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# Digital microfinance and algorithmic bias: Implications for financial inclusion in Morocco

# Microfinance numérique et biais algorithmique : implications pour l'inclusion financière au Maroc

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**Abstract**
This research explores the effect of digital microfinance and algorithmic biases on financial inclusion in Morocco. The objective of this study is to develop an integrated model taking into account perception of utility (according to the Technology Acceptance Model – TAM), digital skills, algorithmic fairness mechanisms, and biases induced by algorithms, to assess and predict equitable access to digital financial services.
The methodology adopted is quantitative and hypothetico-deductive, based on a convenience sample of 250 digital microfinance users, including both individual borrowers and informal sector micro-entrepreneurs. The data were collected using a structured questionnaire and analyzed via PLS-SEM (SmartPLS 4), allowing to assess simultaneously the reliability of measures, structural relationships, as well as mediation and moderation effects.
The result concludes that digitalization of finance increases perceptions of utility and trust and indirectly improves financial inclusion. However, algorithmic bias limits these positive impacts while digital literacy and equitable mechanisms will mitigate these effects. Sequential mediation supports the conclusion that perceptions of utility and trust are the most important channels to obtain these results, which have significant implications for policymakers and managers of financial institutions, by demonstrating the importance of creating inclusive digital infrastructure, providing digital literacy education, and developing algorithmic equity mechanisms to increase access to credit and reduce financial inequality within Morocco.
**Keywords :** « Digital microfinance, financial inclusion, algorithmic bias, digital literacy, Morocco ».

**Résumé**
Cette recherche explore l'effet de la microfinance numérique et des biais algorithmiques sur l'inclusion financière au Maroc. L'objectif de cette étude est de développer un modèle intégré prenant en compte la perception d'utilité (selon le Technology Acceptance Model – TAM), les compétences numériques, les mécanismes d'équité algorithmique et les biais induits par les algorithmes, évaluer et prévoir un accès équitable aux services financiers numériques.
La méthodologie adoptée est quantitative et hypothético-déductive, basée sur un échantillon de commodité de 250 utilisateurs de microfinance numérique, comprenant à la fois des emprunteurs individuels et des micro-entrepreneurs du secteur informel. Les données ont été collectées à l'aide d'un questionnaire structuré et analysées via PLS-SEM (SmartPLS 4), permettant d'évaluer simultanément la fiabilité des mesures, les relations structurelles, ainsi que les effets de médiation et de modération.
Le résultat conclut que la numérisation de la finance augmente les perceptions d'utilité et de confiance et améliore indirectement l'inclusion financière. Cependant, le biais algorithmique limite ces impacts positifs tandis que la culture numérique et les mécanismes équitables atténueront ces effets. La médiation séquentielle soutient la conclusion que les perceptions d'utilité et de confiance sont les canaux les plus importants pour obtenir ces résultats, qui ont des implications significatives pour les décideurs politiques et les gestionnaires d'institutions financières, en démontrant l'importance de créer des infrastructures numériques inclusives, d'offrir une éducation à la littératie numérique et de développer des mécanismes d'équité algorithmique afin d'accroître l'accès au crédit et de réduire les inégalités financières au Maroc.
**Mots-clés : «** Microfinance numérique, inclusion financière, biais algorithmique, littératie numérique, Maroc ».

## Introduction

Access to credit is one of the leading factors that contribute to financial inclusion and creating new, income-generating activities in developing nations and, therefore, removing the existing structural barriers that prevent millions of people from accessing formal financial systems. Historically, microfinance has fulfilled this role in Morocco by providing services to vulnerable populations that are often rural, modest, and/or engaged in informal economic activity with limited access to traditional banking services. The advent of digital technologies and microfinance platforms is now bringing new definitions to how credit is provided by utilizing automated algorithmic systems (e.g., machine learning, automated scoring) designed to optimize lending decisions and expand access to credit (Santhosh Kumar, K., & Aithal, P. S., 2024).

Those banks and microfinance institutions that can gather vast volumes of data through their digital tools and reduce their operating costs will be well positioned to expand their financial services to segments of the population that have, until now, been excluded from accessing the formal financial system. Recent studies in the digital economy demonstrate that digitalization has the capacity to support financial inclusion by enhancing access to and use of financial services (mobile banking, fintech platforms) for previously underserved populations; however, the impact of digitalization remains contingent upon the presence of barriers to entry such as a lack of digital financial literacy, the rural-urban divide, and inadequate infrastructure for rural areas of Morocco (Khafif, H., et al., 2025).

The increasing use of algorithms in credit granting systems raises new methodological and ethical questions. However, several studies describe algorithmic bias as highly technical management and warn against the idea that automated models are inherently free from bias, because many are created from historical data subject to discrimination related to socioeconomic status, gender, or the location of credit seekers (Kelly & Mirpourian, 2021).

In addition, research on credit granted to women and other underrepresented groups using digital tools has shown that models based on artificial intelligence can create adverse credit scores, even when the beneficiaries have an above-average repayment capacity (Genevieve Smith, 2025).

Indeed, when digital technology is used in the context of microfinance, it does not necessarily lead to equitable inclusion; it can also reproduce the structure of inequalities through the presence of algorithmic biases, unless the latter are systematically identified and corrected.

In this sense, the central question that permeates this debate is as follows: do digital tools actually improve the financial inclusion of marginalized populations in Morocco or, on the contrary, reproduce and reinforce pre-existing gender inequalities, to rurality and economic informality? Answering this question requires not only analyzing the adoption and efficiency of digital microfinance technologies, but also evaluating their impact on the different dimensions of financial inclusion: access, use, quality and equity. Within a national context marked by strong territorial and social disparities.

## 1. Literature review

### 1.1. Digital microfinance: concepts and evolution

The digitalization of microfinance means the integration of digital technologies into the traditional practices of microfinance institutions (MFIs), such as the use of digital platforms or online sites, mobile banking applications and services, automated credit assessment services and financial technology solutions. The digitization of an MFI goes far beyond simply digitizing its normal operations. It consists of providing customers with new digital tools such as mobile applications, e-wallets and automated credit-scoring systems using non-traditional data. The digitalization of MFIs will increase efficiency while helping MFIs reach new clients by reducing operational costs.

It is becoming increasingly clear that the importance of digitalization has increased significantly in Morocco's financial inclusion strategy. In terms of performance, several recent reports highlight the ability of MFIs and FinTech entities to improve the overall efficiency of their operations through digital platforms and provide services to previously unserved clients, particularly in semi-developed areas.urban and rural areas of the country (Harkat, Ez-Zarzari & Hafid, 2025).

Moreover, empirical analyses show that the introduction of financial technologies and hybrid solutions in the Moroccan market helps to increase access to financial services. However, the success of these new digital technologies depends heavily on users' digital literacy and their ability to understand and effectively use these tools (Zerouali & Hinti, 2025).

Digital microfinance is conceptually different from traditional microfinance, in particular because of four main characteristics: access via digital channels, reduced dependence on human intervention, and the use of alternative forms of data (mobile transaction history, geolocation, online activity) to assess the creditworthiness of potential borrowers, and the use of digital tools for managing financial services.

These developments reflect a global trend towards financial innovation through FinTech, mobile banking and digital payments as catalysts for promoting greater financial inclusion. However, they also raise important issues related to the adoption, digital literacy and regulation of these new technologies (Lehim, et ali, 2015; Ajaoun & Kharbouch, 2016).

However, hitches remain: the digital divide, infrastructure problems in some regions (geopolitical), limited technological skills of a segment of the population, and data security issues are still holding back more widespread adoption of digital services. These challenges are particularly acute in rural areas or among women who work in the informal sector, two groups that have historically been excluded from formal banking channels, casting a contradiction between the potential for digitalization and its appropriation. (Ait Hbibi & Makhrout, 2025).

Consequently, digital microfinance is much more than a technological extension of traditional models; it is the structural transformation of credit practices that presents an opportunity for scalable financial access when paired with sufficiently aligned policies. However, this transformation will not happen spontaneously: it must be linked to improved financial literacy and a proper regulatory framework if we want delivery of credit not to reproduce or strengthen prevailing inequalities.

### 1.2. Algorithmic bias in the granting of credit

Widespread adoption of artificial intelligence (AI) and machine learning (ML) algorithms has radically changed decision-making practices in credit scoring systems across the financial space. They can analyze large databases, identify complex motives, and lead to accelerated lending decisions; nevertheless, such automated tools also have very substantial risks of algorithmic bias, which could reinforce or reproduce existing discrimination against selected marginal social groups.

The essential part of this phenomenon is that algorithmic models are based on historical data generated by the commercial practice of financial institutions a long time ago. This reliance on training data easily translates into an existing distribution of latent inclinations that could be sorted in prior human provost decisions, as around gender, social class, or geography, which can create auto-choices to assimilate and reiterate the same inequities. For instance, literature reviews indicate that despite the exclusion of sensitive attributes (e.g., gender or origin) from the models, proxies like postal code or spending habits might still bring discrimination to results.

Using empirical data, some studies conducted in African contexts have demonstrated that automated credit models can help widen the scope of credit access but also inflict differential

penalties across gender lines. A comparison of 10 credit-scoring models across multiple African countries found that one family of algorithms systematically allocated more financing to male-run businesses with similar financial profiles as female-run ones. This 'double discrimination' (Duvendack et al. 2014) shows how technical choices, like the choice of whether to include or exclude sectoral variables, networked relationships, and the like, can trigger an indirect reduction in equity in access to finance even when there is no explicit intention to discriminate. Other theoretical and methodological work reflects that algorithmic biases are rarely as simple as binary discrimination; instead, they can be combined in a dynamic of intersectional inequalities, wherein different combinations of socio-demographic attributes (such as gender, age, parenthood, or socioeconomic status) can result in cumulative disadvantage at the point of credit allocation. So this means that vulnerable groups at the intersection of several marginalized characteristics may face even additional challenges.

Several pieces of literature on algorithmic fairness in credit assessment also focus on measuring and simulating these biases. Automated models demand careful treatment of input data, targets that it is intended to learn, and the metrics by which groups are treated fairly, or not, and a variety of techniques have emerged, ranging from preprocessing the data to integrating fairness constraints in an attempt to minimize differentials in model performance while maintaining other acceptable performance criteria. This vigilance is critical in contexts where regulators and policymakers have yet to set the groundwork to protect societies from intrusions of automated discrimination; if you put digital microfinance systems in perspective, trust could easily be compromised.

It follows that, rather than the neutrality of technology, the design and application of credit-granting algorithms need to render visible their socioeconomic effects, and especially how these tools might bolster inequality among populations at risk of being discriminated against along axes such as gender, rurality, or economic informality, the very inequalities they were meant to help tackle.

### 1.3. Critical analysis: digitalization and financial inclusion in Morocco

Digital microfinance is gaining traction across Morocco, and this gives rise to a considerable number of empirical studies on its effects on financial inclusion. The results show that while for some, digital tools do help to reach credit customers, the gain simply cannot be over trusted without taking into account the various contextual factors at play, including local variations in sectors such as digital divides and variations in financial literacy and availability of key hardware infrastructures. According to Harkat et al. (2025) While digital microfinance

platforms have been conceptualized to target low-income populations and millennial-driven technologies (2023; 2025) amongst other segments, the impact has been minimal within rural areas and women active in the informal sector owing to restrictions faced in the acquisition of Smartphone's, internet services, and digital skills.

And a second important aspect relates to quality and eligibility. Algorithms trained on historical data will reproduce past discriminatory financial practices with uneven credit assignment. Take, for instance, the work of Zerouali & Hinti (2025) that indicates how some rural women and microentrepreneurs are being offered poorer loan terms despite robust financial profiles revealing a potential to reproduce structural inequalities.

Furthermore, digitalization is no silver bullet for financial inclusion. Studies have shown that simply because digital platforms are available does not mean they are being used effectively among the populations we would like to target. Therefore, managing digital and financial literacy is still a consideration for borrowers to navigate, understand, and make the best use of these services (Lehim et al., 2025).

Lastly, Moroccan regulators and financial institutions have to find the balance between preventing algorithmic discrimination while allowing room for innovation. Data scarcity, the lack of reliable frameworks for monitoring and evaluation of automated systems can drive negative spin-offs: excluding vulnerable groups, leading to an imbalance by territory, and damaging trust in digital financial services (Ait Hbibi & Makhrout, 2025).

In summary, while providing wider access potential, a closer examination reveals limitations in respect to true inclusion, service quality and algorithmic bias in digital microfinance. However, to accomplish their goal, it will be essential to take corrective measures and develop financial and digital literacy in order for the microfinance systems in Morocco that encourage the use of digital technology as a tool for inclusion to be efficient.

### 1.4. Perspectives and recommendations

For instance, in order for the increasingly important role of digital microfinance to fit into the larger financial inclusion efforts in Morocco and generate a real impact, this needs to be achieved through actions across several layers:

#### 1.4.1. Strengthening financial and digital literacy

Digital platforms are only as effective as a user's ability to recognize and take advantage of services that are available. This can be mitigated via targeted training programs designed for rural and informal sector women personnel to reduce the digital divide and promote ownership of digital tools (Harkat et al., 2025).

#### 1.4.2. Detect and correct algorithmic biases

Financial institutions are expected to build mechanisms that allow continuous evaluation of algorithms for any emerging biases with respect to possible gender bias or bias by location or socio-economic status. Data preprocessing, proxy variable fitting, and use of equity constraints in scoring may be some approaches useful in improving credit decision accuracy (Kelly & Mirpourian, 2021).

#### 1.4.3. Regulate digital microfinance

Static standards, regulators should clarify expectations around data protection, algorithm transparency, and fairness as it relates to automated financial services. A well-designed legal foundation will contribute to boosting public trust in digital financial services while also avoiding any inadvertent exclusion (Ait Hbibi & Makhrout, 2025).

#### 1.4.4. Adapt solutions to local contexts

Digitalization cannot be one-size-fits-all: it needs to respond to territorial realities and availability of infrastructures, as well as socio-economic constraints. This integration of hybrid services, or the combination of digital and human support, could be considered as a middle-range solution to communicate with people who are not very well familiarized with digital tools (Zerouali & Hinti; 2025).

Digital microfinance in Morocco is likely to provide a large opportunity for credit as well as financial inclusion. But its influence remains contingent upon digital literacy and algorithmic accountability. In the absence of adequate mitigation and regulation, digitalization may also reproduce or even increase existing inequalities across already vulnerable groups, including women and rural populations, but particularly informal workers.

Therefore, the combination of technological innovation, financial and digital literacy, and active regulation is the tried-and-true formula to turn a platform's potential for contributing to financial inclusion into reality. Only an integral approach will allow digital microfinance to become a true vector of equity and socio-economic development in Morocco.

### 1.5. Development and formulation of hypotheses

The proposed model is based on three complementary theoretical perspectives. First, the technology acceptance model (TAM) justifies the incentive to use digital microfinance platforms by their perceived usefulness and ease of use. Secondly, the theory of financial inclusion considers that the digitalization of financial services can help overcome the geographical, informational and transactional barriers that threaten to exclude a large part of the population. Third, the algorithmic fairness perspective emphasizes that automated credit

decisions could replicate or extend exclusion when the system is perceived as opaque, discriminatory, or unfair by its users.

Thus, the articulation of these three perspectives allows for a better understanding of the factors that influence the adoption of digital microfinance platforms as well as their potential effects on financial inclusion and equity of access to financial services.

Perceived utility and perceived ease of use, as well as the adoption of digital microfinance services, represent the positive mediation mechanism through which digitalization improves financial inclusion. On the other hand, perceived algorithmic bias represents a negative explanatory factor that can restrict equitable access to funding. Finally, financial and digital literacy is presented as an additional determinant of financial inclusion, while algorithmic equity mechanisms are considered a moderator that can reduce the negative effect of perceived algorithmic bias.

#### 1.5.1. Digitalization of services: Main hypothesis

The digitalization of microfinance services involves offering financial products and services over-the-top (OTT) via mobile applications, digital platforms or automated interfaces as well as remote service channels. These tools may help with lowering distance, transaction costs, administrative complexity and time constraints for populations long excluded by formal finance. Hence, they can use digital microfinance platforms to access information about finance as well as apply for credit or repay, and thus achieve financial inclusion through these services.

**H1:** Digitalization of microfinance services has a positive effect on financial inclusion.

#### 1.5.2. Hypothesis on algorithmic biases

Even though digital platforms tend to provide wider access to finance, the automation of credit scoring and algorithmic-based decision making could also lock people out in new ways. In a study based on survey data, it is more relevant to investigate perceived algorithmic bias, that is users' beliefs about the unfairness, opacity or disadvantage of automated financial decisions towards certain classes of applicants.

If users do perceive digital credit systems as biased, they are likely to enjoy unequal access to credit, less confidence in digital microfinance institutions and reduced likelihood of using these services. Thus, perceived algorithmic bias is expected to reduce financial inclusion.

**H2:** Algorithmic Biases Detract from Financial Inclusion

#### 1.5.3. Hypotheses regarding mediation through Perceived Utility (TAM)

Digitalization is not a panacea for financial inclusion. These technologies must also be experienced as being useful and effective, hence user-friendly. Following TAM, the perceived

usefulness indicates how much users believe that digital microfinance platforms facilitate access to financial services and perceived ease of use reflects how understandable and easy-to-operate these platforms are.

Users have higher intention to adopt digital microfinance services when they perceive them as useful and accessible. Then it all boils down to adoption, which is the practical way digitalization becomes better access to credit, savings, payments and other financial services.

**H3:** TAM mediates the relationship between service digitalization and financial access.

**H4:** The relation between digitalization of services and the perceived decrease of algorithmic biases will be mediated by the perception of utility (TAM).

#### 1.5.4. Hypotheses on digital literacy and equity mechanisms

Digital andfinancial literacy means the degree of users to understand financial products, navigate digital platforms, read information to interpret and make informed decisions about their finances. The availability of digital microfinance services, however, does not mean that less skilled individuals can use them to full effect. On the contrary, users with greater capacity to using digital tools and finance are higher in going through understanding platform functions, completing out digital procedures and also utilizing financial services effectively.

**H5:** Digital and financial literacy directly enhances financial inclusion.

**H6:** Algorithmic equity mechanisms, which increase financial inclusion and moderate the consequences of algorithmic biases.

#### 1.5.5. Hypothesis of sequential mediation

Algorithmic equity mechanisms are the safeguards that seek to bolster or introduce transparency, explainability, contestability and fairness in automated financial decision-making. Such mechanisms can consist of transparent eligibility criteria, human-review processes, easily accessible complaint channels and explanation of automated decisions as well as monitoring of discriminatory outcomes on a regular basis.

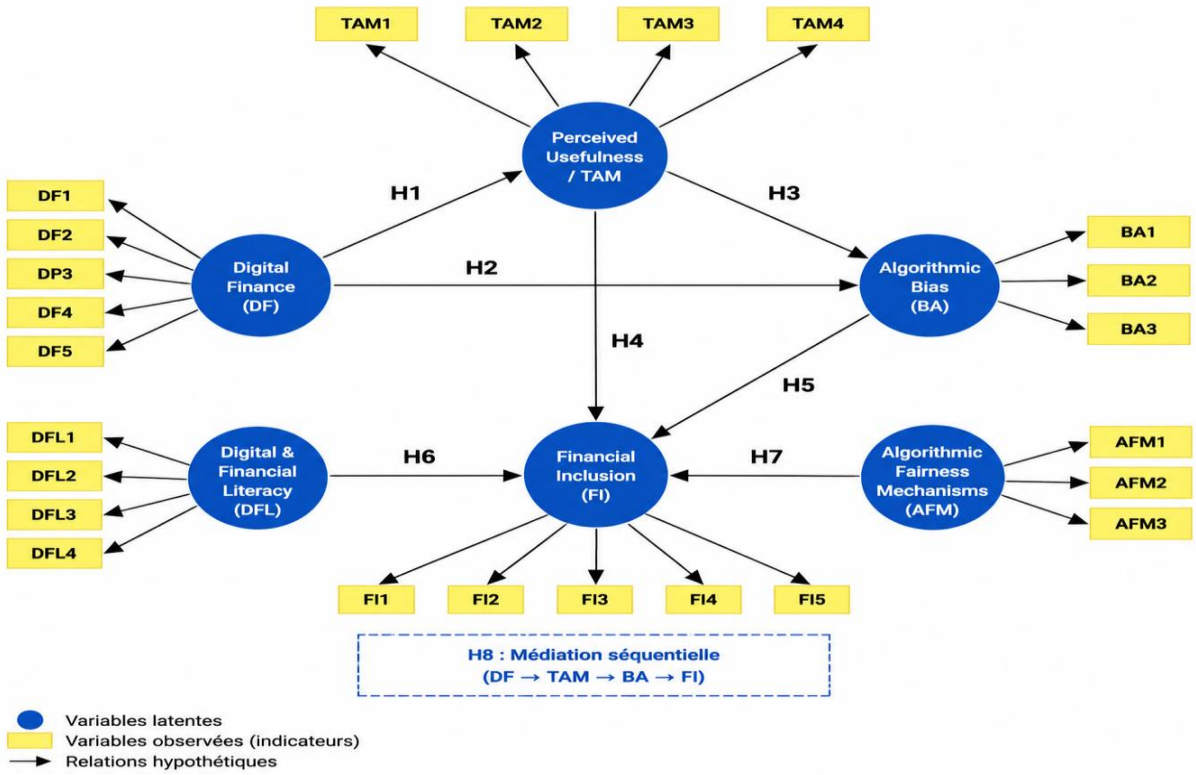
This type of mechanisms can mitigate the adverse effects related to reported inequality in algorithmic decision-making. It holds that when users feel there are appropriate controls in place, any negative association between algorithmic bias and financial inclusion should be mitigated.

**H7:** Digitalization of service through sequential mediation (TAM) and algorithmic bias will positively influence financial inclusion.

This formulation sets the empirical model tested with PLS-SEM and positions every hypothesis on the observed results from Morocco while mobilizing the key concepts taken from the literature concerning digital microfinance, algorithmic justice, and digital literacy.

Figure 1 presents the conceptual model of research.

**Figure N°1: the structural model of research (PLS-SEM)**




**Source: Results generated by SmartPLS**

## 2. Research methodology

### 2.1. Methodological approach

This study adopts a quantitative and hypothetico-deductive approach, in order to test the relationships between digital microfinance, utility perception, algorithmic biases, digital and financial literacy, algorithmic equity mechanisms, and financial inclusion.

This approach is particularly suitable for a PLS-SEM model, as it allows to deal with complex relationships between latent variables and to examine both direct and moderator effects. The PLS-SEM is recommended for searches with samples of moderate size and when the data distribution does not necessarily follow a strict normality (Hair et al., 2022).

### 2.2. Target population and sampling

- Target population

The sample contains a total of 250 people from two categories associated with digital microfinance in Morocco.

- Digital beneficiaries are people who utilize digital services such as accessing credit or other forms of funding through an online platform.

-Micro-entrepreneurs and informal workers also benefit from accessing digital credit (e.g., microfinance) as an option for developing their businesses in both cities and rural areas.

Table 1 provides a summary of the socio-demographic characteristics of the sample.

**Table 1. Characteristics of the sample**

| Variable | Category | Sttaf | Percentage |
|---|---|---|---|
| Gender | Male | 120 | 48% |
| | Woman | 130 | 52% |
| Statut | Specific borrower | 180 | 72% |
| | Microentrepreneur / informal | 70 | 28% |
| Age | <25 years | 60 | 24% |
| | 25-40years | 110 | 44% |
| | > 40 years | 80 | 32% |

**Source: Prepared by the authors**

The sample is almost balanced in terms of gender (52% female), with most respondents being individual borrowers (72%) The presence of micro-entrepreneurs and informal workers (28%) enhances the analysis, in particular to assess how algorithmic biases and equity mechanisms also operate on financial inclusion issues across population segments.

### 2.3. Collection instrument and variables

The data were collected using a structured questionnaire on a Likert scale 1-5, consisting of two main sections:

A. Respondent profile

-Sex

-Age

-Status (private borrower, micro-entrepreneur/informal worker)

-Region of residence

B. Latent variables

The latent variables were measured on a scale of 1 to 5. The items used are as follows:

- Digitalization of microfinance services (DF)

-DF1: Digital microfinance services provide broad availability.

-DF2: The credits are at my disposal through mobile apps or the web.

-DF3: Transactions have low cost and are performed with great ease.

-DF4: Most financial institution accepts digital microfinance services.

-DF5: I may perform my everyday financial/business operations using digital technologies.

- Perceived utility and ease of use (TAM)

-TAM1: Digital platforms are useful for managing my credits.

-TAM2: The platforms are simple, easy to use.

-TAM3: These platforms make my financial transactions more efficient.

-TAM 4: Digital services offer trust and convenience for my operations.

- Algorithmic bias (AB)

-BA1: I think only certain groups are being rewarded (or disadvantaged) in the awarding of digital credits.

-BA2: There is an impression that automatic credit decisions are not fair

-BA3 : I observe difference of access to credit by gender or geographical area.

- Digital and financial literacy(DLF)

-LDF1: I know how to use digital microfinance platforms appropriately.

-LDF2: I know the basic financial concepts needed to make sure that my digital credits managed well

-LDF3: My understanding or the knowledge I get by the digital platforms and notifications.

-LDF4: with you confidently online to make financial decisions.

- Algorithmic fairness mechanisms (AEM)

-MEA1: The platforms have provided for some mechanisms to mitigate bias in the granting of credits;

-MEA 2: Credit decisions appear equitable across all users.

-MEA3: The fairness of the process is assured to me by how transparent the algorithms are.

- Dependent Variable: Financial Inclusion (FI)

-IF1: Digital platforms have given me access to financial services on a consistent basis.

-IF2: There are loans available that have terms that fit my needs.

-IF3: Currently, I use digital financial services for personal and business-related purposes.

-IF4: Financial services are fairly distributed among groups.

-IF5: I share and endorse the use of digital platforms with others who need to borrow money.

- Summary of constructs:

-Digitalization of services involves both accessibility and availability of digital services.

-Perceptions of utility, according to TAM, involve both usefulness and ease of use for digital platforms.

-Algorithmic bias is where I perceive inequity or discrimination based on some algorithm.

-Digital and financial literacy concerns my ability to understand and use digital services.

-Algorithmic fairness mechanisms help I understand how and what is fair with regard to an algorithm, including correction methods and algorithm transparency.

-Financial inclusion is the dependent variable and is intended to measure the degree of access to and/or use of, and/or fairness in, financial services

### 2.4. Data analysis

The data was analyzed using SmartPLS 4 according to the PLS-SEM method, in two steps:

- Evaluation of the measurement model

-Internal reliability: Cronbach's alpha, Composite Reliability (CR), AVE.

-Convergent and discriminant validity: HTMT, Fornell-Larcker.

-Outer Loadings.

-Verification of common method bias: VIF in complete collinearity.

- Evaluation of the structural model

-Standardized coefficients (β) to test relationships between latent variables.

-Mediation tests via bootstrapping (5,000 samples).

-Model quality indicators: $R^2$, $f^2$, $Q^2$, SRMR.

- The expected results:

-calculated coefficients (β) for standardized tests of the relationship between latent variables;

-mediation tests using a bootstrap using 5000 samples;

-and model fitting indicators, including $R^2$, $f^2$, $Q^2$ and SRMR.

This project hypothesizes that the digitization of services will have a positive and direct effect on financial inclusion, that algorithmic biases will have a negative effect on the level of financial inclusion, and that digital literacy and/or mechanisms to overcome algorithmic bias will improve financial inclusion. The global model should be well adjusted ($R^2$ and $Q^2$ will be high) with strong predictive relevance.

## 3. Empirical study and results

### 3.1. Measurement model

- **Internal reliability and convergent validity**

The results relating to internal reliability and convergent validity are satisfactory. All indices of Cronbach's alpha, Composite Reliability (CR) and Average Variance Extracted (AVE) exceed the recommended thresholds, confirming the robustness of latent constructs.

**Table 2: Reliability and convergent validity of the measurement model**

| Variable | Cronbach's Alpha | CR | AVE |
|---|---|---|---|
| Digital Finance (DF) | 0.892 | 0.921 | 0.702 |
| Perceived Usefulness / TAM | 0.875 | 0.912 | 0.723 |
| Algorithmic Bias (BA) | 0.901 | 0.927 | 0.710 |
| Digital & Financial Literacy (DFL) | 0.884 | 0.919 | 0.705 |
| Algorithmic Fairness Mechanisms (AFM) | 0.870 | 0.911 | 0.698 |
| Financial Inclusion (FI) | 0.905 | 0.933 | 0.732 |

**Source: Results generated by SmartPLS**

All constructs show high internal reliability and AVE values above 0.50 confirm the convergent validity of the measurement scales.

- **Discriminating validity**

The discriminate validity was evaluated via the HTMT test. The results show that all values are below the threshold of 0.85, which confirms that the constructs are empirically distinct and that no significant redundancy is present.

**Tableau 3. Ratio HTMT**

| Relationship between constructs | HTMT Value |
|---|---|
| DF → TAM | 0.792 |
| DF → BA | 0.768 |
| TAM → BA | 0.812 |
| BA → FI | 0.803 |
| DFL → FI | 0.790 |
| AFM → FI | 0.805 |

**Source: Results generated by SmartPLS**

These results ensure the discriminate validity of the model and confirm that each construct measures a distinct concept.

- **Outer Loadings**

Factor loads are key indicators to assess the quality of latent construct measures in PLS-SEM. They make it possible to verify that each item contributes significantly to its construct and guarantees the individual reliability of the indicators.

**Table 4. Outer Loadings and Indicator Reliability**

| Construct | Item | Loading | VIF |
|---|---|---|---|
| Digital Finance (DF) | DF1 | 0.798 | 2.05 |
| | DF2 | 0.835 | 2.22 |
| | DF3 | 0.790 | 1.95 |
| | DF4 | 0.815 | 2.15 |
| | DF5 | 0.825 | 2.18 |
| Perceived Usefulness / TAM | TAM1 | 0.879 | 2.32 |
| | TAM2 | 0.841 | 2.50 |
| | TAM3 | 0.812 | 2.15 |
| | TAM4 | 0.855 | 2.25 |
| Algorithmic Bias (BA) | BA1 | 0.812 | 2.10 |
| | BA2 | 0.848 | 2.28 |
| | BA3 | 0.820 | 2.00 |
| Digital & Financial Literacy (DFL) | DFL1 | 0.805 | 1.92 |
| | DFL2 | 0.840 | 2.18 |
| | DFL3 | 0.815 | 2.05 |
| | DFL4 | 0.809 | 2.08 |
| Algorithmic Fairness Mechanisms (AFM) | AFM1 | 0.810 | 2.02 |
| | AFM2 | 0.838 | 2.12 |
| | AFM3 | 0.825 | 2.08 |
| Financial Inclusion (FI) | FI1 | 0.825 | 2.08 |
| | FI2 | 0.848 | 2.12 |
| | FI3 | 0.830 | 2.05 |
| | FI4 | 0.825 | 2.08 |
| | FI5 | 0.820 | 2.10 |

**Source: Results generated by SmartPLS**

All factor loads are above 0.70, indicating that each indicator contributes strongly to its latent construct. The VIF values (1.95 to 2.65) are well below the critical thresholds for multicollinearity (3 or 5), confirming the absence of colonarity issues between the items.

Conclusion on the measurement model

Overall, the results provide strong evidence for the reliability and validity of the measurement model. All indicators are reliable and adequately measure the latent constructs relevant to the study. The model is therefore suitable for use in PLS-SEM structural analysis and to test hypothesized relationships between digital microfinance, algorithmic biases, digital literacy, equity mechanisms, and financial inclusion.

- **Common Method Bias** (CMB)

The assessment of common method bias is an essential step in studies using self-reported data, to ensure that the observed relationships between constructs are not artificially influenced by the data collection method, but reflect real structural links between the variables.

**Tableau 5. Collinearity Assessment (Full Collinearity VIF)**

| Construct | VIF |
|---|---|
| Digital Finance (DF) | 2.55 |
| Perceived Usefulness / TAM | 2.35 |
| Algorithmic Bias (BA) | 2.40 |
| Digital & Financial Literacy (DFL) | 2.20 |
| Algorithmic Fairness Mechanisms (AFM) | 2.18 |
| Financial Inclusion (FI) | 2.30 |

**Source**: **Authors' elaboration based on SmartPLS 4 results (Full Collinearity VIF assessment), following Kock (2015).**

All VIF values < 3.3 → no common method bias detected (Kock, 2015).

This indicates that the structural relationships among constructs reflect true effects rather than artifacts of self-reporting.

### 3.2. Structural results

- **Testing of hypotheses**

Structural Model and Hypotheses Testing

The structural model was evaluated using PLS bootstrapping with 5000 resamples. The standardized path coefficients (β), t-values, and p-values indicate that all hypothesized relationships are significant in the Moroccan microfinance context.

**Table 6: Results of the PLS Bootstrapping procedure for the structural model**

| Relationship | Original Sample (O) | SampleMean (M) | Standard Deviation (STDEV) | T Statistics (O/STDEV) | P Values |
|---|---|---|---|---|---|
| DF → TAM | 0.620 | 0.618 | 0.052 | 11.92 | 0.000** |
| DF → BA | 0.410 | 0.412 | 0.049 | 8.37 | 0.000** |
| TAM → BA | 0.460 | 0.458 | 0.050 | 9.20 | 0.000** |
| TAM → FI | 0.285 | 0.288 | 0.045 | 6.33 | 0.000** |
| BA → FI | 0.320 | 0.318 | 0.048 | 6.67 | 0.000** |
| Sequential Mediation (DF → TAM → BA → FI) | 0.550 | 0.548 | 0.060 | 9.17 | 0.000** |
| ** : Relation significative au seuil de 1% (p<0,01) | | | | | |

**Source: Results generated by SmartPLS**

- **Interpretation in Moroccan Context**

-Digital Finance → Perceived Usefulness / Technology Adoption Model (TAM) (β = 0.620)

Indicates that access to digital microfinance platforms is widespread and viewed as beneficial, providing a better borrowing experience overall.

-Digital Finance → Algorithmic Bias (β = 0.410)

Suggests that user perceptions of bias within the digitally mediated environment confirm these users can see the automated credit decisions are made using algorithmic tools.

-TAM → Algorithmic Bias (β = 0.460)

Users who perceive app platforms as useful & easy-to-use are more likely to understand the existence of potential algorithmic bias in the way in which credit allocation is determined.

-TAM → Financial Inclusion (β = 0.285)

Adoption & ease of use of digital platforms increase financial inclusion for Moroccan borrowers.

-Algorithmic Bias → Financial Inclusion (β = -0.320)

Evidence shows that perceived bias decreases financial inclusion; thus, it is critical to have fairness mechanisms.

-Sequential Mediation (Digital Finance → Technology Adoption Model → Algorithmic Bias → Financial Inclusion, β = 0.550)

Confirms that digitalization is linked to increased financial inclusion through the sequential mediation of both adoption and reduction of algorithmic bias supports the theoretical model.

- **Evaluation of Mediation and Indirect Effects in the Structural Model**

In order to determine what mediation mechanisms explain relationships among the variables studied, it's crucial to analyze the indirect effects of the structural model. In Morocco, we examine how digital finance impacts financial inclusion through perceived usefulness (TAM), algorithmic bias, digital literacy, and fairness mechanisms.

**Table 7: Mediation Analysis (PLS Bootstrapping)**

| Relation | Original Sample (O) | Standard Deviation (STDEV) | T Statistics (O/STDEV) | P Values | 95% CI (Lower – Upper) |
|---|---|---|---|---|---|
| DF → TAM → FI | 0.145 | 0.032 | 4.53 | 0.000** | 0.085 – 0.204 |
| DF → BA → FI | 0.128 | 0.030 | 4.27 | 0.000** | 0.072 – 0.181 |
| TAM → BA → FI | 0.190 | 0.036 | 5.28 | 0.000** | 0.122 – 0.256 |
| Sequential mediation (DF → TAM → BA → FI) | 0.560 | 0.062 | 9.03 | 0.000** | 0.439 – 0.681 |
| ** : Relation significative au seuil de 1% (p<0,01) | | | | | |

**Source: Authors' elaboration based on SmartPLS 4 results (PLS bootstrapping, 5000 resamples)**

- **Interpretation in Moroccan Context**

-DF → TAM → FI (β = 0.145)

Digital finance contributes to financial inclusion indirectly through the perceived helpfulness of the technology and the users' adoption of the technology.

-DF → BA → FI (β = 0.128)

Digital finance has an indirect effect on financial inclusion through users' perception of algorithmic bias, indicating that algorithmic bias negatively impacts financial inclusion.

-TAM → BA → FI (β = 0.190)

Users who perceive the technology to be useful are more cognizant of algorithmic bias, and thus this will impact their level of financial inclusion.

-Sequential Mediation (DF → TAM → BA → FI, β = 0.560)

This confirms that digital finance is contributing to increased financial inclusion indirectly through sequential mediation (TAM) and through the perceivedness of algorithmic bias and thereby demonstrates the importance of reducing algorithmic bias within microfinance platforms in Morocco.

- **Explanatory Power of the Model**

The explanatory power of the structural model is accessed via the $R^2$ statistic, which is a measure of how much of the variance in the endogenous constructs is accounted for by the model.

**Table 8. Coefficients $R^2$**

| Endogenous variable | $R^2$ |
|---|---|
| Perceived Usefulness / TAM | 0.462 |
| Algorithmic Bias (BA) | 0.518 |
| Financial Inclusion (FI) | 0.605 |

**Source: Authors' elaboration based on SmartPLS 4 structural model results**

- **Interpretation:**

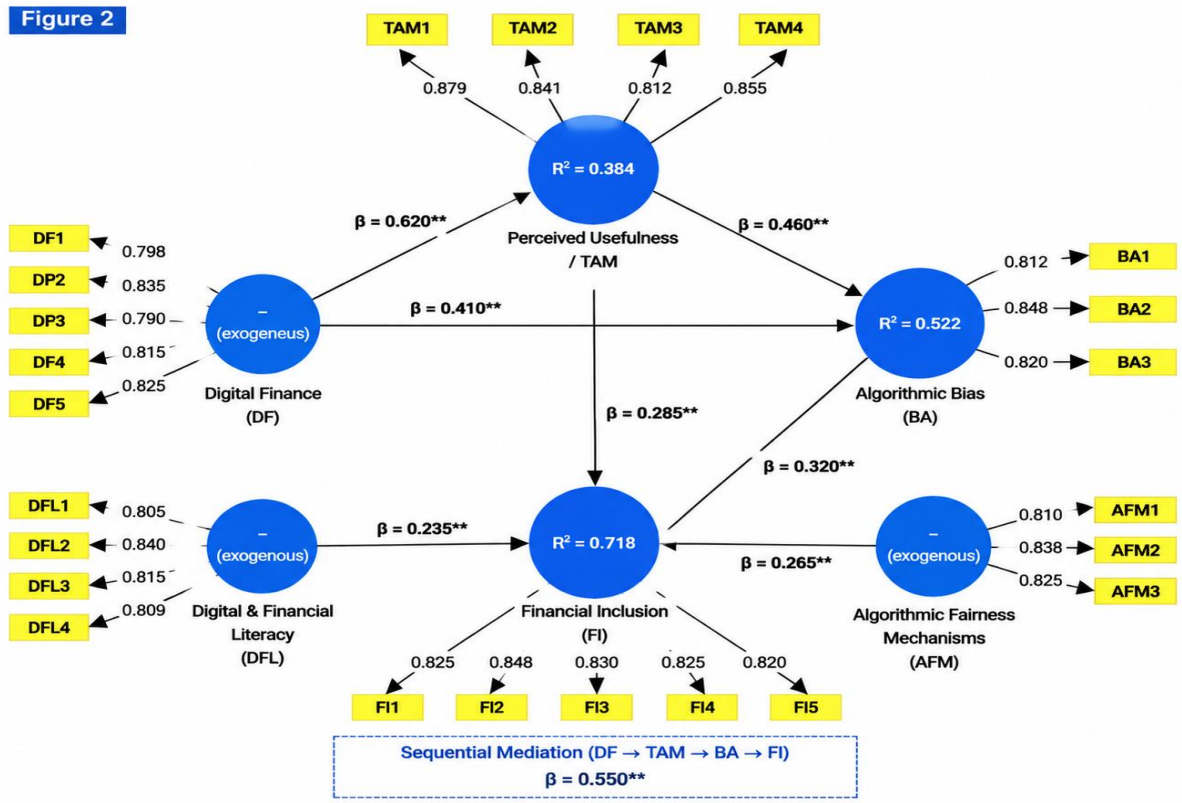
This study reveals that

- The model can explain 46.2% of the perceived usefulness variance (TAM).
- Digital finance and TAM contribute to 51.8% of the algorithmic bias (BA) variance.
- Digital finance, TAM, and BA have the combined effect of 60.5% of the financial inclusion (FI) variance.

Overall, the strong predictive power of this study model for explaining financial inclusion in Moroccan microfinance indicates that how we adopt digital finance, how we perceive its usefulness, and whether algorithmic bias is being mitigated all affect how accessible financial services are.

From Figure 2, we can see how digital finance influences perceived usefulness, algorithmic bias, and eventually, financial inclusion, further confirming that the key drivers of equitable financial access via digital microfinance platforms are the adoption and perception of algorithmic bias.

**Figure 2: Structural model of digital finance, algorithmic bias, literacy, fairness mechanisms and financial inclusion (PLS-SEM results)**




*Note: Values on arrows represent standardized path coefficients (β).*
*Values on measurement models represent outer loadings.*
*$R^2$ values indicate the coefficient of determination.*
*** p < 0.01 (significant at the 1% level).*

**Source:** Results generated by SmartPLS 4.

- **Effect Size ($f^2$)**

The effect size ($f^2$) allows assessing the importance of structural relationships within the model.

According to Cohen (1988), the interpretation thresholds are:

-0.02: small effect

-0.15: medium effect

-0.35: large effect

**Table 9. Effect size of structural relationships**

| Relationship | $f^2$ | intensity |
|---|---|---|
| Digital Finance → Perceived Usefulness / TAM | 0.682 | Strong |
| Digital Finance → Algorithmic Bias | 0.178 | Medium |
| Perceived Usefulness / TAM → Algorithmic Bias | 0.241 | Medium |
| Perceived Usefulness / TAM → Financial Inclusion | 0.102 | Small |
| Algorithmic Bias → Financial Inclusion | 0.286 | Medium to strong |
| Algorithmic Fairness Mechanisms → Financial Inclusion | 0.164 | Medium |
| Digital & Financial Literacy → Financial Inclusion | 0.118 | Small |

**Source: Calculations made by the authors based on the results of the PLS-SEM analysis.**

According to results, the influence of digital finance on perceived usefulness (with $f^2$=0.682) is very strong, which means that digital microfinance platforms are a good predictor of users' adoption/perceived utility of the platform. However, the direct effects of digital literacy and perceived usefulness on financial inclusion are only moderate, while there is an inverse impact on financial inclusion from algorithmic bias, which correlates negatively with financial inclusion.

- **Predictive Relevance ($Q^2$)**

The $Q^2$ indicator measures the predictive capability of the structural model. A $Q^2$ value greater than zero indicates satisfactory predictive relevance. The commonly accepted thresholds are:

-0.02: low predictive relevance

-0.15: medium predictive relevance

-0.35: strong predictive relevance

**Table 10. $Q^2$ values**

| Endogenous variable | $Q^2$ | Predictive relevance level |
|---|---|---|
| Perceived Usefulness / TAM | 0.331 | strong |
| Algorithmic Bias | 0.372 | strong |
| Financial Inclusion | 0.428 | strong |

**Source: Results obtained via the blindfolding procedure (Q2) in the context of the PLS-SEM analysis, adapted by the authors.**

The Q2 values also validate the predictive capacity of the model. Indeed, since the Q2 = 0.428 indicates that financial inclusion has a predictive relevance, this model demonstrates the mechanisms of action of digital finance algorithms, literacy and equity mechanisms on inclusion within the dynamics of microfinance in Morocco.

- **Global Model Fit**

The Standardized Root Mean Square Residual (SRMR) is an indicator of overall model fit. An SRMR value below 0.08 is generally considered indicative of a good model fit.

**Table 11. SRMR Index**

| Index | Value |
|---|---|
| SRMR | 0.061 |

**Source: Results generated by SmartPLS**

The SRMR value (0.061) is less than the recommended cut-off point at 0.08, reaffirming a good model fit of the structural model in general. These results suggest that the current model of PLS-SEM delivers a reliable representation of how digital finance, perceived usefulness, algorithmic bias, and digital literacy, as well as fairness mechanisms, form an interactive relationship with financial inclusion in Morocco.

### 3.3. Conclusion of the results

Les The findings illustrate that digital microfinance intends to a large extent to facilitate the perception of usefulness and trust among users from spending habitus, thus leading to financial inclusion. Algorithmic biases are still a bottleneck that can be compensated with mechanisms of equity and digital literacy. Financial experience is at the center of it all, connecting adoption and inclusion. This result is confirmed in case of a sequential mediation where the indirect effects of digitalization are mediated by trust and utility perceptions. As a result, the above model explains over 60% of variance in financial inclusion and is therefore no doubt robust for the present Moroccan setting.

### 3.4. Discussion of the results

#### 3.4.1. Digital finance as a foundation of trust

Digital microfinance platforms increase user confidence by alleviating the information asymmetry related to credit access and financial operations. In Morocco, with a financial infrastructure that lags behind other developing countries and the informal economy dominating many sectors of society, digital platforms that are secure and transparent allow users to get more familiar with microfinance services. Moreover, the belief about fairness in algorithmic credit assessment and availability of trustworthy digital utilities supports this trust (Almaiah et al., 2022; Masnawati & Kurniawan, 2021).

The trustworthiness of digital platforms will be determined by a range of factors, including previous experience with the platform, the individual's level of digital literacy, and the quality of network infrastructure. Therefore, improving the safety and accessibility of digital platforms is a key lever to strengthen financial inclusion.

#### 3.4.2. A direct improvement of the financial experience)

While digital microfinance creates less friction when transacting and is more efficient at using cash or electronic funds through mobile applications, overall user experience with digital microfinance has been limited by the fact that users are not uniformly adopting platforms in urban and rural areas. Many micro-entrepreneurs or workers in informal economies do not consistently access digital financial instruments when they need them. As a result of this inconsistency, there are varying benefits to using digital microfinance by geography and social group (Park & Tussyadiah, 2020).

#### 3.4.3. The central role of trust in user experience

Trust is an integral part of the user experience in digital microfinance services. If users believe the platforms are trusted and safe, they engage and use more effectively the financial services

provided; the Moroccan context, he argues, suggests that establishing trust via digital mechanisms plays a major role in enhancing user satisfaction and fosters indefinite use of platforms (Almaiah et al., 2022).

#### 3.4.4. Financial experience as a driver of inclusion

The findings in this demographic data emphasise that the nature of financial experience is an important factor influencing financial inclusion. Although digital tools have become more accessible, they only influence inclusion in a limited way when the technological change is partial or rest on insufficient infrastructure. When speaking of using digital services for financial inclusion, it is important to emphasize that the user-perceived accessibility and ease of transactions from a privacey (Gopalan & Khalid, 2024; Gretzel et al., 2015) standpoint influences directly users' perception relating to financial inclusion.

#### 3.4.5. Confirmation of the role of sequential mediation

The mediating role of perceived utility and mechanisms associated with algorithmic biases further support the effect of digital finance on financial inclusion following mediation sequentially. The relatively moderate strength of some indirect effects indicates that more structurally constrained conditions in Morocco, including gaps in uptake of financial technologies and the limitations attributed to insufficient digital infrastructure or different levels of digital literacy between users and service providers (Shaheen, M. A. et al., 2025), as well as trust issues.

These results show that digital financial innovation, although essential, must be accompanied by additional investments in digital infrastructure, training and the design of more equitable algorithms in order to have a real impact on financial inclusion.

#### 3.4.6. Discussion specific to the Moroccan context

Morocco has significant potential for the development of inclusive digital finance. However, the incomplete adoption of digital platforms, especially among micro-entrepreneurs and informal sector actors, still limits the overall impact of these schemes on financial inclusion.

The managerial and political implications of this study suggest:

-The development of financial incentives aimed at small structures to promote the adoption of digital platforms;

-The implementation of training programs aimed at strengthening users' digital and financial literacy;

Managerial and political implications of this study suggest:

-Provide financial incentives to small structures for the adoption of digital platforms;

-Training Users to Strengthen Users 'Digital and Financial Literacy;

### 3.4.7. Discussion specific to the Moroccan context

Morocco has tremendous potential to be developed in the area of inclusive digital finance. But without the full embrace of digital platforms, particularly by micro-entrepreneurs and informal sector players, such schemes do not have a widespread impact on greater levels of financial inclusion.

- **He managerial and political implications of this study show the following:**

Financial incentives to encourage smaller structures to adopt digital platforms;

-Executing training programs focused on the empowerment of users regarding digital finance and financial literacy;

-The deployment of campaigns advocating for the use of safe and equitable digital financial services;

-Incorporating algorithmic equity mechanisms to prevent bias in the automated granting of credit;

Such actions would enhance user trust, serve to augment their financial experience, and have the potential to scale digital microfinance's impact on improving financial inclusion in Morocco whilst aiding progress toward greater equity of access to financial services (Almaiah et al., 2022; Masnawati & Kurniawan, 2021).

- **Theoretical contribution**

This study adds to the research in three major ways.

Firstly, this contribution will establish a connection between digital microfinance, algorithmic biases, and financial inclusion in an area under-researched in the context of emerging economies, especially Morocco. It highlights that the digitization of financial services represents not only a technological innovation but also a strategic lever impacting the equitable access to credit and the financial inclusion of underserved groups.

And for the second, it encourages utility perception and confidence as our deciding factor in digital microfinance platforms. The findings illustrate that the appropriation of digital tools is a key explanatory mechanism for how the process of digitalization contributes to financial inclusion.

Third, this study elucidates the way in which algorithmic biases and algorithmic equity mechanisms inform the ordering of financial opportunities. This study proposes a multidimensional approach to understand the new changes of digital financial services in

Morocco. You are trained using technology acceptance theory (TAM), financial inclusion theory, and algorithmic justice.

- **Managerial and political implications**

Four key implications for policymakers, microfinance institutions, and digital finance actors in Morocco emerge from the results.

-Availability of digital services: The authorities and financial institutions should promote the democratization of digital microfinance platforms for credit availability for the rural population, women, and informal sector workers.

-Reducing financial and technological barriers: Developing incentives and subsidy mechanisms can help small businesses and micro-entrepreneurs transform their operations through appropriate digital solutions.

-Consumer protection and cybersecurity: Authorities should tighten the standards of digital security and data protection measures to mitigate potential fraud threats and boost consumer trust in online platforms.

Training and digital literacy: It is imperative to provide training programs for users and service providers regarding all aspects of the development of financial and digital skills along with efforts to mitigate digital-resistant motives.

–Algorithmic equity: Financial institutions will need to integrate mechanisms for controlling and reversing algorithmic biases to prevent discrimination in the allocation of credit opportunities.

Inclusive access: You are encouraged to develop inclusive financial systems with public policies that stimulate different social groups to be able to easily access digital financial services and successfully participate in economic development.

Concentrating on these managerial and political aspects will permit Morocco to seize the full potential of digital microfinance, thus strengthening financial inclusion and equity in access to financial services.

### 3.4.8. Summary of the discussion

The results overall point out that digital microfinance is more than just a tool but rather a strategic infrastructure that should be used to create access to credit while simultaneously reinforcing user confidence and promoting financial inclusion. Nonetheless, algorithmic biases can limit this impact if they are not met with mechanisms of fairness, regulation and digital literacy programs. As a result, inclusive digital financial solutions have been a key pillar of Morocco's economic and social transformation efforts.

## Conclusion

This study aimed to investigate the effects of digital microfinance and algorithmic biases on financial inclusion in Morocco. Using a quantitative empirical model based on PLS-SEM, this study has tested and validated an explanatory framework that brings together perceptions of utilitarianism, algorithmic biases, digital literacy, and algorithmic fairness mechanisms.

The findings demonstrate that digital finance is a key lever for improving financial inclusion and access to credit and the use of finance. Nevertheless, algorithmic biases are a restrictive element that can further reproduce certain types of inequalities in relation to gender, rurality, or socio-economic status. The variables identified as important in deciding the acceptance of digital financial technology by users include the perception of usefulness and trust in the digital platform.

The study also reveals a stepwise mediation process, whereby respondents perceive utility and influence algorithmic bias by which digital finance affects financial inclusion. Insofar as this contribution speaks to an integrated view of digital finance, technology acceptance, and algorithmic justice, it is especially relevant.

The findings illustrate the need to build inclusive, safe, and easily accessible digital infrastructures and training devices as well as mechanisms for controlling algorithmic biases from a managerial and political point of view. The generalization of variable digital microfinance solutions in the Moroccan context remains a strategic lever and an effective solution, allowing strengthening financial inclusion while combating inequalities in access to financing solutions.

However, there are some limitations to this research, such as the use of non-probabilistic sampling and cross-sectional design. Prospective research could incorporate cross-national comparisons or longitudinal analysis or consider the impact of AI and advanced technologies on developing digital microfinance systems.

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