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Financial Inclusion Index for Pakistan from 2008 to 2022 using Three-Staged PCA Analysis

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ABSTRACT

This study estimates Financial Inclusion Index (FI Index) for Pakistan over the period 2008 to 2022 applying three-stage Principal Component Analysis (PCA) technique. Financial inclusion (FI) has emerged as a vital component of sustainable development, aiming to provide access to affordable and functional financial services for all society. It plays a critical role in promoting economic growth, reducing poverty, and advancing financial stability. This research constructs a composite FI index by capturing both traditional and digital dimensions of financial inclusion. It incorporates access and usage components across various financial services. The study employs a multi-dimensional approach. It employs supply-side dimensions such as the number of bank branches, ATMs, and mobile subscriptions. The demand-side variables like account ownership, savings behavior, and mobile payment usage are considered. The PCA method facilitates the construction of separate sub-indices for traditional and digital financial inclusion. These are then combined to create a comprehensive FI index. Findings indicate significant progress in both traditional and digital financial inclusion in Pakistan. Though challenges remain in fully integrating underserved populations. The developed FI index provides insights into the evolution of financial inclusion. It contributes to policymaking aimed at encouraging inclusive financial systems and achieving broader economic development objectives.

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Introduction

Financial exclusion has been detected as key barrier to advancement around globe. It prompts authorities prioritize banking facilities to realize financial inclusion (FI) (Demirguc Kunt et al., 2015). The view of FI developed in ending of 20th century. It focuses goal providing financial facilities with ease to every person of economy. It grabbed reputation in 2010 (Kabakova and Plaksenkov, 2018). FI gathered significant consideration in current period as one of seventeen

Sustainable Development Goals. It also act in emphasis to other objectives. Those include economic development, poverty reduction, equality and education (Kithinji, 2017; Ozili, 2020). Thus it helps realize improved and more workable economy.

FI is key goal for every financial structure. It is closely interrelated with further goals. Those include financial steadiness, financial integrity, and financial protection (Elsayed, 2020). FI is known as easiness of access and usage of several financial facilities for all people. FI implies paths in which people approach functional and reasonable financial facilities. It gather their demands e.g. transactions, payments, savings, credit, insurance, and sustainably (The World Bank Annual Report, 2008).

There is nil consent in previous studies to how evaluate FI. It leads to ongoing debates amongst researchers and stakeholders. It is theoretical notion which may not be clearly assessed quantitatively. It is determined via interface of various connecting variables. The magnitude of FI has mainly been referred via usage and access to conventional financial facilities. It will employ cumulative supply-side information (Sarma, 2008, 2012; Van et al., 2021). Although some studies incorporate demand-side statistics concentrating on specific usage statistics and obstacles (Avom et al., 2021). A contribution to literature includes a anew composed indicator of FI in Pakistan over period 2008–2022. This metric accounts for traditional and digital dimensions of FI: availability and usage. The selection of these magnitudes is encouraged by data convenience and current advancement in literature. These magnitudes deemed to have significant impact on FI and are highly correlated (Ahamed and Malick, 2019).

The focus is limited to data on banks, as banks considered primary spot for access to prime financial facilities. Banking-inclusion or exclusion often employed as equivalent to FI. Leeladhar (2006) explains, "financial inclusion is providing reasonable banking facilities to low-income and deprived groups. As banking facilities are in spirit of a society advantage. It is necessary that their accessibility to whole society without prejudice is a major public policy goal." Banks have thus acted a primary position in advancing FI (Sarma and Pais, 2011).

There are numerous crucial attributes of determining FI in a multi-dimensional approach. Initially, aggregating numerous indicators into a individual index eases sum up the complicated landscape of FI and trace its development. Secondly, a reliable gauge of FI lets to investigate its link with other variables. Thirdly, data by attribute assists well realize challenges for FI. It will be suitable instrument for proposing and assessing development strategies. FI is not just essential but is a high-priority objective globally. As noted by Sarma (2016), determination is the primary stage for advancing perception for FI. Determining FI is essential for assessing effect of distinctive stakeholder proposals and for guiding potential actions (Nguyen, 2020).

Literature Review and Theoretical Framework

Theoretical Foundation

Financial Growth Theories

Theories of financial growth explore how financial development, and creative environments influence economic growth. It follow either a demand-following or supply-leading approach. They suggest that economic inactivity often results from income disparities and restricted access to financial services. Thus, ensuring secure, convenient, affordable access to financial resources is crucial for accelerating economic growth and income equality. This promotes equal opportunities, both social and economic integration. It strengthens financial sector development and provides elasticity anti economic shockwaves (Aduda and Kalunda, 2012).

There remains considerable debate about the role of the financial system in driving economic growth. Some economists argue that it plays a fundamental role, while others believe its impact is negligible. The demand-following theory implies that financial system evolves as response to

developments for the real sector. It indicate that financial development follows economic growth. In contrast, the supply-leading theory suggests that the financial system actively drives economic progress. It provide credit and nurture investments.

The idea that finance promotes growth was initially introduced by Bagehot (1873). He argued that a robust financial sector facilitates economic expansion. Similarly, Schumpeter (1911) contended that banks play a key role in fostering economic progress. They offer adequate financing to innovative entrepreneurs. Several other scholars, including Goldsmith (1969), McKinnon (1973), Levine and Zervos (1996), and Ndebbio (2004), also highlight the same. They argue that well-functioning financial systems and affordable services contribute positively to economic growth. According to the supply-leading perspective, financial market development creates demand for financial services. It can be seen especially in economies showing promising growth potential. Thus, financial development is often seen as an indicator of growth across various segments in country.

Theories of Financial Intermediation

It refers to process through which financial institutions bridge the gap between surplus and deficit units by connecting savers with borrowers. These theories address a critical question: why investors prefer not to lend directly to borrowers, but rely on financial intermediaries instead (Ndebbio, 2004). Diamond (1984) highlights the role of banks in minimizing risks through effective monitoring of loans and investments. Financial intermediaries also provide secondary financial products. It allow investors to access primary assets more efficiently and at lower costs.

Eliminating financial intermediaries can lead to market frictions. It hinder economic growth by increasing income inequality and trapping individuals in poverty (Aduda and Kalunda, 2012). One key issue associated with financial intermediation is information asymmetry. It occurs when one party has more information than the other. This can give rise to challenges such as moral hazard and adverse selection (DemirgüçKunt et al., 2013). In the case of adverse selection, lenders struggle to differentiate between high-risk and low-risk borrowers. Meanwhile, moral hazard occurs when borrowers act irresponsibly, knowing they are unlikely to face consequences for defaulting. These information gaps increase transaction costs, discouraging investments and impairing financial exclusion.

Efforts to promote financial inclusion aim to mitigate market frictions by providing broader access to financial services. Inclusion improves market efficiency by reducing information asymmetry, enabling all participants to make better-informed decisions. Expanding financial opportunities for marginalized groups promotes entrepreneurship. It enhances resource allocation, and drives economic growth (DemirgüçKunt and Levine, 2007).

Theories linking financial intermediation to economic development are further supported by Schumpeter (1911) and King and Levine (1993). It emphasize that banks are key financial intermediaries. It significantly influence continuing growth and efficiency via capital increase. However, the performance of financial systems varies depending on geographical, temporal, and institutional factors (Beck, 2007). The relationship between financial development and economic growth can either be uni-direction or bi-direction (Robinson, 1952). Lavin (1993) notes technological innovation and capital accumulation are essential pathways. It aids financial systems impact economic growth.

The view that financial development positively affects economic growth is further supported by Goldsmith (1969) and McKinnon (1973). It argue that competitive interest rates stimulate savings and investments. Increased competition among financial institutions drives demand for financial products. It encourage more savings and investments, which ultimately promote economic expansion. Furthermore, Sharma (2016) emphasizes the positive link involving financial

accessibility and national economic progression.

Empirical Review

Emerging research highlights multiple dimensions for promoting financial inclusion. It include financial knowledge, technological modernization, financial stability, and advancements in fintech. The above elements identified as critical success factors for enhancing financial inclusion (Kapadia, 2019; Ozili, 2018; Beck et al., 2014).

Several studies (Kapadia, 2019; Atkinson and Messy, 2013) examine significance for financial knowledge in advancing financial inclusion. Empirical evidence shows a positive relationship between financial literacy. In India, for example, financial education initiatives have boosted financial inclusion. It also improved household living standards. Conversely, low levels of financial inclusion are often associated with inadequate financial literacy and ineffective educational policies. Furthermore, empirical research has demonstrated the positive correlation involving financial knowledge and financial inclusion for Ghana (Grohmann et al., 2018). These findings are consistent with results from cross-country analyses.

Several researchers explore role of financial modernization and hi-tech progress for enhancing financial inclusion. It emphasize that current financial systems often struggle to promote inclusion effectively (Al-Mudimigh and Ansari, 2020; Chinoda and Kwenda, 2019). Financial modernization refers to hi-tech advancements, increase in new financial instruments, and upgraded methods for delivering financial facilities. Ouma (2017) found modernization for instance mobile phones have facilitated financial inclusion by enabling savings and other financial transactions. Mobile technology and technological advancements significantly contributed to financial inclusion across 49 selected countries (Chinoda and Kwenda, 2019). Populations having high total of internet consumers and FinTech enterprises experienced higher levels in financial inclusion, specifically unbanked individuals (Anshari, 2020). Technological advancements have been particularly transformative in Africa. Smartphone lending, women's empowerment, foreign banks, and microfinance institutions have promoted financial inclusion (Bravo et al., 2018; Leon and Zin, 2019). Agent banking, and postal services integration are key drivers of financial inclusion (Yi et al., 2018). Proximity between banks to customers, and access points significantly enhance financial inclusion (Sherraden, 2013; Banka, 2014).

Most of researchers and policymakers working on financial inclusion associated to key development entities or study centers. It reveal potential conflicts of interest. These institutions often support research projects promoting financial inclusion. Outcomes of research frequently aligned with institutional goals. A review results suggests much of research originates from scholars affiliated with these well-established institutions.

In recent years, policymakers have intensified efforts to promote financial inclusion. It includes the formulation of consistent financial standards and policies globally (Andriospoulos et al., 2019). The even regulations have enhanced the supervision and oversight for financial inclusion initiatives across economies. However, more research required to understand how these policies and regulatory frameworks can be optimized. I helps in achieving higher levels of financial inclusion worldwide (Beck, 2017).

While several studies have developed composite indices for measuring FI. There is no consensus on the most effective approach. A summary of prior studies focusing on developing FI indices is presented in Table 1 (Appendices).

Measurement of Financial Inclusion

To accurately examine connection amongst financial inclusion and other factors, it is essential to

have an appropriate measurement of financial inclusion. However, there is no universally accepted method for quantifying financial inclusion across economies. Literature presents two broad methods for assessing financial inclusion: (1) individualistic statistics, and (2) the construction of composite financial inclusion index (commonly referred as FI index).

Beck, DemirgucKunt, and Peria (2007) are pioneers in quantifying a country's access to financial services by developing indicators of banking access. Their model assessed three major financial services: deposits, lending, and payments. These were analyzed utilizing two aspects; accessibility, and usage, of financial facilities. While this framework offers valuable insights into an economy's access to the financial system. It falls short when it comes to providing a general assessment of financial inclusion at the national level. For instance, Sarma (2016) observed, Albania positioned 4th in relation loan-to-income ratio. While same held 85th position in relation to commercial bank branches per 100,000 adults. It highlights how varying indicators can complicate cross-country comparisons.

Global datasets further enhance the analysis of financial inclusion by tracking indicators. It covers the number of bank branches, ATMs, deposit accounts, and outstanding deposits or loans. Building on these datasets, many studies have developed a composite FI index to measure financial inclusion. One popular approach to constructing such an index is inspired by the Human Development Index (HDI). It is evident in research by Park and Mercado (2018), Kaur and Abrol (2018), and Prastowo and Putriani (2019).

Sarma (2008, 2012, 2015, 2016) introduced an innovative method for calculating financial inclusion. It develop subindices for individual dimensions instead of relying on weighted averages, as had been the norm in earlier studies. The final FI index was computed as standardized inverse of the Euclidean gap from reference work standard view. Components considered in index determine standardization factor. Sarma allocated weights for the three components built on practical understanding. It assign 1 to accessibility, and 0.5 each to usability and usage. Many studies, including those by Wang and Guan (2017), Sethi and Sethy (2019); and Huang and Zhang (2020), subsequently adopted Sarma's methodology for building their FI indices.

Despite offering a more robust measure of financial inclusion compared to individual indicators, this approach has faced criticism. It rely on arbitrary weights determined by the researcher's judgment. To address these concerns, later studies proposed parametric methods. It assign endogenous weights based on statistical models. Mialou et al. (2017) and Camara and Tuesta (2018) tackled limitations in earlier methods by using data-driven approaches. It employed Factor Analysis (FA) and Principal Component Analysis (PCA).

Mialou et al. (2017) developed FI index that encompassed multiple dimensions. It include outreach (both geographical and demographic), utilization (deposits and loans), and value (disclosure, query resolution mechanisms, and utilization costs). They standardized the data for each component. It combined them employing numerical weightiness through a weighted geometric mean. However, it has its limitations. The use of FA reduces the number of variables considered. It potentially leave some data points unutilized. Furthermore, though they identified proxies for measuring service quality. It excluded this dimension due to the lack of reliable data.

Camara and Tuesta (2018) utilized a two-stage PCA technique for constructing their FI index. Initially, they assessed three sub-indices; utilization, accessibility, and hurdles. In the second stage, these sub-indices were used as explanatory variables to determine the overall FI index and corresponding weights. This method ensures that the weightiness derived using existing values rather than considering researcher intuition. As of a methodological standpoint, PCA approach chosen over FA. It does not require assumptions about the raw data (Camara & Tuesta, 2018).

Consequently, many subsequent researches, such as those by Ahamed and Malick (2019), Yorulmaz (2018); and Shaban et al., (2020), employed PCA techniques to develop comprehensive FI indices.

From a policymaking perspective, financial inclusion is assessed through three dimensions: access, usage, and quality of financial services (Mialou et al., 2017; World Bank). However, comparing value of financial facilities across economies remains challenging. As a result, some studies excluded the quality component while constructing their FI indices.

While development of composite indices has improved the measurement of financial inclusion. Debates continue about their sufficiency in capturing the full extent of financial inclusion. Each method for constructing an FI index offers unique strengths and weaknesses. There remains no consensus on the most appropriate way to measure financial inclusion (Park and Mercado, 2018). The differences in methodology and indicator selection further complicate this challenge.

With the rapid growth in mobile phone usage, particularly in developing countries, mobile devices have become an essential tool for accessing financial services. Mobile phone penetration now serves as a proxy for mobile banking adoption and has gained acceptance as a component of financial inclusion capacity (Chauvet and Jacolin, 2017). Additionally, mobile money account have emerged as a key financial transaction platform for many households in developing economies (Mehrotra and Nadhanael, 2016). However, due to data constraints, mobile money indicators are not yet consistently incorporated into FI indices.
Most previous studies on financial inclusion have focused primarily on banking services. However, the scope of financial inclusion has recently expanded to encompass other financial services, such as microfinance, and fintech. These services complement traditional banking variables in measuring financial inclusion.

Research Model
FI is multi-dimensional degree of a economy's financial segment inclusiveness. Today, there`s no universally accepted approach for assessing FI. Several institutions, including the World Bank, central banks, and Gallup World Poll, have made efforts to do so. An evaluation of literature shows two main approaches to determine FI:
Non-parametric approach: These allocate rank to markers by considering percentages externally built on researcher perception. This method is sensitive to subjective weight assignments. Small changes in percentages will significantly change the results. A common example is Sarma's approach (2008, 2012).
Parametric approach: These are established on the principle a underlying construct explains deviation in associated markers. It is allowing the significance of markers (percentages) to calculated internally by co-variation among markers on each attribute. Two common parametric methods are Principal Component Analysis (PCA) and Common Factor Analysis (CFA).

Additionally, universal databases like Financial Access Survey (FAS) and Global Findex Survey (Findex) assess FI using various financial access indicators. These indicators are number of bank branches, ATMs, deposits, outstanding deposit, credits. These records enable construction for composite index "FI Index". It computes intensity of FI. Numerous studies adopted this method to assess FI levels (Jungo et al., 2022).

For the purpose of this study, FI index will be constructed by considering demand, supply, infrastructure and drag factors. Based on work of Khera et al. 2021, three-stage Principal Component Analysis (PCA) method will be utilized. This approach aims including multiple dimensions for FI across each stage: in initial stage, consideration will be given to both provision ("access"), utilization ("usage") elements for FI; the later stages will research FI offered by

conventional financial institutions ("traditional"), those vested for technology ("digital"); finally, third stage will involve the development of a comprehensive index that holds all these constituent parts. The proportions for the fundamental indicators through PCA will be influenced in direction of indicators that exhibit high correlation with each other. By approximating the sub-indices separately in different stages, this bias can be addressed. The method is parallel to the procedure adopted in prevailing research on traditional FI (Camara and Tuesta, 2017).

Since these indices (traditional, digital, and composite) will be built and controlled separately using data from 2008 to 2022, their corresponding readings can be related for periods. However, direct comparisons among indices will not be possible. Nonetheless, they will provide an indication of relative position within sample, being more progressive in digital FI rather around usual in traditional FI.

This index captures various dimensions for FI, including access, usage, and technology empowerment. We included it to understand how broader FI initiatives impact bank profitability and stability, considering the significance of inclusive financial systems in promoting economic development.

A detail of variables used in research model is presented in Table 2 (Appendices).

First-stage PCA:

At this phase, sub-indices for 'access' and 'usage' categories constructed traditional (FI_T^a, FI_T^u) and digital (FI_D^a, FI_D^u) FI.

$$(FI_T^a)_{it} = \sigma_1(A_1)_{it} + \sigma_2(A_2)_{it} + d_{it} \quad \text{(I)}$$

$$(FI_T^u)_{it} = \omega_1(U_1)_{it} + \omega_2(U_2)_{it} + \omega_3(U_3)_{it} + \omega_4(U_4)_{it} + \omega_5(U_5)_{it} + d_{it} \quad \text{(II)}$$

$$(FI_D^a)_{it} = \rho_1(C_1)_{it} + \rho_2(C_2)_{it} + d_{it} \quad \text{(III)}$$

$$(FI_D^u)_{it} = f_1(S_1)_{it} + f_2(S_2)_{it} + f_3(S_3)_{it} + f_4(S_4)_{it} + d_{it} \quad \text{(IV)}$$

Second-stage PCA:

In second stage PCA, access and usage sub-indices resulted above, converted into FI index for traditional and digital inclusion.

$$(FI_T)_{it} = \beta_1(FI_T^a)_{it} + \beta_2(FI_T^u)_{it} + d_{it} \quad \text{(V)}$$

$$(FI_D)_{it} = \beta_1(FI_D^a)_{it} + \beta_2(FI_D^u)_{it} + d_{it} \quad \text{(VI)}$$

Third-stage PCA:

Lastly, composite FI index (CFI_{it}) calculated using PCA for above indices.

$$CFI_{it} = \beta_1(FI_T)_{it} + \beta_2(FI_D)_{it} + d_{it} \quad \text{(VII)}$$

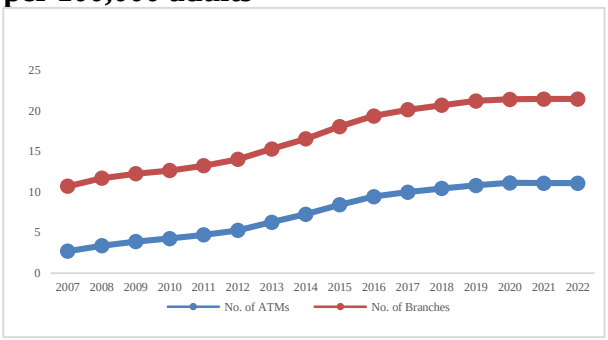
Data: The data used to construct the indices extracted from IMF Financial Access Survey (IMF FAS) and World Bank Financial Inclusion Database (WB Findex) for Pakistan from 2008 to 2022.

Dimensions of Financial Inclusion

Although substantial developments over time, a significant gap of financial inclusion still persists, particularly in services provided by financial institutions for various underserved populations in Pakistan during 2008 to 2022.

- Access to financial institutions, as determined by the number of ATMs per 100,000 adults, shows significant increase over the past years (Figure 1). Similarly, number of bank branches per 100,000 adults shows same behavior.

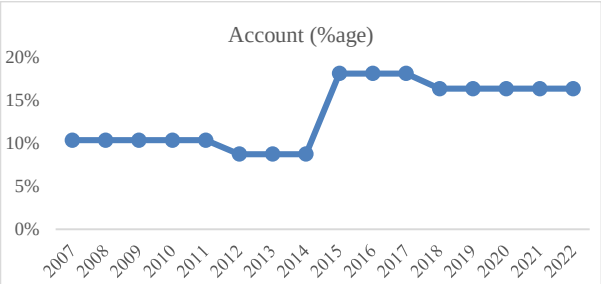
Figure 1: Number of ATMs and branches per 100,000 adults



- The share of adults with financial institutions account is degree of usage

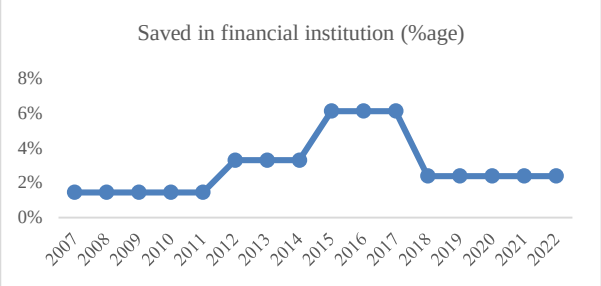
Figure 2: %age of individuals with financial institution account

for financial facilities. It shows further increased level of development in the recent years, roughly twice in lower 2014-15 (Figure 2). The development is more definite as wider account holdings, probably reflecting expanded mobile money products.



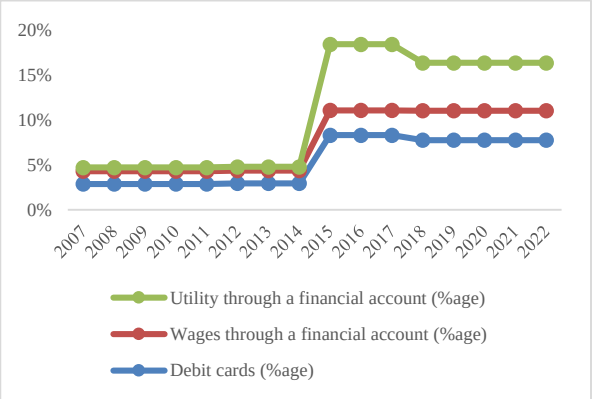
- Holding an account does not always reflect authentic usage of financial facilities. Above operating indicators for financial service usage such as portion of people that saved in financial institution showed deviate behavior (Figure 3).

Figure 3: %age of individuals who saves in a financial institution



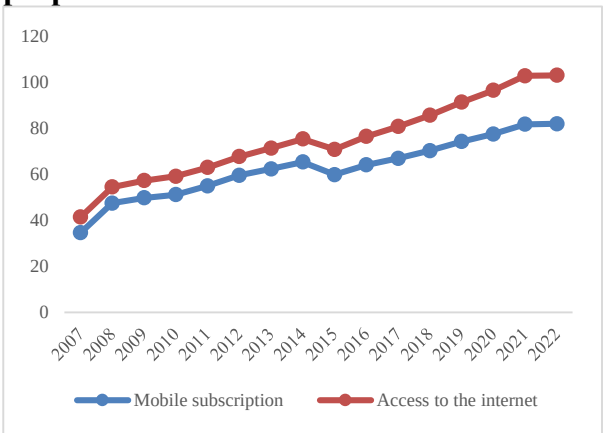
- In order to further elaborate the actual use of financial services, more active indicators of financial service usage such as the share of the population that used debit cards, receiving wages through a financial institution, and paying utility through a financial institution showed a deviate behavior (Figure 4).

Figure 4: %age of individuals who used debit cards, receiving wages, and paying utilities through a financial institution



- With significant improvements in approach for technology over the recent years, there is notable advancement in technology usage for financial transactions. Mobile subscriptions surged in Pakistan and have become the primary means of accessing the internet (Figure 5). This shift was partly driven by the increased affordability of mobile phones, including smartphones. As a result, mobile phone usage for financial transactions has grown significantly.

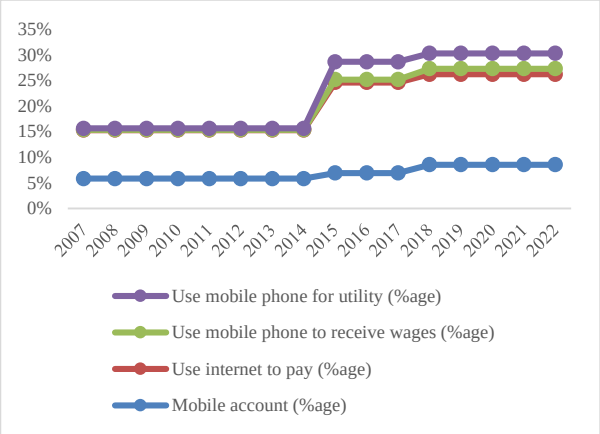
Figure 5: Mobile subscription, and %age of people with internet access



additionally, percentage of population operating mobile account, utilizing

internet to pay bills or purchasing using debit cards risen in country, with higher increase in trend of using mobile to receive wages and paying for utility (Figure 6).

Figure 6: %age of people having mobile account, uses internet to pay, uses mobile to receive wages, and utility



Weighing of variables: A three-stage principal component analysis (PCA) employed to derive a composite FI index. Financial inclusion is unobserved and is revealed in relation of various variables mentioned earlier. To calculate a quantitative extent of financial inclusion, we adopt there is an inherent latent variable, 'financial inclusion,' behind a set of correlated variables. PCA helps compute input of each variable in supporting variability for dataset.

First Stage PCA:

At this phase, sub-indices for 'access' and 'usage' categories constructed for traditional (FI_T^a, FI_T^u) and digital (FI_D^a, FI_D^u) FI. These are based on selected variables as in Table 2 (Appendices).

The access component (FI_T^a) of traditional FI is determined employing two indicators: number of ATMs per 100,000 population (A_1) and number of bank branches per 100,000 population (A_2). Usage component (FI_T^u) is determined by the following indicators: percentage of population having financial institution account (U_1), who save at financial institution (U_2), use debit cards (U_3), who receive wages through financial institution account (U_4), and who use financial institution account for utility payments (U_5).

$(FI_T^a)_{it} = \sigma_1(A_1)_{it} + \sigma_2(A_2)_{it} + d_{it}$

$(FI_T^u)_{it} = \omega_1(U_1)_{it} + \omega_2(U_2)_{it} + \omega_3(U_3)_{it} + \omega_4(U_4)_{it} + \omega_5(U_5)_{it} + d_{it}$

In this model for Pakistan, i denotes country, and t represents the years (2008 to 2022) under analysis. The total variation in access and usage indicators is divided into two impertinent components: variation explained by explanatory variables and variation due to error, denoted by d_{it}. If the model is well stated, then $E_e = 0$ and $E_\mu = 0$, meaning error variance is insignificant related to variance for latent variables, which represent 'access' and 'usage' for traditional payment facilities in Pakistan.

For proportions of digital financial inclusion, access component (FI_D^a) is computed by two indicators: mobile subscriptions per 100 persons (C_1) and percentage of the people having internet access (C_2). Usage component ((FI_D^u) is determined by the following indicators: percentage of people having mobile account (S_1), who use the internet for making payments (S_2), who receive wages via mobile phone (S_3), and who adopt mobile phone to pay utility bills (S_4).

$(FI_D^a)_{it} = \rho_1(C_1)_{it} + \rho_2(C_2)_{it} + d_{it}$

$(FI_D^u)_{it} = \mathfrak{f}_1(S_1)_{it} + \mathfrak{f}_2(S_2)_{it} + \mathfrak{f}_3(S_3)_{it} + \mathfrak{f}_4(S_4)_{it} + d_{it}$

For above dimension-related sub-index, PCA generates linear amalgamations of underlying variables to produce principal components. These workings ranked so that first principal component represent largest probable variation in explanatory variables. The first principal component, PC_1, describes more than 84 percent of total variation in the explanatory variables (Table 5: Appendices). This highlights the significance of the first component in capturing the majority of the data's variability.

To estimate sub-indices for each year, the underlying explanatory variables (x) and corresponding

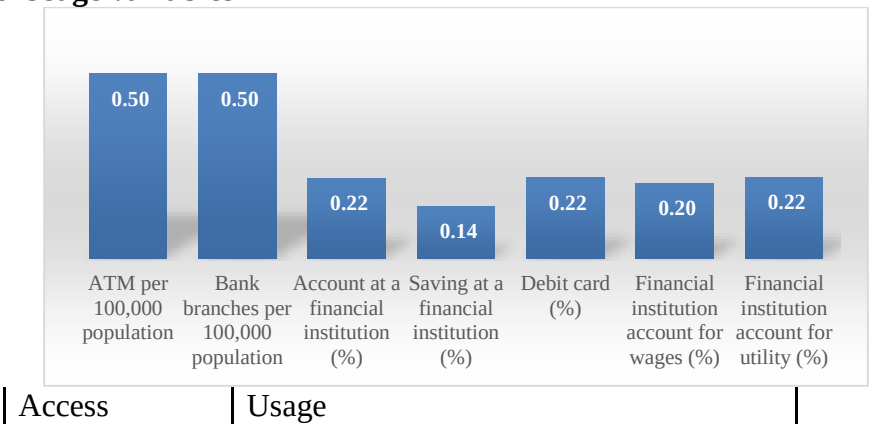
absolute loadings (L) from the first principal component are required. In this process, explanatory variables are normalized so that standard deviation stands 1 and mean comes 0. The absolute loadings, obtained from first principal component, determine the weight each variable contributes to the calculation of the sub-indices (Table 6: Appendices). This standardization ensures that the variables are on the same scale for accurate comparison across years.

To determine relative significance of each explanatory variable in sub-indices, the study can get weightings from loadings results of the first principal component. These weightings represent percentage involvement of every variable to sub-indices. By analyzing loadings, the study can identify how much each variable influences the overall index. The weightings for each explanatory variable are displayed in the results of the first principal component (Figure 7a, b). It will provide insight into their relative impact on the sub-indices.

Figure 7: First stage principal components analysis weights

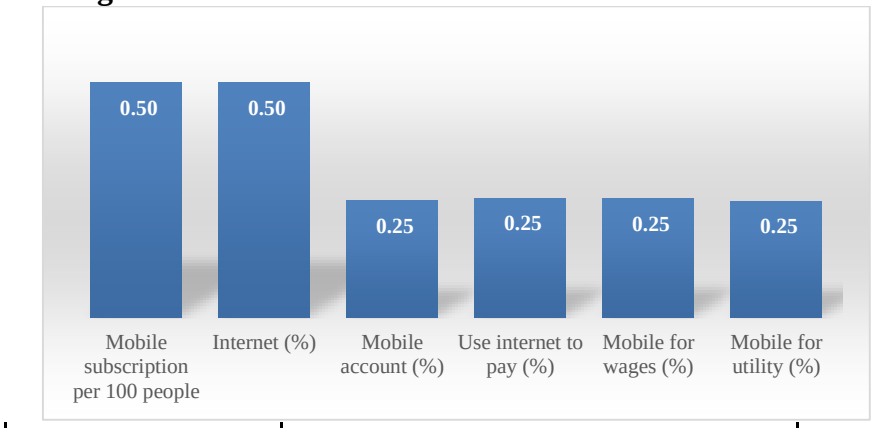
a) Traditional Financial Inclusion Index

Access and Usage variables



b) Digital Financial Inclusion Index

Access and Usage variables



Second-stage PCA:

In second phase PCA, access and usage sub-indices resulted above, converted into FI index for traditional and digital inclusion.

$(FI_T)_{it} = \beta_1(FI_T^a)_{it} + \beta_2(FI_T^u)_{it} + d_{it}$

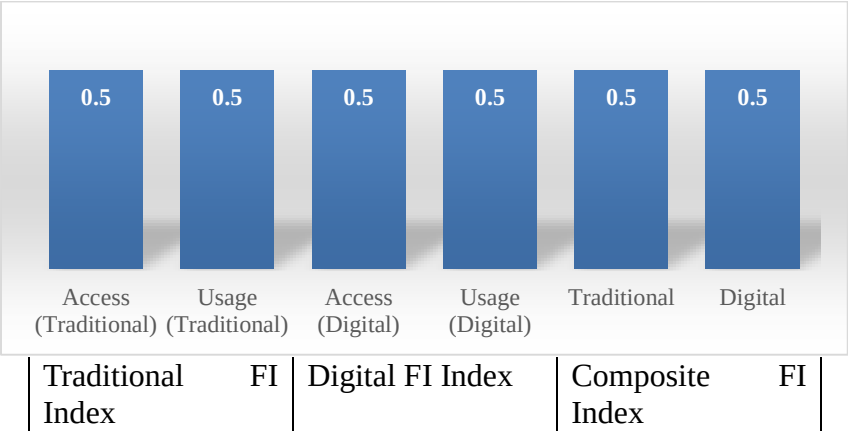
$(FI_D)_{it} = \beta_1(FI_D^a)_{it} + \beta_2(FI_D^u)_{it} + d_{it}$

Third-stage PCA:

Lastly, composite FI index (CFI_{it}) is estimated by using PCA on above indices.

$CFI_{it} = \beta_1(FI_T)_{it} + \beta_2(FI_D)_{it} + d_{it}$

Figure 8: *Second- and third-stage principal components analysis: Weights*



Results and Discussion

The financial inclusion landscape in Pakistan has undergone significant shifts from 2008 to 2022. It is evident from the trends in traditional, digital, and composite financial inclusion indices (Table 10). Table 10 highlights these shifts, illustrating the growing importance of digital financial services. It is alongside the gradual decline in traditional financial inclusion channels. The composite index reflects these changes, capture the overall progress in financial inclusion over the years.

Decline in Traditional Financial Inclusion (2008–2022)

The traditional financial inclusion index shows a consistent decline from 2.68 in 2008 to 1.40 in 2014. This downward trend indicates diminishing access to or usage of conventional banking services, such as bank branches and ATM networks. The years following 2015, however, saw a modest recovery, with the index rebounding to 2.22 by 2022. This recovery may reflect efforts by the banking sector. These include addressing infrastructure gaps and expand physical access points. Although the growth remains limited compared to the earlier years.

The initial decline could be attributed to several factors. It include high operational costs for banks in maintaining physical branches and limited outreach in rural areas. It also covers general shift in consumer behavior toward digital platforms. Additionally, economic challenges and regulatory changes during the early 2010s may have contributed to the declining importance of traditional banking channels.

Steady Growth of Digital Financial Inclusion

The digital financial inclusion index presents a contrasting trend, rising steadily from 2.39 in 2008 to 3.20 in 2022. This growth highlights the increasing adoption of digital financial services. These are mobile banking, ewallets, and branchless banking. A pivotal point can be observed around 2015, where the index rose from 0.60 to 3.20 over the next few years. It reflects an accelerated shift toward digital platforms.

Several factors contributed to this trend, including:

- Government initiatives promoting digital payments and financial services.
- Increased smartphone penetration and improved internet connectivity across the country.
- COVID19 pandemic, which further pushed consumers toward digital channels as physical access to financial institutions became restricted.

The significant rise in digital inclusion post2017 suggests that consumers are increasingly comfortable using digital platforms for transactions, payments, and savings. The role of fintech companies and mobile money services has also been instrumental in deepening digital financial inclusion.

Composite Financial Inclusion Index: A Balanced Perspective

The composite index, which captures the combined effect of both traditional and digital financial inclusion, mirrors the trends seen in digital financial services. It begins at 3.58 in 2008, drops to a low of 1.99 in 2014, and then starts rising again, reaching 3.83 by 2022. The early decline reflects the challenges faced by the banking sector. The subsequent rise indicates that digital inclusion efforts have largely offset the fall in traditional banking services.

The period from 2018 onwards marks a turning point, with the composite index showing sustained growth. This upward trajectory suggests that digital financial services are not only complementing traditional channels but, in some cases, replacing them. The continued rise in the composite index highlights that Pakistan's financial inclusion agenda is evolving with an increased focus on digital transformation.

Transition from Traditional to Digital: The results emphasize a clear transition from traditional financial services to digital platforms. While the reliance on traditional banking methods has diminished. Digital inclusion has surged, reflecting changing consumer preferences and technological advancements.

Role of Policy Interventions: Government policies promoting financial inclusion through digital payments, mobile wallets, and branchless banking have played a critical role in boosting the digital financial inclusion index. Initiatives such as Pakistan's National Financial Inclusion Strategy (NFIS) and regulatory frameworks for fintech have created an enabling environment for digital growth.

Challenges and Future Directions: Although digital inclusion has grown, there remains a need to address infrastructure challenges. It includes improving rural internet access and promoting financial literacy. Additionally, traditional banking services still play a role in serving segments that prefer physical banking access. It necessitate a hybrid approach to financial inclusion.

Conclusion

Financial inclusion is gradually acknowledged fundamental pillar to sustainable advancement. It empowers modest families by improving livelihoods, promoting financial interest, particularly among small and medium enterprises. For macro level, greater financial inclusion positively impacts financial system stability, monetary policy effectiveness, economic development (Nasir et al., 2020). Despite its importance, the measurement of financial inclusion remains a challenge. Existing indices are often criticized for their arbitrary weighting methods. The exclusion of mobile money is a critical component in today's financial landscape, renders traditional measures incomplete.

This study addresses these gaps in financial inclusion measurement. It propose a new multidimensional composite FI index using a three-stage Principal Component Analysis (PCA). The FI index incorporates crucial dimensions such as penetration, availability, and usage of financial services. The grouping of financial inclusion into three sub-indices allows policymakers to assess the key drivers of inclusion in a more granular way. It provide clearer guidance for policy reforms.

One of the strengths of this method is that it avoids biases in weighting by focusing on highly correlated indicators within each sub-index. Thus, it improve the accuracy of the FI measurement. The index is especially useful in capturing the transition from traditional banking services to digital financial services. It has been a significant trend post-2018.

While the quality dimension of financial inclusion remains challenging to measure due to data constraints. This research offers a relatively objective and comprehensive framework for analyzing financial inclusion. It provides a foundation for policymakers to craft targeted strategies to improve financial access, particularly in developing countries. Additionally, this index can serve as convenient instrument for assessing impact for financial inclusion on macroeconomic variables.

Thus, it promote sustainable economic growth.

Future research could expand this framework by incorporating digital financial markets, and the effects of emerging technologies. With the ongoing changes in global financial systems, a more refined measurement of financial inclusion will enable better policy formulation. It will meet the evolving needs of financial ecosystems.

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Appendices

Table 1: Previous work on developing FI indices

Methodology	Researcher(s)	Dimension	Variables
Principal Component Analysis	Jungo et al. (2022)	Access	Commercial banks per 1000 km^2 Commercial banks per 100,000 adults ATMsper1000 km^2 ATMsper100,000 adults
		Usage	Depositors in commercial banks per 100,000 adults Deposit accounts in commercial banks per 100,000 adults Borrowers in commercial banks per 100,000 adults Demand deposits in commercial banks as a percentage of GDP
Principal Component Analysis	Khera et al. (2021)	Access	Traditional: ATMsper100,000 adults Commercial banks per 100,000 adults
			Digital: Mobile subscription per 100 people % of population who has access to the internet
		Usage	Traditional: % of adults with a financial institution account % of adults who saves at a financial institution % of adults with debit cards % of adults who receives wages through a financial institution account % of adults who uses a financial institution account for utility
			Digital: % of adults who has a mobile account % of adults who uses internet to pay % of adults who uses mobile phone to receive salary or wages % of adults who uses mobile phone to make utility payments
Principal Component Analysis	Nguyen (2020)	Availability	Branches ATMs Mobile money agents
		Access	Deposit accounts Mobile money accounts
		Usage	Deposits Loans Mobile money transactions
Principal Component Analysis	Avom et al. (2021)	Availability	Proportion of adults with an account in a formal institution Ownership of a bank card Proportion of adults with a mobile account
		Access	ATMs per 100,000 people Commercial banks per 100,000 people Number of commercial banks and ATMs per 1000 km^2
		Usage	Saving in a formal institution Withdrawals and loans from a formal financial institution Use of digital payments Life and non-life insurance policies
Three panel cointegration Method	Huang and Zhang (2019)	Availability	Number of bank employees and bank branches per 10,000 members of the population
		Access	Number of bank employees and bank branches per 10,000 km^2
		Usage	Deposits and credit per capita relative to GDP per capita

Sarma's methodology (Sarma 2008)	Park and Mercado (2015, 2018)	Availability	ATMs per 100,000 adults Commercial bank branches per 100,000 adults
		Usage	Commercial bank borrowers per 1000 adults Commercial bank depositors per 1000 adults Household credit/ GDP ratio
Principal Component Analysis	Camara and Tuesta (2014)	Access	ATMs and commercial bank branches per 100,000 adults ATMs and commercial bank branches per 1000 km^2
		Usage	Accounts Loans Savings
		Barriers	Distance Affordability Documentation Lack of trust
Combining approaches of Sarma (2008) and Park and Mercado (2015)	Van et al. (2021)	Availability	Number of commercial bank branches and ATMs per 100,000 adults
		Usage	Ratio of bank credit of the private sector to GDP
Multi-dimensional approach	Sarma (2008, 2012, 2015, 2016)	Availability	Number of bank branches and ATMs per 100,000 adults
		Access	Number of bank deposit accounts per 1000 adults
		Usage	Volume of credit and deposits to adults as a proportion of GDP

Table 2:

Detail of variables used in PCA analysis:

Variables	**Notation**	**Measure**	**Variables**	**Notation**	**Measure**
Traditional FI index			**Digital FI index**		
Access			**Access**		
Number of ATMs	A1	Number of ATMs, per 100,000 adults	Mobile subscription, per 100 people	C1	%age of people, with mobile subscription
Number of bank branches	A2	Number of commercial bank branches, per 100,000 adults	% of population, who have access to internet	C2	%age of population, who have access to internet
Usage			**Usage**		
% of adults, with a financial institution account	U1	%age of adults, with a financial institution account	% of adults, who have a mobile account	S1	%age of adults, who have a mobile account
% of adults, who save at a financial institution	U2	%age of adults, who save at a financial institution	% of adults, who use internet to pay	S2	%age of adults, who use internet to pay
% of adults, with debit cards	U3	%age of adults, with debit cards	% of adults, who use mobile phone to receive salary or wages	S3	%age of adults, who use mobile phone to receive salary or wages
% of adults, who received wages through a financial institution account	U4	%age of adults, who received wages through a financial institution account	% of adults, who use mobile phone to make utility payments	S4	%age of adults, who use mobile phone to make utility payments

% of adults, U5 who use a financial institution account for utility	%age of adults, who use a financial institution account for utility

Table 3: *Summary statistics of the selected variables for the traditional and digital FI index*

	Mean	Median	Standard Deviation	Range	Min	Max
Access (Traditional)						
ATM per 100,000 population	7.526	7.860	3.134	6.353	2.720	11.140
Bank branches per 100,000 population	9.393	9.480	0.894	1.885	8.020	10.410
Usage (Traditional)						
Account at a financial institution (%)	0.133	0.133	0.038	0.060	0.087	0.180
Saving at a financial institution (%)	0.029	0.024	0.017	0.018	0.014	0.061
Debit card (%)	0.054	0.053	0.026	0.049	0.029	0.083
Financial institution account for wages (%)	0.022	0.021	0.009	0.019	0.014	0.033
Financial institution account for utility (%)	0.033	0.029	0.030	0.049	0.004	0.074
Access (Digital)						
Mobile subscription per 100 people	62.457	63.065	13.056	21.114	34.551	81.747
Internet (%)	12.187	10.500	5.063	8.638	6.800	21.037
Usage (Digital)						
Mobile account (%)	0.069	0.063	0.012	0.027	0.058	0.085
Use internet to pay (%)	0.136	0.135	0.042	0.082	0.095	0.177
Mobile for wages (%)	0.005	0.003	0.005	0.010	0.001	0.011
Mobile for utility (%)	0.017	0.017	0.015	0.027	0.003	0.035

Table 4: *Correlation matrix: Explanatory variables*

Variables	No. of ATMs	No. of Branches	Account (%age)	Saved in financial institution (%age)	Debit cards (%age)	Wages through a financial account (%age)	Utility through a financial account (%age)	Mobile subscription	Access to the internet	Mobile account (%age)	Use internet to pay (%age)	Use mobile phone to receive wages (%age)	Use mobile phone for utility (%age)
No. of ATMs	1												
No. of Branches	0.9977	1											
Account (%age)	0.8269	0.8333	1										
Saved in financial institution (%age)	0.4245	0.4391	0.5571	1									
Debit cards (%age)	0.9066	0.9119	0.9837	0.5608	1								
Wages through a financial account (%age)	0.9386	0.9393	0.9191	0.324	0.9585	1							
Utility through a financial account (%age)	0.8508	0.8585	0.9863	0.6695	0.9867	0.8994	1						
Mobile subscription	0.9306	0.9206	0.6098	0.243	0.7204	0.8068	0.6387	1					
Access to the internet	0.9233	0.9127	0.7356	0.1223	0.8091	0.9177	0.7157	0.9148	1				
Mobile account (%age)	0.8986	0.8949	0.7841	0.075	0.8439	0.9618	0.7455	0.8305	0.9514	1			
Use internet to pay (%age)	0.9195	0.9237	0.9765	0.5041	0.9975	0.9761	0.9729	0.7444	0.8413	0.8795	1		
Use mobile phone to receive wages	0.916	0.9134	0.8259	0.1417	0.8807	0.9792	0.792	0.8304	0.9495	0.9974	0.9117	1	

(%age)													
Use mobile phone for utility (%age)	0.8953	0.9011	0.9875	0.5807	0.9994	0.9488	0.9914	0.7026	0.7914	0.8261	0.9947	0.8649	1

Table 5: *First-stage PCA: Cumulative variance explained by principal components*

Access (Traditional)		**Access (Digital)**	
PC_1	0.9988	PC_1	0.9574
PC_2	1.0000	PC_2	1.0000
Usage (Traditional)		**Usage (Digital)**	
PC_1	0.8435	PC_1	0.9344
PC_2	0.9905	PC_2	1.0000
PC_3	1.0000	PC_3	1.0000
PC_4	1.0000	PC_4	1.0000
PC_5	1.0000		

Table 6: *First-stage PCA: Loadings*

	Notation	**PC_1**	**PC_2**	**PC_3**	**PC_4**	**PC_5**
Access (Traditional)						
ATM per 100,000 population	A_1	0.707	-0.707			
Bank branches per 100,000 population	A_2	0.707	0.707			
Usage (Traditional)						
Account at a financial institution (%)	U_1	0.479	0.105	0.685	-0.454	0.291
Saving at a financial institution (%)	U_2	0.314	-0.890	-0.251	-0.191	0.099
Debit card (%)	U_3	0.484	0.124	-0.138	0.671	0.530
Financial institution account for wages (%)	U_4	0.449	0.424	-0.636	-0.452	-0.102
Financial institution account for utility (%)	U_5	0.486	-0.044	0.212	0.320	-0.784
Access (Digital)						
Mobile subscription per 100 people	C_1	0.707	-0.707			
Internet (%)	C_2	0.707	0.707			
Usage (Digital)						
Mobile account (%)	S_1	0.495	0.561	-0.640	0.175	
Use internet to pay (%)	S_2	0.506	-0.397	0.243	0.726	
Mobile for wages (%)	S_3	0.505	0.424	0.668	-0.345	
Mobile for utility (%)	S_4	0.493	-0.590	-0.292	-0.569	

Table 7: *Second and Third-stage PCA: Cumulative variance*

Traditional FI Index		**Digital FI Index**	
PC_1	0.9410	PC_1	0.9389
PC_2	1.0000	PC_2	1.0000
Composite FI Index			
	PC_1	0.9692	
	PC_2	1.0000	

Table 8: *Second and Third-stage PCA: Loadings*

Traditional FI Index		**Digital FI Index**	
PC_1	0.707	PC_1	0.707
PC_2	0.707	PC_2	0.707
Composite FI Index			
	PC_1	0.707	
	PC_2	0.707	

Table 9: *Summary Statistics of Financial Inclusion Indices*

No. of	**Category**	**Mean**	**Median**	**Standard Deviation**	**Min.**	**Max.**

years						
Traditional FI Index						
15	Access	-0.000000044	0.1447	1.413	-2.17	1.59
15	Usage	-0.000000129	-0.1527	2.054	-2.011	2.623
15	Traditional	-0.000000122	0.33	2.38	-2.956	2.689
Digital FI Index						
15	Access	0.000000000	-0.2368	1.384	-2.263	2.28
15	Usage	-0.000000200	-0.3376	1.932	-1.834	2.239
15	Digital	-0.000000141	-0.406	2.274	-2.897	3.195
Composite FI Index						
15	Overall	-0.000000186	-0.02357	3.239	-4.138	3.83

Table 10: *Financial Inclusion Indices*

Year	Traditional	Digital	Composite
2008	(2.68)	(2.39)	(3.58)
2009	(2.57)	(2.25)	(3.41)
2010	(2.51)	(2.15)	(3.29)
2011	(2.35)	(2.00)	(3.08)
2012	(2.03)	(1.82)	(2.72)
2013	(1.70)	(1.62)	(2.35)
2014	(1.40)	(1.41)	(1.99)
2015	2.15	0.60	1.94
2016	2.47	0.90	2.38
2017	2.69	1.14	2.71
2018	2.06	2.19	3.00
2019	2.20	2.51	3.33
2020	2.19	2.82	3.54
2021	2.22	3.19	3.82
2022	2.22	3.20	3.83