

***Spatiotemporal Visualization of Financial Infrastructure Disparities in Algeria:  
2009–2023***

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***Abstract:***

*This study employs a multidimensional visual analytics approach to dissect the evolution of Algeria's financial infrastructure between 2009 and 2023. Through the deployment of advanced static visualizations—including 3D surface plots, radar charts, and heatmaps—the paper reveals entrenched disparities in banking and postal financial service distribution across spatial and demographic lines. While infrastructural expansion has occurred, the analysis demonstrates that growth remains unevenly concentrated in urban areas, with rural zones persistently underserved. Additionally, depositor and borrower profiles expose significant gender and institutional asymmetries. By transforming raw datasets into intelligible visual narratives, the study not only uncovers latent structural inequalities but also proposes new directions for inclusive financial policymaking. The findings suggest the need for integrative strategies that transcend mere numeric expansion, advocating for spatial equity, demographic inclusivity, and systemic interoperability. This work contributes to the growing literature on financial inclusion by demonstrating the critical utility of visual analytics as a methodological innovation in the analysis of financial systems.*

***Keywords:*** *Financial Inclusion; Visual Analytics; Spatial Inequality; Banking Infrastructure; Postal Financial Services*

***Jel Classification Codes :*** *G21 ; R12*

## **1. Introduction :**

In a world increasingly driven by data-centric policy and digital economic ecosystems, the disparity in financial access remains one of the most persistent paradoxes of modern development. According to the World Bank (2022), over 1.4 billion adults globally remain unbanked (Ganji, 2024), with significant concentrations in rural and economically marginalized populations. While digital banking technologies proliferate and financial institutions diversify, vast segments of populations in the Global South still navigate financial exclusion. In such a context, the Algerian case offers both an emblematic and a perplexing scenario: a country with a complex hybrid financial system—banking and postal—that is simultaneously expanding and fragmenting. This study leverages visual analytics to interrogate how financial infrastructure has evolved over the past 15 years in Algeria, and what it reveals about structural inclusivity and institutional priorities (Fatma & Khadidja, 2023).

Algeria, North Africa's largest country by landmass, is characterized by stark geographical dualities: a densely populated northern corridor and a vast, underserved Saharan hinterland. This spatial bifurcation is mirrored in its financial infrastructure, with urban areas benefiting from concentrated banking networks, while rural and southern regions endure chronic underrepresentation. The central hypothesis of this paper is thus: the evolution of financial infrastructure in Algeria between 2009 and 2023 has been spatially uneven, reflecting entrenched institutional centralism and selective modernisation rather than inclusive development.

Previous empirical such (Benachenhou, 2022; Gassem et al., 2024; SEDDIKI, 2023; Talahite, 2021; ZEMRI & KHETIB ) investigations into Algeria's financial system have predominantly focused on banking penetration, microfinance limitations, or monetary policy constraints. However, there exists a significant analytical gap in the literature with regard to visual-spatial representations and their implications for equity-oriented financial planning. Few studies have mapped the comparative dynamics of postal versus banking channels, or the demographic asymmetries in access to ATMs, agencies, and accounts. This article aims to fill that gap through a visually augmented exploration of financial inclusion metrics across time, geography, and institutional modality.

The primary objective of this paper is to decode the multilayered evolution of Algeria's financial landscape through a sequence of high-resolution visual analyses. By examining key indicators—such as the distribution of ATMs, the growth of agency networks, the typology of account holders, and regional service disparities—the study seeks to illuminate hidden trajectories and critical fault lines in the national financial system.

In doing so, the research contributes added value not merely through statistical extrapolation but via a novel visual methodology that renders complex data comprehensible and policy-actionable. The significance of the study lies in its potential to guide evidence-based policy formulation,

infrastructural rebalancing, and inclusive financial innovation strategies within Algeria and comparable economies.

The study employs a mixed-methods visual analytics framework, combining quantitative longitudinal data (2009–2023) with multidimensional static visualization techniques such as 3D surface plots, radar diagrams, and heatmaps. Financial data pertaining to banks, postal services, and depositor profiles were extracted from national statistical bulletins and harmonized across spatial (wilayas, zones) and institutional categories. The visual outputs were then interpreted through a critical spatial-institutional lens to derive patterns, gaps, and structural implications.

The structure of this paper unfolds through a sequentially layered exploration of Algeria's financial infrastructure. It begins with a critical review of existing literature, synthesizing both theoretical and empirical perspectives on financial inclusion within the Algerian context. This is followed by a detailed exposition of the methodological approach, including data harmonization protocols and the application of advanced visualization techniques. The core of the study presents the empirical findings through thematically organized visual analyses, encompassing dimensions such as institutional outreach, depositor behavior, ATM distribution, and spatial disparities. A subsequent section engages in a rigorous interpretive dialogue, situating the results within the broader institutional and geographic asymmetries that characterize Algeria's financial landscape. The final portion of the paper reflects on the implications of the findings for public policy and institutional reform, acknowledges the study's methodological constraints, and proposes avenues for future inquiry that build upon the visual-analytical foundation established herein.

## **2. Literature review:**

Algeria's banking infrastructure has expanded markedly in the last decade, driven by both state-led and market-led initiatives. Quantitative analyses of postal and bank data reveal that automated teller machines (ATMs) and branches grew substantially until about 2019, reflecting concerted inclusion strategies.

Youssef and Redouane (2021) provide a comprehensive analysis of Algeria's financial inclusion landscape, emphasizing its critical role in socio-economic development. Their study reveals that only 43% of Algerian adults possess a current account, with a significant gender gap of 27%, surpassing the global average of 7%. Moreover, digital financial engagement is minimal, as merely 5% of account holders utilize the internet for bill payments or online purchases. Traditional savings methods, such as storing cash at home or investing in jewellery and real estate, remain prevalent, while informal borrowing from family and friends is the primary source of emergency funds. The authors argue that enhancing financial inclusion can facilitate more efficient financial transactions and assist impoverished populations in escaping poverty by promoting education, health, and entrepreneurship. They advocate for the development of a national financial inclusion strategy that focuses on expanding digital infrastructure, implementing electronic payment systems, and initiating financial literacy programs. This study underscores the necessity for Algeria to transition from a cash-based economy to a more inclusive digital financial ecosystem to achieve equitable economic growth.

Benaini and Metair (2022) study offers a rigorous empirical examination of the determinants influencing financial inclusion in Algeria between 2004 and 2019. Employing the Autoregressive Distributed Lag (ARDL) bounds testing approach, they constructed a composite Financial Inclusion Index (FII) based on Sarma's (2008) multidimensional framework, encompassing banking penetration, service availability, and usage metrics. The analysis revealed that GDP per capita, oil rents, deposit interest rates, and fixed-line subscriptions (serving as a proxy for internet access) positively and significantly impact financial inclusion. Conversely, money supply (M2) was found to be statistically insignificant, suggesting that liquidity expansion alone does not enhance inclusion. Notably, the study identified a strong positive correlation between corruption levels and financial inclusion, implying that informal practices may facilitate access to financial services in certain contexts. The authors advocate for policy interventions focusing on digital infrastructure development, anti-corruption measures, and financial literacy programs to foster a more inclusive financial environment. This research contributes to the broader discourse on financial inclusion by highlighting the complex interplay of economic, technological, and institutional factors within the Algerian context.

(Tharouma, 2022) provides a comprehensive examination of financial inclusion in Algeria, utilizing data from the World Bank's Global Findex 2017 to assess the current state, barriers, and determinants of financial access. The study reveals that Algeria significantly lags behind comparable economies in key financial inclusion metrics, such as account ownership, electronic payments, and formal savings. Notably, only 29% of adults reported having a bank account, and a mere 3% had borrowed from a formal financial institution. The research identifies both involuntary barriers—such as lack of funds (34%), high costs, and geographical distance—and voluntary exclusions, including perceived lack of need and distrust in financial institutions. To address these challenges, Tharouma recommends the development of a national financial inclusion strategy that emphasizes digital infrastructure, electronic payment systems, and financial literacy initiatives. The study underscores the necessity for Algeria to transition from a cash-based economy to a more inclusive digital financial ecosystem to promote equitable economic growth.

Fella (2024) shows that the number of ATMs in Algerian postal offices climbed from just 612 (2011–2013) to 1,920 by 2022. This surge after 2014 coincides with digitalization drives: postal networks modernized their services while the government promoted fintech as a tool for inclusion. Concomitantly, traditional banks expanded their branch networks in urban centers (though precise branch counts are unevenly reported), and implemented electronic payment platforms. Notably, a slight plateau in ATM growth was observed around 2023, which analysts attribute to a strategic shift toward mobile and electronic banking, maintenance costs of machines, and a reorientation of branch networks towards more efficient digital channels. In sum, the literature documents a dynamic phase of infrastructure build-out – encompassing new branch openings, ATM installations and digital services – particularly after 2014, reflecting Algeria's national inclusion policies. However, researchers caution that this growth is undergirded by a confluence of factors (technology adoption, policy incentives, and urban demand) and may be moderating as the sector adapts to cashless trends.

Basit et al. (2025) explore the relationship between financial inclusion and human development in Algeria from 2004 to 2021. Employing a composite index of financial inclusion and the Autoregressive Distributed Lag (ARDL) model, the study assesses the long-run and short-run dynamics between these variables. The results confirm a long-run cointegration between financial inclusion and human development towards equilibrium in the short run. The study underscores the vital role of financial inclusion in enhancing human development, suggesting that policies aimed at strengthening financial systems can have significant socio-economic benefits.

Basit et al. (2025) investigates the relationship between financial inclusion and the banking loan industry in Algeria through a field study conducted in the Wilaya of Algiers. The study involved distributing a structured questionnaire to 200 banking customers, with 53 statements designed to gauge perceptions of financial inclusion and its impact on bank loans. Using SPSS for data analysis, the study found a significant positive correlation between financial inclusion and bank loans, with mean scores of 3.9954 and 3.9268, respectively, and low standard deviations, indicating a consensus among respondents. The findings suggest that enhancing financial inclusion can positively influence the banking sector's capacity to provide loans, thereby supporting economic growth. The study recommends policy interventions aimed at promoting financial literacy and expanding access to banking services, particularly in underserved regions.

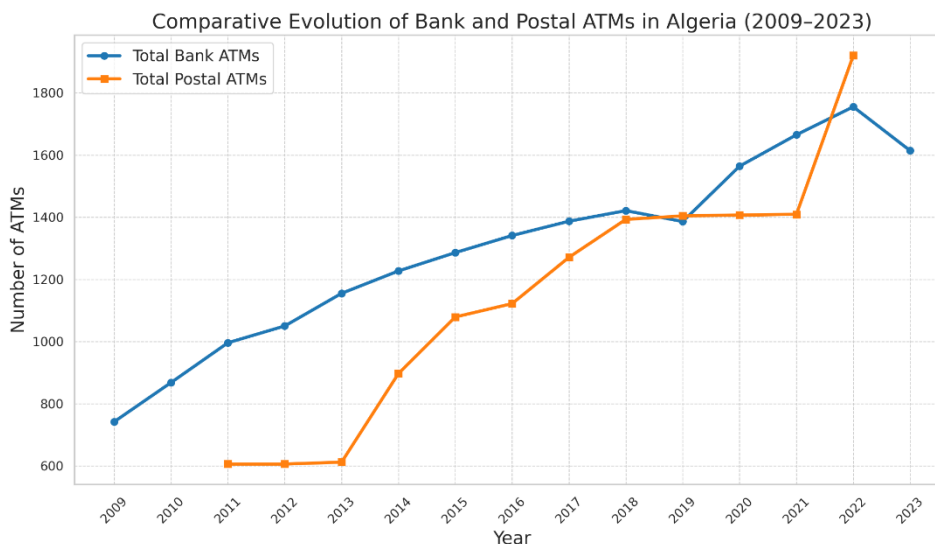
While prior studies have laid important groundwork by statistically evaluating financial inclusion determinants in Algeria, they often lack a multidimensional, spatiotemporal lens that contextualizes infrastructural disparities across both institutional types and geographies. Unlike conventional regression-based inquiries, this study integrates visual analytics with granular geographic disaggregation, offering a cartographic and volumetric perspective that unveils latent asymmetries obscured by national-level aggregates. It uniquely juxtaposes postal and banking infrastructures over a 15-year period, thus revealing patterns of selective modernization and institutional bifurcation. Additionally, the study leverages novel visual tools—3D surface plots, radar diagrams, and polar mappings—to elucidate systemic concentration biases and regional service voids. This methodological departure enables a more policy-actionable understanding of infrastructural equity. Furthermore, by encoding financial inclusion trends into spatially explicit formats, the research transcends descriptive diagnostics to propose visual narratives as a decision-support mechanism. In doing so, the paper substantially enriches the empirical corpus on Algerian financial development through a hybrid analytical framework that bridges economic geography and institutional finance.

### **3. Visual Analysis of Financial Infrastructure in Algeria:**

Recognizing the foundational role of financial infrastructure in fostering inclusive economic growth and mitigating spatial and social disparities, this section undertakes a multilayered visual analysis of Algeria's financial ecosystem. Through a diverse array of advanced graphical representations, the aim is to elucidate temporal evolutions, spatial distributions, and institutional asymmetries across banking and postal networks. The visualizations serve not merely as descriptive tools but as analytical instruments that interrogate the central hypothesis concerning the uneven accessibility and structural bifurcation of financial services. By decoding patterns of infrastructural concentration, depositor behavior, and geographic inequities, this diagnostic exploration provides an

empirical substrate for the critical discussion that follows, thereby reinforcing the evidentiary rigor and policy relevance of the study’s findings.

**Figure (1): Comparative Evolution of Bank and Postal ATMs in Algeria (2009–2023)**



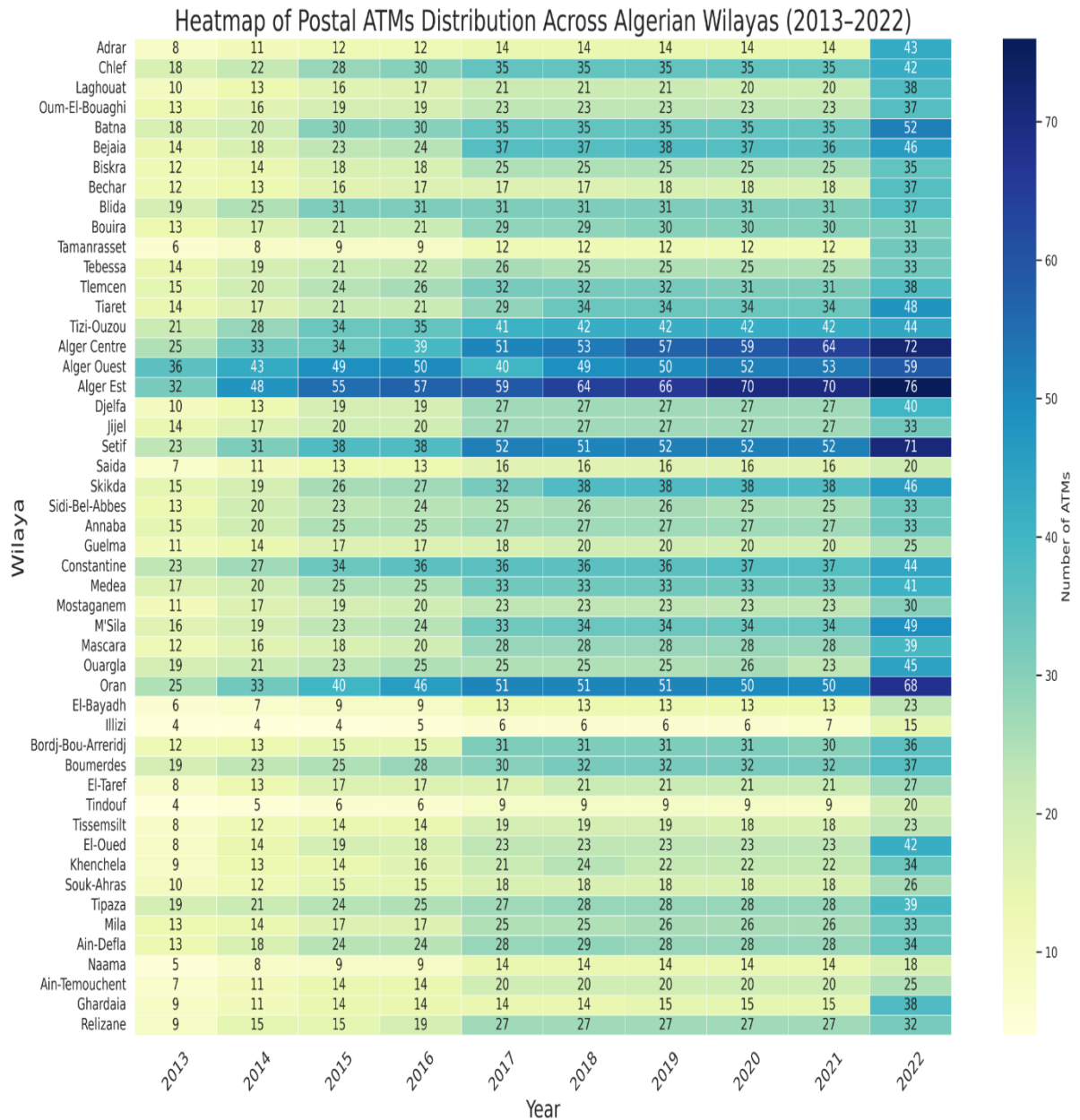
**The source:** Author's elaboration based on Python 3.13.3 outputs

Figure 1 provides a compelling longitudinal visualization of the divergent trajectories characterizing the deployment of Automated Teller Machines (ATMs) by banking institutions and postal services in Algeria between 2009 and 2023. Initially, the banking sector held an indisputable infrastructural advantage, reflecting its historical dominance in formal financial intermediation. However, the graphical trendline reveals pronounced episodes of stagnation and cyclical volatility, indicative of systemic rigidity, regulatory inertia, and possibly institutional complacency. In stark contrast, the postal sector, traditionally relegated to peripheral financial functions, demonstrates a decisive and accelerated expansion post-2015. The sharp inflection point around 2022–2023, wherein postal ATM installations surge dramatically, suggests the operationalization of state-led financial inclusion strategies aimed at recalibrating the spatial accessibility of basic financial services. This inversion of deployment dynamics not only evidences selective modernization but also mirrors Algeria’s broader institutional landscape where policy interventions, though impactful, tend to be uneven and reactive rather than holistic and anticipatory.

Critically, the figure encapsulates the paradox at the heart of Algeria’s financial infrastructural evolution: quantitative expansion devoid of qualitative homogenization. While the postal sector’s late-stage ascendancy partially bridges the urban-rural divide, the banking sector’s structural inertia perpetuates longstanding asymmetries between core urban centers and peripheral regions. The visual narrative thus corroborates the conclusion that financial modernization in Algeria has been spatially skewed and institutionally fragmented, favoring a model of selective infrastructural deepening over

comprehensive inclusivity. Moreover, the emergent prominence of postal ATMs, while symbolically significant, may conceal deeper systemic fissures unless integrated within a cohesive national financial strategy prioritizing interoperability, demographic inclusivity, and equitable spatial redistribution.

**Figure (2): Heatmap of Postal ATM Distribution Across Wilayas (2013–2022)**

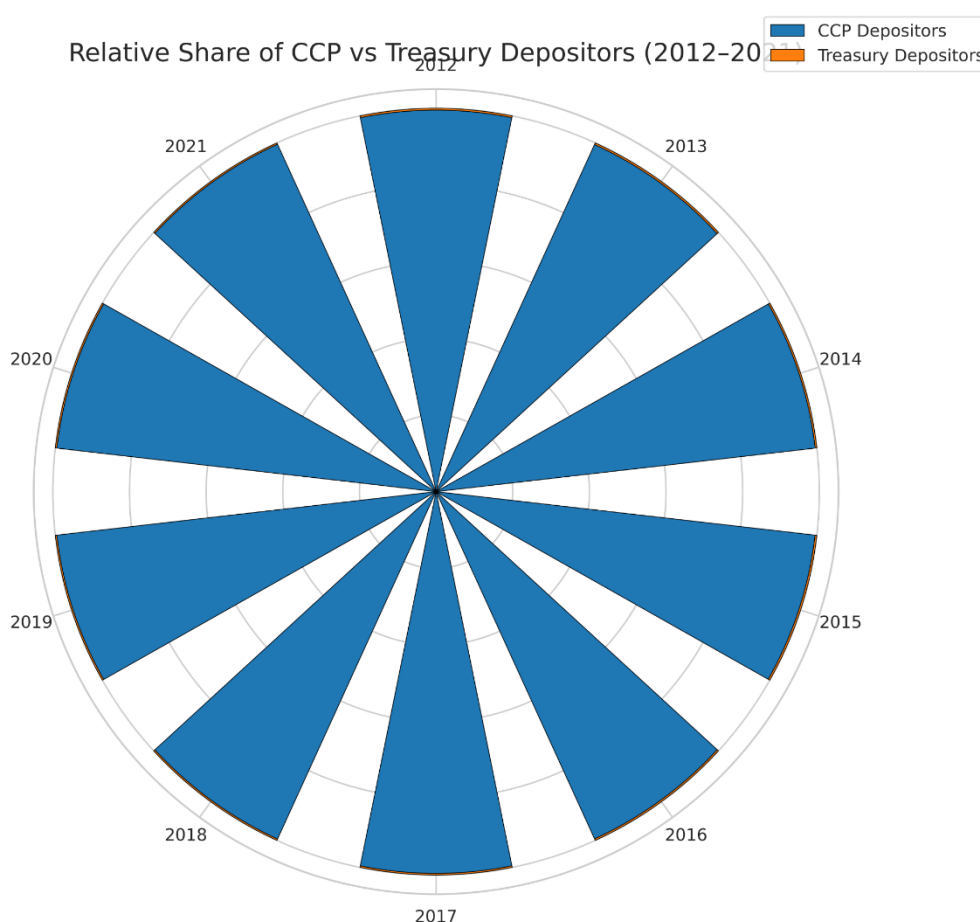


The source: Author's elaboration based on Python 3.13.3 outputs

Figure 2 presents a granular heatmap of postal ATM distribution across Algeria's 48 wilayas between 2013 and 2022, offering a powerful visual interrogation of the spatial asymmetries embedded

within the country’s financial infrastructure. The chromatic gradient—ranging from pale green to deep blue—signifies relative ATM density, with darker hues concentrated overwhelmingly in the northern urbanized wilayas such as Algiers, Oran, Setif, and Constantine. This concentration reflects the entrenched infrastructural of economically central zones, underscoring a developmental bias that favors regions with higher population density, administrative centrality, and institutional visibility. In contrast, the heatmap reveals a persistent infrastructural underrepresentation in southern and peripheral wilayas like Tindouf, Illizi, and Adrar.

**Figure (3): Polar Plot – Relative Share of CCP vs Treasury Depositors (2012–2022)**



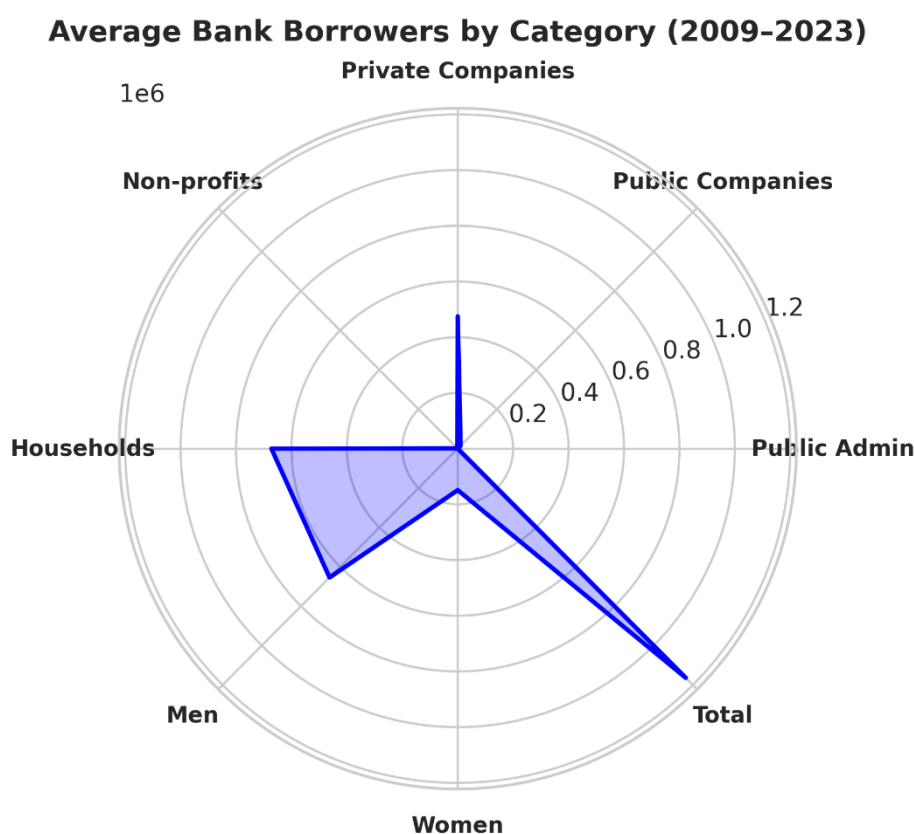
**The source:** Author's elaboration based on Python 3.13.3 outputs

Figure 3 offers a radial visualization of the proportional dominance between CCP (Compte Chèque Postal) and Treasury depositors over the period 2012–2022, employing a polar plot to underscore the structural asymmetry between the two institutional modalities. The concentric uniformity and saturated segments representing CCP depositors throughout the decade indicate a sustained and overwhelming reliance on the postal financial infrastructure as the principal channel for deposit mobilization in Algeria. This dominance may be attributed to a confluence of factors, including institutional trust in postal services, lower procedural barriers for account opening, and their

expansive physical footprint, especially in underserved regions. Conversely, the near-invisibility of Treasury depositors on the same radial spectrum underscores a persistent marginalization of this channel—whether due to policy neglect, limited public outreach, or operational inaccessibility. The graphical design, with its stark contrast, symbolically reinforces the study’s broader narrative of institutional imbalance and selective modernization.

Importantly, this polar configuration substantiates the hypothesis that Algeria’s financial landscape is not only spatially uneven but also institutionally bifurcated. The entrenched dominance of CCP accounts suggests a monopolistic orientation in deposit behavior, which poses risks for systemic resilience and diversification. As echoed in the study’s conclusion, such institutional overreliance reveals critical gaps in Algeria’s financial inclusion strategy, whereby certain channels flourish while others remain structurally dormant. Rather than reflecting consumer preference alone, the figure may also indicate the absence of robust Treasury-driven financial instruments tailored to various demographic and regional needs.

**Figure (4): Radar Chart – Average Bank Borrowers by Category (2009–2023)**



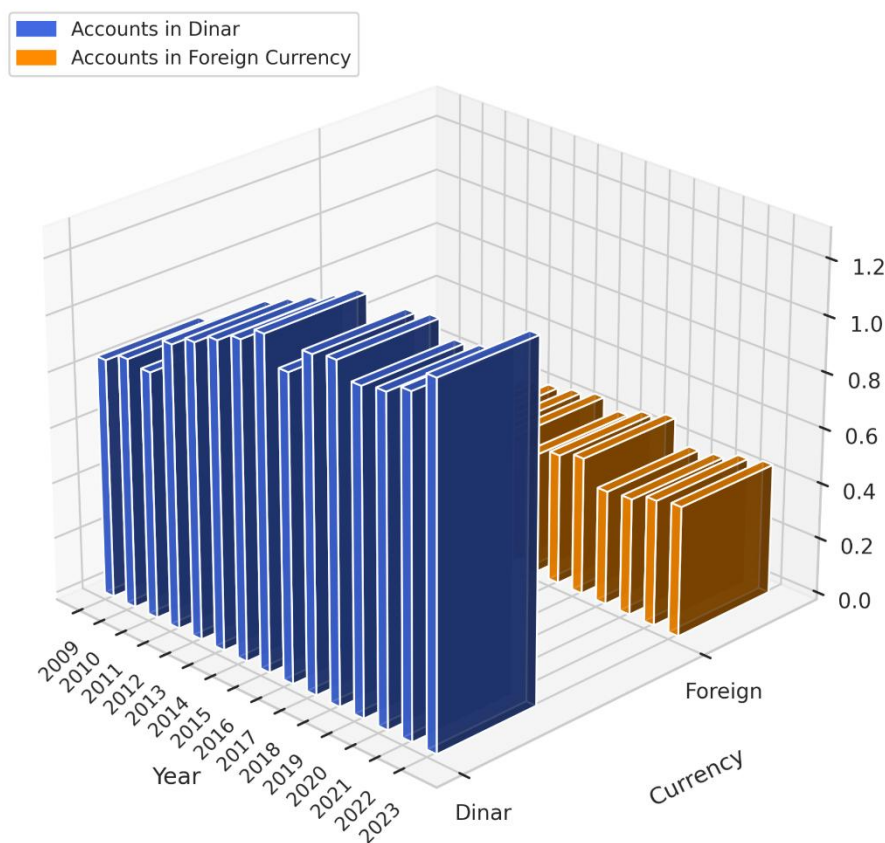
**The source:** Author's elaboration based on Python 3.13.3 outputs

Figure 4 presents a multidimensional radar chart delineating the average volume of bank borrowers in Algeria across various institutional and demographic categories between 2009 and 2023. The chart reveals a pronounced volumetric concentration in the household segment, indicating that consumer credit remains the primary axis of Algeria’s banking activity. This disproportion suggests

a financial ecosystem heavily skewed towards short-term retail lending, possibly driven by limited diversification in loan portfolios or cautious lending policies toward corporate and nonprofit entities. The relatively minimal borrowing figures for public companies, non-profits, and public administration entities further reinforce the narrow institutional base of credit circulation. Such patterns underscore the risk-averse nature of Algerian financial institutions and expose structural gaps in their engagement with productive sectors, particularly private enterprises, which are vital for inclusive economic development and employment generation.

**Figure (5): 3D Evolution of Active Bank Accounts by Currency (2009–2023)**

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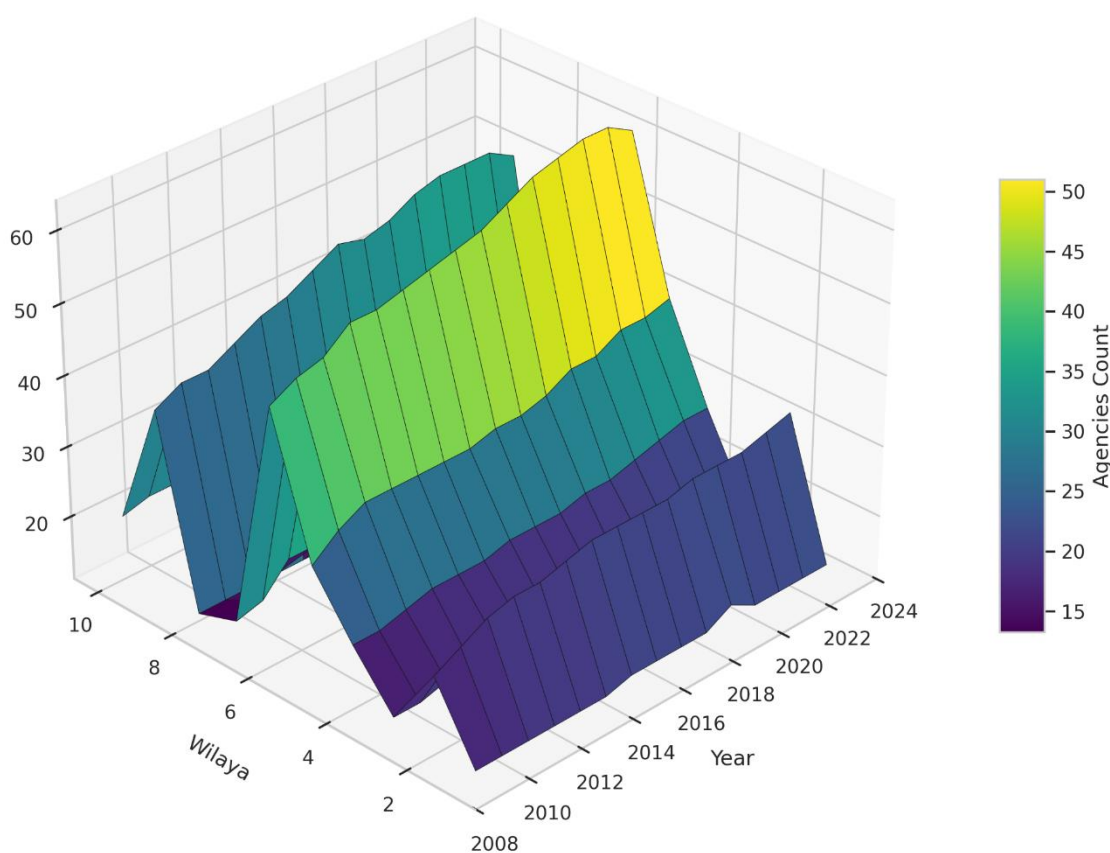
**The source:** Author's elaboration based on Python 3.13.3 outputs

Figure 5 offers a tridimensional perspective on the evolution of active bank accounts in Algeria disaggregated by currency denomination—Dinar versus foreign currencies—over the period 2009–2023. The visual immediately highlights a structural dominance of Dinar-denominated accounts, reflecting a financial system heavily anchored in domestic monetary circulation. This predominance may stem from Algeria’s capital control regimes, conservative foreign exchange policies, and the population’s limited engagement with globalized financial instruments. In contrast,

the relative stagnation and marginal growth of foreign currency accounts suggest systemic restrictions or underdeveloped financial products catering to foreign currency needs. The volumetric stability of the Dinar series, despite minor fluctuations, underscores the centrality of state-backed currency in shaping retail banking behavior, while the constrained expansion of foreign currency holdings alludes to macroeconomic uncertainties, limited trust in exchange mechanisms, and possibly regulatory disincentives.

**Figure (6): 3D Surface Plot – Bank Agencies by Wilaya (2009–2023)**

**3D Evolution of Bank Agencies per Wilaya (2009–2023)**



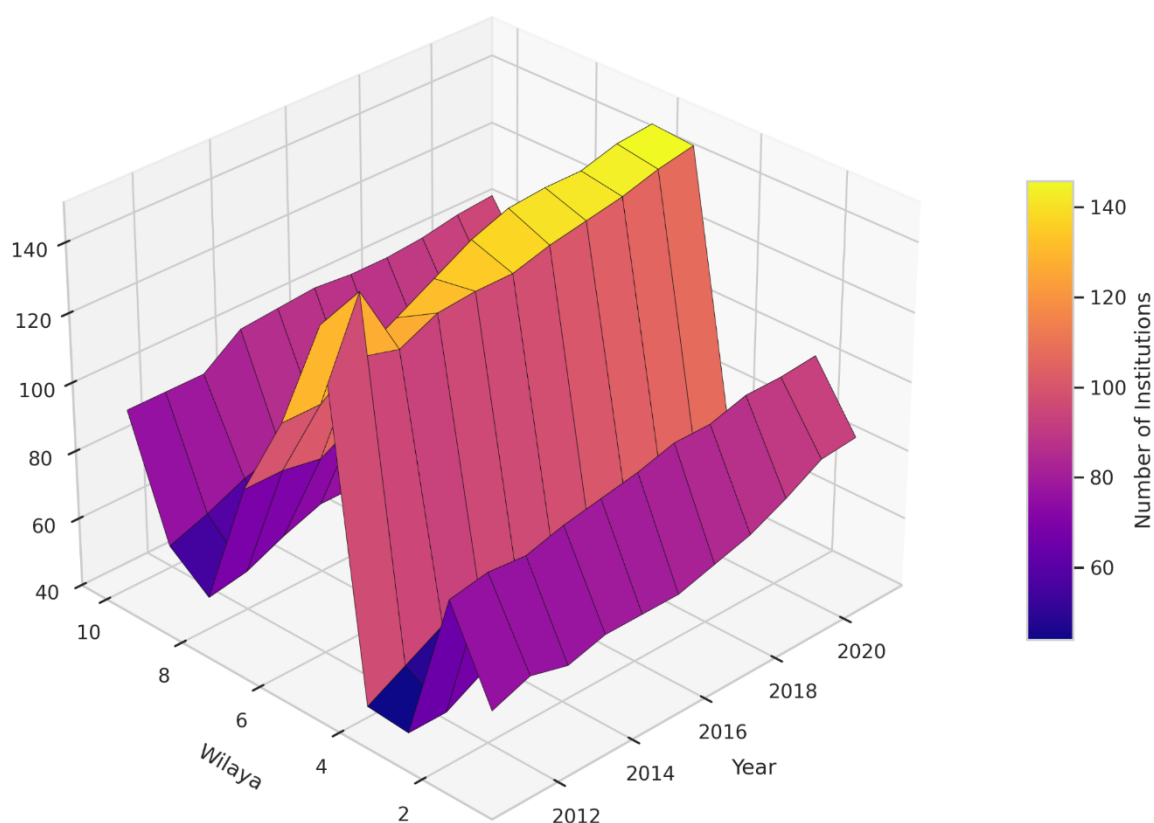
**The source:** Author's elaboration based on Python 3.13.3 outputs

Figure 6 provides a three-dimensional surface plot illustrating the temporal and spatial evolution of bank agency deployment across Algerian wilayas from 2009 to 2023. The gradient of elevation across the surface conveys not only the magnitude of agency concentration but also its geographic bias. Wilayas represented by higher surface elevations—Algiers, Oran, and Constantine—exhibit sustained and pronounced infrastructural densification, reflecting an entrenched pattern of urban-centric financial development. Conversely, the flatter surface zones denote regions where agency growth has remained stagnant or marginal, corresponding to Algeria’s southern and interior provinces. This visual asymmetry mirrors the institutional prioritization of high-

density administrative hubs at the expense of peripheral territories. While some elevation progression is observable over time, its spatial concentration reinforces the hypothesis of spatially selective modernization, whereby financial infrastructure growth is vertically deepened rather than horizontally distributed.

**Figure (7): 3D Surface Plot – Postal Financial Services by Wilaya (2011–2021)**

**3D Surface Plot: Postal Financial Services by Wilaya (2011–2021)**

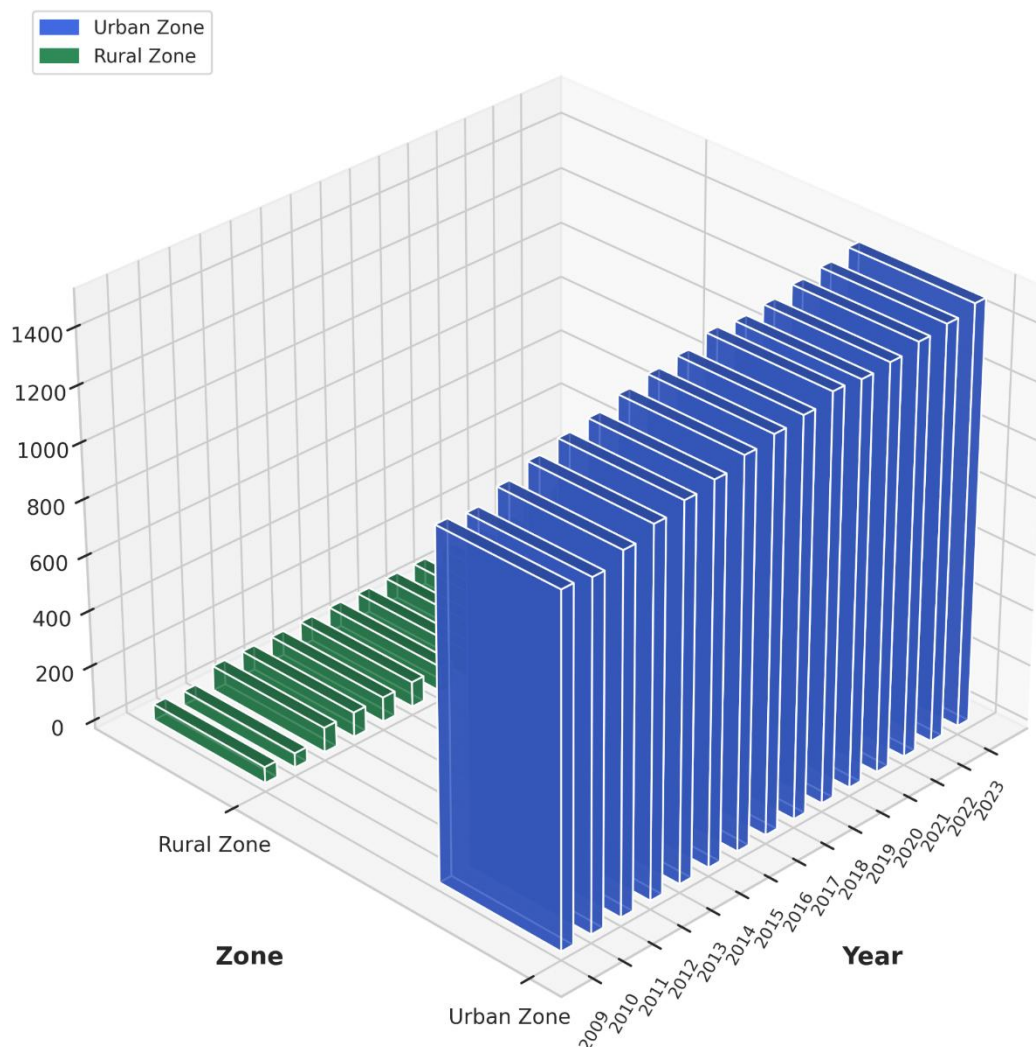


**The source:** Author's elaboration based on Python 3.13.3 outputs

Figure 7 visualizes the temporal and spatial expansion of postal financial services across Algerian wilayas between 2011 and 2021, offering a topographical narrative of state-led infrastructural outreach. The pronounced elevation peaks in certain wilayas—corresponding to mid-density administrative regions such as Batna, Tizi Ouzou, or Blida—indicate targeted investment patterns and strategic service densification. These vertical protrusions imply the existence of regionally focused postal development policies, linked to broader decentralization agendas or pilot inclusion programs. In contrast, the persistently low-lying surfaces representing other wilayas—from southern and remote interior zones—point to systemic neglect and infrastructural inertia. The sharp gradients separating adjacent territories reveal a fragmented national strategy that privileges

accessibility in select regions while perpetuating deprivation elsewhere. The figure thus exposes a spatially partial financial inclusion trajectory within the postal sector.

**Figure (8): 3D Bar Plot – Bank Agencies by Zone (Urban vs Rural, 2009–2023)**



**The source:** Author's elaboration based on Python 3.13.3 outputs

Figure 8 offers a three-dimensional bar plot illustrating the distributional disparity in bank agency deployment across Algeria’s urban and rural zones from 2009 to 2023. The volumetric dominance of the urban zone, consistently exceeding 1,200 agencies across the timeline, visually encapsulates the structural centralization of Algeria’s financial infrastructure. In stark contrast, the marginal and stagnant trajectory of rural agency deployment—barely exceeding 100 agencies even in the most recent years—reveals an enduring institutional neglect of non-urban geographies. This pronounced divergence is not merely a reflection of demographic concentration but a manifestation of systemic prioritization, wherein financial institutions gravitate towards urban centers perceived as economically viable, logistically efficient, and politically salient.

#### **4. Conclusion:**

The intricate visualization of Algeria's financial infrastructure evolution between 2009 and 2023 reveals a complex tapestry of advancement intertwined with persistent systemic asymmetries. While the expansion of banking agencies, postal services, and ATM installations denotes a commendable infrastructural deepening, the spatial analysis uncovers entrenched urban-rural divides, institutional fragmentation, and demographic discrepancies in financial accessibility.

The comparative dynamics between bank and postal networks, as rendered through multidimensional visual analytics, illuminate a pattern of selective modernization rather than holistic inclusion. Despite quantitative growth in financial service points, qualitative disparities persist, particularly disadvantaging remote and rural populations. The overrepresentation of urban zones and the dominance of dinar-denominated accounts further reflect Algeria's centralist developmental orientation, leaving substantial pockets of financial marginalization unresolved.

This study's findings reaffirm the central hypothesis: the financial infrastructure's expansion in Algeria has been spatially uneven, institutionally skewed, and selectively modernized. The visual methodology employed herein not only clarifies complex data structures but also exposes latent fault lines that conventional statistical narratives might obscure.

From a policy perspective, the implications are profound. To genuinely democratize financial access, Algerian policymakers must transcend numeric infrastructural expansion and prioritize spatial equity, demographic inclusivity, and institutional interoperability. Integrating postal networks more effectively into the formal financial ecosystem, incentivizing rural banking, and fostering gender-responsive financial products could constitute vital steps toward an authentically inclusive financial system.

Future research could benefit from integrating behavioral financial data, mobile banking adoption trends, and qualitative field surveys to triangulate the visual findings and enrich the interpretive framework. Moreover, comparative analyses with peer economies could further contextualize Algeria's financial trajectory within broader regional and developmental paradigms.

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