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DIGITAL ACCESS DOES NOT GUARANTEE SAVINGS WHEN MATH ANXIETY IS HIGH

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Abstract
This paper investigates whether the effect of digital accessibility on formal savings participation is reduced by math anxiety. In the random effects regression model which uses panel data of 513 regencies and cities in Indonesia from 2016 to 2025, internet penetration is used as a proxy for digital accessibility, per capita savings is used as a proxy for savings participation, and the regional gap between literacy and numeracy scores is used as a proxy for math anxiety. The findings show that digital accessibility has a positive and significant effect on savings participation, but this effect is significantly weaker in areas with higher math anxiety. The negative interaction between digital accessibility and math anxiety is statistically significant, which implies that math anxiety limits the return to investment in digital infrastructure. Our results imply that digital access by itself is insufficient to foster increased participation in formal savings; the interface design of digital banking products and the content of financial literacy programs need to be calibrated to the numerical anxiety that impedes some users' adoption of these tools.
Keywords*: Math Anxiety, Digital Accessibility, Savings Participation, Behavioral Finance, Cognitive Load Theory.*

1. Introduction

East Asia and the Pacific has advanced in financial inclusion faster than almost any other developing region. Account ownership across the region was 83% of adults in 2024, up from 69% a decade earlier, and has largely paralleled the expansion of mobile phones and internet access. Indonesia is only partially within this regional trend; it is one of eight countries that together account for most of the world's adult population without a bank account, even as internet penetration in many of its provinces approaches the regional average. This is the same pattern observed across the country, where regencies with high access to the internet do not always show a corresponding increase in participation in formal savings.

The global gap between access and usage is well documented. In 2024, forty percent of adults in low- and middle-income economies saved formally, a significant increase over previous years and yet still well below account ownership rates in the same economies (Demirguc-Kunt, Klapper, Singer, Ansar, & Hess, 2018). Indonesia's own experience fits this broader pattern: connectivity is moving faster than formal saving behaviour is catching up, and the gap between the two is large enough, and persistent enough, to need its own explanation rather than being treated as a lag that will close on its own.

The most common explanations of this gap are poor physical infrastructure or low financial literacy. Both do have real explanatory power (Hastings, Madrian, & Skimmyhorn, 2013; Grohmann, Kluhs, & Menkhoff, 2018). But they share a common assumption: if someone can get into a banking app and knows, in broad terms, what a savings account is meant for, adoption should happen. The present study challenges this assumption and examines a common factor underlying both explanations: math anxiety, defined as the tension and fear a person experiences when dealing with numbers (Ashcraft & Moore, 2009). Math anxiety is different from general anxiety and different from low literacy. One may be a fluent reader, understand what a savings goal means in theory, and still wince at the sight of a percentage, a fee calculation, or a running balance.

Mobile banking apps and e-wallets are, by their very nature, numerical environments. Opening one means reading a balance, checking a transaction fee, entering a transfer code correctly, or tracking a minimum-balance requirement, often under the implicit pressure that a mistake could

mean losing money. For someone with math anxiety, these small, routine tasks are far from neutral. Previous studies of financial decision-making have shown that math-anxious individuals tend to disengage from numerically demanding tasks long before they fail at these tasks, preferring to avoid the task rather than risk a mistake (Skagerlund, Lind, Stromback, Tinghog, & Vastfjall, 2018; Choi, Taber, Thompson, & Sidney, 2020). But when this is brought to banking, it means that a savings app could be something customers shy away from instead of use, no matter how strong the connection is or how close the nearest signal tower is.

This is not contested here, and existing research confirms that digital accessibility supports financial participation (Ozili, 2018; Demirguc-Kunt et al., 2018). What this literature has not asked is what happens when access meets a population that is uncomfortable with numbers, whether the benefit of accessibility is the same for everyone or whether it relies on a psychological precondition that has so far gone unmeasured at scale. Much of the existing literature on math anxiety is focused on individual-level phenomena (Storozuk & Maloney, 2023), often in educational environments, and has not been systematically related to regional patterns of financial behaviour. The study addresses that gap head-on with a specific testable question: does math anxiety limit the return on digital accessibility, and if so, by how much?

We argue that math anxiety takes up the working memory a person needs to work a banking interface, drawing on Cognitive Load Theory (Sweller, 1988; Chalmers, 2003), leaving less capacity for the transaction itself and producing avoidance instead of adoption. Working memory is a shared, limited resource between emotional regulation and task performance (Ashkenazi & Danan, 2017). The more anxious a user is about numbers, the less of that interface they can process calmly, and the more likely they are to disengage.

To summarise, the key proposition here is that even with digital access, savings participation is not guaranteed if math anxiety is high; infrastructure offers an opening that psychology can still close. To test this claim, one requires data that can address both sides of the relationship at the same time: regional variation in digital access, and regional variation in a proxy for math anxiety, over a long enough time to distinguish a lasting pattern from short-term noise. The rest of this paper does just that, using 10 years of panel data from 513 Indonesian regencies and cities.

2. Literature Review

1.1 Digital Accessibility and Participation in Saving

Digital accessibility, taken here to mean access to internet infrastructure that enables people to access financial services remotely, is anticipated to increase savings participation by reducing transaction costs and the need to visit a physical branch (Ahmad, Green, & Jiang, 2023). Where banks are physically scarce, internet access enables people to open digital accounts and hold money securely, which should lift aggregate financial inclusion (Batista & Vicente, 2020). This logic is behind much of the recent infrastructure spending in emerging markets, and is well supported empirically when accessibility is measured on its own. Mobile money, in particular, has been shown to be a reliable driver of digital financial inclusion and a stepping stone toward savings adoption (Suri & Jack, 2016; Demirguc-Kunt et al., 2018).

The financial inclusion literature has developed increasingly sophisticated indices to capture the digital dimension of inclusion, moving beyond simple account ownership toward measuring access, usage, and quality of digital financial services (Khera, Ng, Ogawa, & Sahay, 2022). These advances reflect a growing recognition that connectivity and financial behaviour do not automatically move in the same direction.

1.2 *Cognitive Demands of Digital Banking*

Access is not ease of use. Digital banking apps mainly communicate through dashboards, codes, percentages and running totals, and using them competently requires a specific set of cognitive skills. For a large part of the population, the numerical environment is an obstacle in itself.

Cognitive Load Theory (Sweller, 1988) suggests that working memory has a limited capacity. When a math-anxious person opens a banking application, that limited capacity is split between completing the task and dealing with the anxiety the task provokes (Skagerlund et al., 2018; Ashkenazi & Danan, 2017). The result is cognitive overload, where transaction details become harder to follow, and transfers feel riskier than they objectively are. Math-anxious users tend to withdraw from the application rather than taking advantage of what it offers, and rely instead on cash or other informal, non-numerical ways of holding money.

Numeracy has consistently been shown to be the strongest predictor of financial literacy and of superior financial decision-making (Estrada-Mejia, de Vries, & Zeelenberg, 2016; Skagerlund et al., 2018). Low numeracy is associated with poorer financial outcomes and wealth accumulation (Peters, Vastfjall, Slovic, Mertz, Mazzocco, & Dickert, 2006; Lusardi, 2012), and even predicts objectively worse financial outcomes such as mortgage default (Gerardi, Goette, & Meier, 2013). At a global level, low numeracy is systematically linked to poor financial well-being across countries (Bruine de Bruin & Slovic, 2021).

1.3 *Interaction Between Digital Accessibility and Math Anxiety*

The main hypothesis of this study is that digital accessibility and math anxiety do not function independently. Digital accessibility throws open the door; math anxiety determines whether people walk through it.

In a region with high internet penetration but high prevalence of math anxiety, the expected gain in savings participation from digital infrastructure should be smaller than in a region with low prevalence of math anxiety. The psychological barrier compensates for the infrastructural advantage: people can freely use the internet for entertainment or communication, but still avoid it for anything involving managing money. Financial anxiety is a distinct psychological construct from general anxiety (Shapiro & Burchell, 2012), and it is precisely this numerical-financial interface, rather than the device itself, that constitutes the barrier. Based on this, math anxiety is hypothesised to attenuate, not just coexist with, the relationship between digital accessibility and savings participation.

Hypotheses: Math anxiety negatively moderates the relationship between digital access and participation in savings. The positive effect of digital accessibility on savings participation decreases as math anxiety increases.

3. Research Methods

3.1 *Data and Sample*

This study uses secondary macro-level panel data from 513 regencies and cities (kabupaten/kota) in Indonesia for ten years (2016-2025), yielding 5,130 observations. The data are collected from official sources, namely the Central Statistics Agency (BPS), the Ministry of Education, Culture, Research and Technology, and the Financial Services Authority (OJK).

3.2 *Measurement of Variables*

The model employs the following variables: (1) Savings participation (Y): natural log of per capita total savings (tabungan), indicating the aggregate level of regional participation in formal and digitised savings accounts. (2) Digital accessibility (X): internet usage in the population of each city or regency. To reduce multicollinearity, this variable is mean-centred (da_centered). (3) Math anxiety (Z): macro-level proxy, operationalised as the standardised difference between literacy and numeracy scores from national educational assessments (ma). The wider the gap, the more numerically difficult the region and therefore the more averse to numbers psychologically. (4) Control variables: log GRDP per capita (economic capacity), mean years of schooling (human capital), log population (demographic size), and a proxy for income.

3.3 *Analytical Model*

To test the interaction hypothesis, a Random Effects (RE) moderated regression model was estimated, chosen on the basis of the Hausman test. The interaction term (da_ma) is the product of mean-centred digital accessibility and math anxiety. The equation is:

$$ln_Savings_pc = a + b1(DA) + b2(MA) + b3(DA \times MA) + b4(Controls) + e \quad ..... (1)$$

The coefficient of interest is b3. A negative and statistically significant b3 suggests that math anxiety diminishes the positive impact of digital accessibility on savings participation.

4. Research Findings and Discussion

4.1 Classical Assumption Tests

The Variance Inflation Factor (VIF) values for all independent variables were below 5.0, indicating no serious multicollinearity. The Breusch-Pagan test and the Wooldridge test did not find evidence of heteroskedasticity and autocorrelation. The Hausman test ($p > 0.05$) preferred the Random Effects model over the Fixed Effects model.

4.2 *Regression Results*

We present the results of the Random Effects regression in Table 1 with ln_Savings_pc as the dependent variable.

Table 1. Random Effects Regression Results (Dependent Variable: ln_Savings_pc)

Variable	Coefficient	Std. Error	t-stat	p-value	Sig.
DA (digital accessibility, centered)	0.0152	0.0018	8.444	0.0000	***
MA (math anxiety)	-0.0750	0.0115	-6.521	0.0000	***
DA x MA (interaction)	-0.0045	0.0010	-4.500	0.0000	***
Log GRDP per capita	1.1050	0.1650	6.697	0.0000	***
Mean years of schooling	0.2350	0.0300	7.833	0.0000	***
Log population	-1.7800	0.0720	-24.720	0.0000	***
Income proxy	0.0000	0.0000	1.050	0.2940	
Constant	9.8500	2.9500	3.339	0.0008	***

*Note: *** p < 0.01. Standard errors clustered by entity. Source: authors' calculation.*

4.3 *Testing of Hypotheses*

The positive coefficient on DA ($b = 0.0152$, $p < 0.01$) confirms that on average, digital accessibility increases savings participation. The interaction term (DA x MA) shows a negative and highly significant coefficient ($b = -0.0045$, $p < 0.01$), supporting the hypothesis that the positive impact of internet accessibility on savings participation is significantly smaller in areas with high math anxiety.

4.4 *Limits of an Infrastructure-First Approach*

For many years, the conventional wisdom in financial inclusion policy has been that infrastructure is enough: build it, and participation will follow. Governments have invested heavily in bringing 4G and 5G coverage to remote regencies, and the positive main effect of DA in this model supports part of that logic, since internet access does increase savings participation on its own (Ahmad et al., 2023; Ozili, 2018).

This conclusion is qualified by the negative interaction term. The relationship between digital access and participation in savings is flatter in regencies with a large literacy-numeracy gap and therefore a high inferred level of math anxiety. The internet reaches these areas, but a part of the population does not use it for banking or saving. The infrastructure delivers the application to the user's phone, but the user's own cognitive response limits engagement with it, as the numerical interface is perceived as a source of difficulty rather than convenience. This

distinction between access and usage-level inclusion is central to recent measurement efforts in digital financial inclusion (Khera et al., 2022).

4.5 *Cognitive Overload in the Banking Interface*

Why would this interaction be centred around savings? Even a digital savings account requires constant numerical processing to manage it. In a typical mobile banking app, a user will read account balances, minimum-balance requirements, transaction histories, and transaction fees, all in the same session. Cognitive Load Theory (Sweller, 1988) states that these elements tax working memory (Chalmers, 2003; Ashkenazi & Danan, 2017).

For a person with math anxiety, even opening the app can trigger anticipatory anxiety. The cognitive resources that would normally be used for the transaction are instead used to manage that anxiety and worry about a numerical mistake, such as sending funds to the wrong account or misreading a balance (Skagerlund et al., 2018). This overload makes the tool feel more complex and less safe than it really is. The likely response is avoidance: holding savings in cash, or transferring them through informal, non-numerical means, and circumventing the digital infrastructure that is, in principle, available. This is consistent with evidence that low numeracy is associated with poorer financial decision-making (Peters et al., 2006; Estrada-Mejia et al., 2016; Lusardi, 2012), that numerical ability predicts concrete financial mistakes (Gerardi et al., 2013), and that financial anxiety promotes avoidance behaviour (Shapiro & Burchell, 2012; Storozuk & Maloney, 2023).

4.6 *Implications for the Measurement of Digital Readiness*

These findings have direct implications for the assessment of digital readiness by policymakers. Financial inclusion cannot be measured only by internet penetration without taking into account the psychological readiness of the population (Grohmann et al., 2018; Morgan & Trinh, 2020). If a region has high levels of math anxiety, it can have 90 percent internet penetration and still lag behind in participation in formal savings. If allowed to continue, this dynamic is likely to increase, rather than decrease, financial inequality, as the digital economy continues to fail to serve the population that is least comfortable with numbers (Suri & Jack, 2016; Geng & He, 2021).

4.7 *Limitations and Directions for Future Research*

Two limitations must be noted. First, math anxiety is here measured at the level of the regency, through the gap between literacy and numeracy scores, rather than via individual-level psychometric instruments such as the Abbreviated Math Anxiety Scale. This macro-level proxy is well-suited to a panel study of this scope, but it cannot capture within-region variation in math anxiety and assumes that a wide literacy-numeracy gap reflects anxiety rather than, for instance, differences in the quality of numeracy instruction. Second, the data are observational, and thus the interaction coefficient should be interpreted as an association rather than a causal effect. Unobserved regional characteristics, such as the quality of banking infrastructure or local financial institutions, could plausibly affect both digital accessibility and savings behaviour.

Future work could combine this macro-level analysis with household surveys measuring math anxiety directly (Choi et al., 2020), allowing for a cleaner test of the cognitive-overload mechanism. Field experiments that vary interface design (e.g., a numerically dense vs. visually simplified dashboard within the same population) would also help establish whether interface changes reduce avoidance behaviour (Chalmers, 2003), rather than assuming it from the survey-based interaction effect alone.

5. Conclusion

This study tackles a perennial puzzle in the financial inclusion literature: why does digital access not automatically translate into formal financial participation? We integrate Cognitive Load Theory into the economics of digital finance to hypothesise that math anxiety, a psychological aversion to numerical processing, is a cognitive barrier that dampens the effectiveness of digital

infrastructure (Sweller, 1988; Ashkenazi & Danan, 2017).

Using random effects regression with a panel dataset of 513 regencies and cities in Indonesia from 2016 to 2025, we find a strong, negative, and statistically significant interaction between regional internet penetration and the literacy-numeracy gap, our macro-level proxy for math anxiety. Empirical evidence suggests that, although digital accessibility generally encourages participation in savings (Batista & Vicente, 2020; Ahmad et al., 2023), its marginal returns are greatly constrained in areas where math anxiety is prevalent (Skagerlund et al., 2018). This result adds to the behavioural finance literature by showing that psychological frictions can offset the declines in transaction costs achieved through technological infrastructure (Estrada-Mejia et al., 2016; Storozuk & Maloney, 2023). People who are anxious about maths experience cognitive overload in numeric environments such as digital banking and, as a consequence, tend to disengage from formal financial institutions and resort to informal, non-numeric saving mechanisms, whether or not the network is available.

These findings have major implications for policymakers and financial service providers. The prevailing paradigm of financial inclusion, with its heavy emphasis on hardware and network expansion, needs to evolve to incorporate cognitive accessibility. The digital banking interface needs to be rethought to make the digital world less intimidating for anxious users. This can be accomplished by lowering cognitive load through reducing raw numerical density, using visual aids, and automating complicated calculations (Chalmers, 2003). Second, financial literacy programs must move beyond teaching users how to use apps and instead focus on addressing number anxiety and building basic math confidence (Hastings et al., 2013; Kaiser, Lusardi, Menkhoff, & Urban, 2022). Finally, infrastructure deployment strategies must include regional cognitive profiles; for example, regions of high math anxiety may need transitional digital services with human assistance to bridge the psychological gap before moving to fully self-service models (Geng & He, 2021).

While this study offers important macro-level evidence for the moderating role of math anxiety, it is not without limitations. While the use of regional literacy-numeracy gaps as a proxy for math anxiety is effective for large-scale panel analysis, it masks individual variation. Future research should use micro-level psychometric data and experimental designs (e.g., A/B testing of interface complexity) to establish a direct causal link between cognitive load, interface design, and financial avoidance behaviour. Ultimately, the goal of true digital financial inclusion is to ensure the digital economy is not just physically accessible but also psychologically manageable.

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