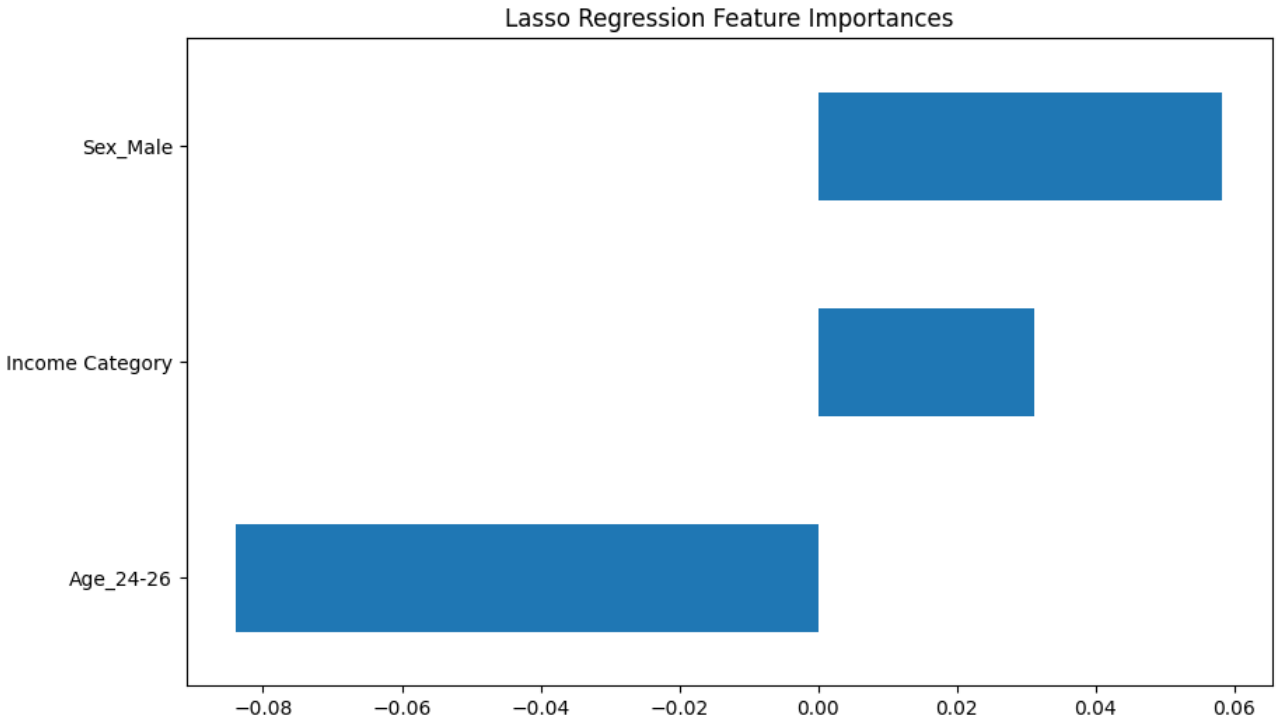

Figure 6

However, the low R^2 score and the small magnitude of the coefficients indicate that these factors alone do not sufficiently explain the decision to switch, reinforcing the conclusions drawn from earlier models. The Lasso Regression's ability to select only a few relevant features underscores the possibility that other, unmodeled factors may play a more significant role, and that further investigation is needed to fully understand the drivers behind this decision-making process.

5 Conclusion and Future Work

This study set out to explore the potential of blockchain technology in encouraging young adults in Mexico to engage in retirement planning, particularly through the adoption of blockchain-based pension systems. Through a comprehensive survey and the application of various statistical models—including Ordinal Regression, Decision Tree, Random Forest, Ridge Regression, and Lasso Regression—the analysis aimed to uncover the factors that might influence the likelihood of switching to such a system.

Despite the extensive efforts to identify significant predictors, the results across all models were inconclusive. None of the models demonstrated strong predictive power, with accuracy levels generally hovering around 27-30%. Even though some variables, such as income category and education level, showed relevance in certain models, their impact was not consistent or strong enough to draw definitive conclusions. The Lasso Regression, while helping to narrow down the most relevant predictors, still failed to explain the decision-making process adequately, as indicated by its low R^2 score.

These findings suggest that the variables selected for this study—such as age, sex, marital status, income, and education—may not fully encapsulate the complexities involved in the decision to adopt a blockchain-based pension system. It is possible that other,

unmeasured factors play a more significant role, or that the decision-making process itself is influenced by a more intricate interplay of variables than what was captured in this research.

In conclusion, while the study provided valuable insights into the attitudes of young adults towards blockchain technology and retirement planning, it also highlighted the limitations of the current models and variables. Future research should consider expanding the scope of variables and perhaps employ more advanced modeling techniques to better understand the drivers of adoption for blockchain-based pension systems in Mexico. This approach may help to uncover the deeper factors influencing retirement planning decisions and ultimately contribute to the development of more effective strategies for engaging young adults in securing their financial futures.

References

Mercer. Mercer CFA Institute Global Pension Index [Online], 2023, available at https://www.mercer.com/globalpensionindex.

Instituto Nacional de Estadística y Geografía (INEGI). (2021). *Clasificaciones del Censo de Población y Vivienda 2020*. Aguascalientes, México: INEGI. Retrieved from https://en.www.inegi.org.mx/temas/estructura/

Forbes México. (2023). Así es como funciona el sistema de pensiones actual en México. Forbes México. Retrieved from https://www.forbes.com.mx/portada-dinero/consar-asi-es-como-funciona-el-sistema-de-pensiones-actual-en-mexico/

Alanis Gutiérrez, T. L., & Soto Esquivel, R. (2020). Sistema de pensiones en México: Una burbuja a punto de estallar. Ola Financiera, 13(35), 32-51. https://doi.org/10.22201/fe.18701442e.2020.35.75508

INEGI. (2023). Encuesta Nacional de Ingresos y Gastos de los Hogares 2022: Presentación de resultados. Instituto Nacional de Estadística y Geografía. Retrieved from https://www.inegi.org.mx/contenidos/programas/enigh/nc/2022/doc/enigh2022_ns_presentacion_resultados.pdf

CONEVAL. (2019, August 28). *Un sistema de protección universal que sustituya programas inconexos y dispersos, recomendable para la población adulta mayor*. Ciudad de México: Consejo Nacional de Evaluación de la Política de Desarrollo Social. Retrieved from https://www.coneval.org.mx

Sarker, I., & Datta, B. (2022). Re-designing the pension business processes for achieving technology-driven reforms through blockchain adoption: A proposed architecture. Technological Forecasting & Social Change, 174. https://doi.org/10.1016/j.techfore.2021.121059

Zapata Aguilar, J. A., Navarrete Moguel, J. J., & Cabrera Ignacio, E. (2023). Conocimiento sobre pensión y AFORE entre jóvenes universitarios. Panorama Económico (1870-2171), 18(38), 55–71.

Colín, F. (2019). *The old-age pension law in Mexico: The promise of poverty in old age?* International Social Security Review, 72(4), 29-53. https://doi.org/10.1111/issr.12195

Apella, I., & Zunino, G. (2023). *Work histories and workers' failure to satisfy pension contribution requirements: A comparison of Mexico and Uruguay*. International Social Security Review, 76(2), 77-100. https://doi.org/10.1111/issr.12231

Gatteschi, V., Lamberti, F., Demartini, C., Pranteda, C., & Santamaría, V. (2018). Blockchain and smart contracts for insurance: Is the technology mature enough? *Future Internet*, 10(2), 20. https://doi.org/10.3390/fi10020020

Mlika, F., Karoui, W., & Romdhane, L. B. (2024). Blockchain solutions for trustworthy decentralization in social networks. *Computer Networks*, *244*. https://doi.org/10.1016/j.comnet.2024.110336

Andrew, J., Isravel, D. P., Sagayam, K. M., Bhushan, B., & Sei, Y. (2023). Blockchain for healthcare systems: Architecture, security challenges, trends and future directions. *Journal of Network and Computer Applications*, *215*, 103633. https://doi.org/10.1016/j.jnca.2023.103633

An, A. B. (2002). Performing logistic regression on survey data with the new SURVEYLOGISTIC procedure. In *Proceedings of the 27th Annual SAS Users Group International Conference* (Paper 258-27). Cary, NC: SAS Institute Inc.

Kern, C., Klausch, T., & Kreuter, F. (2019). Tree-based machine learning methods for survey research. *Survey Research Methods*, *13*(1), 73-93. https://doi.org/10.18148/srm/2019.v13i1.7395

Buskirk, T. D., & Kolenikov, S. (2015). Finding respondents in the forest: A comparison of logistic regression and random forest models for response propensity weighting and stratification. *Survey Methods: Insights from the Field (SMIF)*, 1-17. https://doi.org/10.13094/SMIF-2015-00003