

The Relationship Between Mental Health and Mobile Banking Adoption: Evidence from Canada

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Data Availability Statement

The dataset used for statistical analysis is publicly available, published by Abacus Data Network in 2022, and cited in the paper (BibTeX citation provided by the publisher). The following hyperlink to Abacus Data Network, Statistics Canada Open License can be used to directly access the dataset: <https://hdl.handle.net/11272.1/AB2/NUVBX2>.

The Relationship Between Mental Health and Mobile Banking Adoption: Evidence from Canada

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Abstract

Mobile banking (m-banking) is the use of a mobile device such as a smartphone to do banking tasks. We investigate the direct and moderated effect of mental health on m-banking adoption. Moderators in our study are extracted from theories in technology adoption paradigm or from literature related to mental health. These variables are relationship satisfaction (RS), smartphone dependency (SD), and social networking/social media (SNS) use. We use the Canadian Internet Usage Survey conducted by Statistics Canada in 2020–21 as the main source of data. The impact of mental health on m-banking adoption is analyzed across levels of RS, SD, and SNS use. A fixed effect logistic regression model is utilized to investigate the relationship of variables, considering the grouping based on province following the cluster sampling design of the dataset. Our results indicate that mental health significantly negatively affects m-banking adoption: better mental health outcomes are associated with lower likelihood of m-banking adoption. We observe that social media users and those that are more dependent on their smartphones are more likely to adopt m-banking, therefore one suggestion for banks is to use social media platforms as marketing channels. We do not find sufficient evidence that significant differences exist for the effect of mental health on m-banking adoption across levels of SNS, SD and RS.

Keywords: Mobile Banking, Mental Health, Technology Adoption, Mixed effect Logistic Regression

1 Introduction

Mobile technologies such as smartphones are exceptionally popular nowadays, making up a higher portion of internet access devices than personal computers and laptops combined [1]. Smartphone ownership is projected to increase almost 31% between 2024 and 2029 globally [2]. Mobile banking (m-banking) is the use of a smartphone to do banking tasks such as payment of bills, viewing account balance, and transferring funds. Our goal is to examine the impact of mental health and other factors that might influence this impact on m-banking adoption. The notion of "*Adoption*" appears in various forms throughout the Information Systems (IS) literature, such as technology adoption. Adopting technology is not merely a singular choice but involves a series of phases over an extended period of time [3]. In this study, adoption is the recent or new use of m-banking (more specifically, a time period of three months).

One reason for m-banking's popularity is convenience [4]. In-person visits to a bank pose multiple challenges such as: queues, commute time and costs, potential system shutdowns, and many others. Banking via a smartphone, a daily companion for most, resolves these challenges. The perpetual accessibility of smartphones contrasts with the restrictions imposed by brick-and-mortar banks, offering users access beyond business hours and other constraints. Despite the potential benefits of m-banking, not all m-banking apps achieve success in user uptake. The m-banking adoption literature has examined a multitude of factors related to the uptake of m-banking [5–19], but has rarely studied psychological and emotional constructs that impact consumers' decision on adopting m-banking [20–24].

Emotions have been shown to impact consumers' technology adoption decisions [25, 26]. However, to the best of our knowledge, the literature has only focused on emotions that arise due to technology adoption such as apprehension and anxiety about a new technology [27] which is different from pre-existing anxiety that is unrelated to technology; satisfaction and joy gained from use of a new technology [21], which is not the same as being content with life in general regardless of the existence of a technology; and the notion of trust [22–24] which

is the measure of how safe the consumer deems the products from a certain brand to be, and how willing they are to invest money to purchase a brand's products or services. Thus, we see that *pre-existing emotional states* and *emotions due to technology adoption* are different. Our study aims to address the lack of research on the impact of emotions existing before the adoption of a technology on the adoption decision in the specific area of m-banking.

Mental Health (MH) is elected to replicate the (pre-adoption) emotional state of individuals, independent of technology adoption. MH is influenced by a combination of internal factors, such as emotions and mood, and external factors, including relationships, and environment [28]. Therefore, to develop a comprehensive understanding of its effect, we introduce other variables to our model that we believe might affect MH's impact on m-banking and are relevant in the context of our study. We use literature to identify these variables: Relationship Satisfaction (RS), Smartphone Dependency (SD) and Social Media/Networking Sites use (SNS). Relationship satisfaction (RS) is considered in this study in accordance with Sociometer theory, which states that a person's well-being depends fundamentally on their sense of belonging or acceptance from others [29].

Our emphasis on mobile technology sets us apart from other (non-mobile) technology adoption studies. This indicates the importance of considering the device type that is being studied in all aspects of the adoption. Specifically because device differences influence mobile technology adoption [30]. Therefore, we consider two smartphone specific constructs which we verify impact MH to be included in our study: Smartphone Dependency (SD) and Social Media use (SNS)¹. In short, in this study, we ask and seek answers to the following questions:

1. Does consumers' mental health state prior to adoption of m-banking impact their m-banking adoption decision?
2. Does relationship satisfaction change how consumers' mental health prior to adoption of m-banking impact their m-banking adoption decision?

¹See discussion in section 2.

3. Does smartphone dependency change how consumers' mental health prior to adoption of m-banking impact their m-banking adoption decision?
4. Does social media or social networking use change how consumers' mental health prior to adoption of m-banking impact their m-banking adoption decision?

Mobile banking has the potential to positively impact society, thus making it a worthwhile topic to investigate. Financial institutions, and banks specifically, may use the results of our study to efficiently plan, strategize, develop, and promote their m-banking products. Consequently, consumers gain access to better m-banking apps tailored to accommodate their preferences and constraints. The main research question of our study is: does the state of consumers' mental health impact m-banking adoption? Controlling for relationship satisfaction, smartphone dependency and social media use as well as demographic information such as age, income and education helps identify associations between mental health and m-banking adoption that are not confounded with pre-existing individual variations in mental health.

The remainder of the paper proceeds as follows: Section 2 combines the review of related literature and development of our hypotheses. Section 3 is concerned with introducing the study's main source of data. Section 4 presents the study's modeling and analytical methods. In section 5, we discuss the results of our model(s) in detail and offer theoretical and managerial insights. Lastly, the paper concludes in section 6.

2 Related Work and Hypotheses Development

The discourse surrounding affective constructs in technology adoption traces back to seminal works such as Diffusion of Innovation [31] and the Theory of Reasoned Action [32] in the 1960s. Despite the rich literature, a notable gap persists regarding the exploration of individuals' attitudes towards adoption of new technologies that are influenced by their psychological/mental state. Our main goal is to address this gap. We consider individuals' mental health as an indicator of their susceptibility to various mental states (emotions). Unlike many other technology adoption studies, we do not base our discussion on a single technology

adoption theoretical framework. This is because our study is the first to incorporate mental health and variables that impact its effect on technology adoption. Our results could be used to enhance our understanding of how mental health impacts technology adoption and potentially lead to developing more comprehensive models (read discussions in section 5.5). In this section, we will develop our main hypotheses and justify the choice of each variable using various literature.

2.1 Mental Health (MH)

Recently there has been an increase in incorporation of psychological dimensions into the investigation of technology adoption through the study of affective constructs [33, 34]. However, thus far, the focus has been on post-consumption positive and negative mental states (positive and negative emotions), for example feeling happy (positive emotion/mental state) as a result of using a new technology [35, 36]. Emotions are the results of neurobiological activity in the brain [37]. They are temporary states of being, often reflections of thoughts and circumstances [38]. In many consumer research studies the main focus is on loyalty and continued use, thus only the consequences of an emotional response to an experience (use of an app or service) are considered and not how certain emotions arise and what their antecedents are [39]. Emotions arise due to various stimuli and impact individuals' decision on performing a behavior such as technology adoption [40].

An example of a positive emotion (positive mental state) that encourages further use of an application would be: Offering discounts and gifts to consumers makes them feel special and important, thus appreciative towards the business [41]. M-banking users who feel appreciative are more likely to use m-banking apps [42]. On the other hand, certain stimuli that result in negative emotions such as anger and frustration, are negative mental states that hinder m-banking use [43]. An example of such negative emotions arising is adding too many features to an m-banking app which could confuse users, cause accidental misuse, and many other issues. Lyu et al. argues that the addition of non-core features to m-banking apps leads

to "user fatigue", which they show negatively impacts m-banking use [42]. These examples showed how stimuli (gifts, discounts, too many features) cause emotions (appreciation, anger and frustration) that impacts technology use.

Most studies that have explored technology use due to pre-existing emotions and emotional susceptibility have focused on negative usage such as addictive internet use [44–46]. Liu et al. shows that Alexithymia (the inability to recognize emotions) and proneness to boredom positively correlate with an addiction to reading fiction novels online [47]. However, no such studies exist in the m-banking domain that discuss the impact of susceptibility to emotions and pre-existing emotions (not caused by m-banking app use) on m-banking adoption. To fill this gap in knowledge in the m-banking literature, we consider Mental Health (MH) as a proxy to show both the susceptibility to emotions and represent the pre-existing emotional (mental) state of consumers.

While mental health is different from emotions, it is a valid measure of emotional state and susceptibility to emotions as it is the precursor to emotions felt by individuals. Being sad (sadness as the emotion) is different from being depressed (depression is a mental illness²), but a depressed individual is more likely to *be* sad; i.e., sadness is a symptom of a mental health problem [49]. Therefore, we contest that MH is an appropriate measure of individuals' mental state because mental health controls and predicts people's emotional reactions to stimuli [50–54].

Product adoption literature has confirmed that pre-existing mood biases user attitude and perception associated with a product [55–57]. This is also prevalent in other technology adoption problems as the results of [58] indicate. Park et al. investigate the effects of anxiety and social influence on mobile payment (m-pay) benefits and in turn mobile payment usage [58]. The authors use Mental Accounting Theory (MAT) to show that technology adoption is influenced by the expectation of value (benefit) of technology use.

²Mental illness is when individuals are suffering from psychiatric conditions [48].

According to MAT, individuals engage in a cognitive evaluation process wherein they assess potential economic outcomes, weighing benefits, risks, and uncertainties before making decisions [59]. The findings of Park et al. highlight the importance of considering MH differences in individuals. Their results are in stark contradiction to established norms in the area of technology adoption when anxiety is concerned: anxiety positively influences the perceived benefits associated with m-pay, subsequently fostering its adoption [60]. In other words, their evidence suggests that heightened anxiety about m-pay correlates with a greater propensity to adopt m-pay solutions. The authors attribute this surprising outcome to variations in the intensity of anxiety among individuals, a factor they had not accounted for in their study. This shows that proneness to anxiety needs to be considered, which is why it is important to include a measure for this, which we do so by using MH.

To summarize our discussion on mental health (MH), we highlight the rationale behind its selection as the primary focus of our study. Firstly, the results from Park et al. [58] prompted us to incorporate a measure of susceptibility to various psychological responses and subsequent behavioral choices within the realm of technology adoption. Secondly, MH has been shown to impact consumers' behavior in product adoption literature, which is closely related to technology adoption. Consequently, we formulate the inaugural hypothesis of our study by extending the findings of product adoption about MH to m-banking:

H1 The probability of m-banking adoption is independent of individuals' MH state.

2.2 Factors influencing MH's effects on m-banking

Many factors, both internal (biological, hereditary, emotional) and external (such as a global pandemic) affect MH [61]. We first consider Relationship Satisfaction (RS), which has been established to influence MH according to various studies, across multiple disciplines [62–64]. Additionally, because device type impacts technology adoption [30], we consult the literature and choose two smartphone-specific constructs that also affect MH: 1) Smartphone Dependency/Addiction (SD), which is closely related to the excessive use of a smartphone, and

2) Social Networking/Media (SNS) use. Both of the smartphone-specific constructs seem to have a negative impact on mental health according to the literature: SD is directly linked to deteriorating mental health [65], and SNS use is often portrayed in relevant literature as having a negative influence on users' overall mental health [66]. We hypothesize that each of these variables influence MH and its subsequent impact on m-banking adoption.

2.2.1 Relationship Satisfaction (RS)

The association between Relationship Satisfaction and MH has been extensively studied in the psychological literature [67–69]. Humans are intrinsically social creatures, thus, it is not surprising that loneliness impacts mental health outcomes of people regardless of their age and overall health [70, 71]. Loneliness is the lack of a social support systems; in our context, manifesting as dissatisfaction with one's relationships. Loneliness negatively impacts MH, i.e., the lonelier a person feels the worse their mental health is going to be [70, 71]. Many studies have explored the impact of social support on MH in various contexts. Even though it is argued that having almost any social relationship is considered to be better than none at all [62], not all social relationships have positive impacts on MH.

Supportive social relationships, which we conceptualize as high relationship satisfaction, improve MH [62, 72]. On the other hand, dysfunctional or maladaptive relationships or unsupportive social circles significantly impair psychological well-being, leading to increased stress, depression, and anxiety [73]. Research has consistently shown that negative social interactions undermine MH by exacerbating feelings of loneliness and lowering self-esteem [74–76]. Therefore, social relationships have the ability to either support or harm MH of individuals based on their quality. Hence, we use relationship quality to include both good and bad social relationships.

Drawing from our discussion so far and the extensive body of research exploring various social determinants linked to mental health, we posit that Relationship Satisfaction (RS) is an important factor influencing MH. Nevertheless, we aim to understand whether this observed

effect significantly influences MH's impact on m-banking adoption. Thus, we have the following hypothesis:

H2 The impact of MH on m-banking adoption remains constant across levels of RS.

2.2.2 Smartphone Dependence (SD)

Smartphone addiction typically correlates with extensive use of smartphones [77] and is connected to increased risks of depression and anxiety [78]. Excessive use of smartphones impact physical and psychological health in various way. For example, in a study by Shoukat [78] it was found that teenagers use their smartphones the most at night which leads to sleep deprivation, subsequently contributing to physical and mental health issues, including increased anxiety. Numerous other studies have thoroughly explored the impact of smartphone addiction or excessive use on mental health (MH) [79–81]. High levels of anxiety is one of the most frequently cited mental health outcome of high smartphone dependence across the literature [65, 78, 82]. Especially in the recent years and with the impact of the COVID–19 pandemic on people's smartphone usage, we deem the addition of this construct to our study essential.

Chopdar et al. [83] argues that COVID-19-related phobia has reshaped people's smartphone usage patterns. Constant and frequent exposure to pandemic-related news negatively affect MH of individuals. In turn, the heightened anxiety, fear, and concerns about COVID–19 exacerbate smartphone addiction. The study by Chopdar et al. is similar to our study in that their goal is to investigate the impact of excessive smartphone usage on online shopping adoption (an effect they prove significant). Because online shopping is a different form of technology adoption than m-banking[84], it is unclear whether the factors that influence online shopping are transferable to our study. Therefore, it is important to consider studies such as Chopdar et al. with the aim of investigating the significance of factors in various technology adoption settings.

Thus far, evidence supports the existence of a relationship between SD and MH, however, it remains unclear whether the effect of SD alters MH's influence on m-banking adoption.

We analyze this through the following hypothesis:

H3 The impact of MH on m-banking adoption remains constant across levels of SD.

2.2.3 Social Networking/Social Media Use (SNS)

The m-banking literature has thus far been unsuccessful in establishing a direct and unequivocal relationship between social media use and m-banking. Most studies in the literature consider social media as a means of communication between banks and consumers. Social Media is the most popular platform for m-banking advertisement which directly impacts m-banking adoption [85, 86]. Most studies argue that social media platforms are beneficial to banks by providing easy access to communication channels with consumers especially to advertise for m-banking [86, 87]. However, there have been studies that offer contradictory findings which suggest social media can have negative impacts on m-banking adoption [88]. Naeem and Ozuem interview bank personnel and managers, who offer insights into how social media negatively influences customers: *negative reviews*. Social media provides easy access for people to anonymously share feedback and opinions.

Anonymity impacts consumers' emotional expressions and rating behavior in the context of online reviews, where people are more likely to express negative emotions and give lower ratings [89]. Negative reviews are deemed more helpful [90] and more persuasive [91] across the board. Therefore, potential adopters are more likely to be impacted by reading negative comments and sentiments from others, dissuading them from adopting m-banking. In addition to the direct effect of SNS use on m-banking, we also consider its relationship with MH. It seems that the most natural deduction is that SNS use leads to worsening of MH due to various factors such as exposure to unrealistic and unattainable standards and comparisons [92].

While that is true, and many other studies have also ascertained as much [66, 93–95], there have also been studies that discover and illustrate the opposite. The caveat is that it is not always clear whether SNS use's impact on MH is positive or negative. Some studies suggest that SNS use alleviates loneliness leading to better MH outcomes [96], while others

show that spending more time on SNS is associated with higher levels of loneliness leading to worsening of MH [97]. These contradictory findings suggest that our understanding of SNS's effect on technology adoption and MH is limited. This prompts us to consider SNS in our study to contribute to better understanding of its effects on MH and subsequently on m-banking adoption. We hypothesize the following:

H4 The impact of MH on m-banking adoption remains constant across levels of SNS.

3 Data Analysis and Measurements

The dataset used in this study is the Canadian Internet Usage Survey (CIUS), conducted from November 3rd, 2020 to March 3rd, 2021 across Canada [98]. The dataset includes various question on the impact of COVID-19 pandemic on the lives of Canadians and thus effectively reflects the changes brought about due to the pandemic. Questions from CIUS are used as model variables. First, we make sure to consider only the subset of participants in the dataset that use a smartphone to connect to the internet. CIUS includes a question on the internet access device: "What device do you use to access the Internet? A smartphone." We use this question to select only those individuals that use a smartphone device, regardless of whether they use other devices or not. The outcome variable is question *UI_Q050D* on CIUS relating to online banking, which measures m-banking after the selection of smartphone users. The question is: "During the past three months, which of the following online activities have you done over the Internet? Conducted m-banking."

The use of *adoption* is appropriate since the question for m-banking considers a three month long time period. As previously discussed in section 1, adoption is a repeated action and not a single point in time. Mobile banking is a binary variable as the responses to this question are Yes (1) for having used m-banking in the last 3 months, and No (0) otherwise. MH is measured by the following question on CIUS: "In general, how is your mental health?". The answer choices are: 5 = Excellent, 4 = Very Good, 3 = Good, 2 = Fair and 1 = Poor.

For RS, we use two questions from the survey: Question *TS_Q010A* and *TS_Q010B*: "In general, on a scale from 1 to 5 (where 1 means completely dissatisfied and 5 means completely satisfied), how satisfied are you with the relationships you have with *friends/Relatives or Family members, excluding those you live with?*". Answers to the former are scores on Friendship Satisfaction (FRISAT) while answers to the latter are scores on Familial Relationship Satisfaction (FAMSAT), with both having values of 1–5.

Regarding SD, it is important to recognize that smartphone addiction is described in scholarly works as the compulsive use of smartphone devices [99]. Therefore, to measure SD, we use the following question from CIUS: "In a typical day, how often do you check your smartphone?". The answer choices are: 6 = at least every 5 minutes, 5 = at least every 15 minutes, 4 = at least every 30 minutes, 3 = once every hour, 2 = once/few times a day, and 1 = less than one time per day. SNS is measured using the following question: "During the past three months, which of the following activities have you done over the internet? Used Social Networking websites/apps.". The answers are Yes (1) indicating use of SNS, and No (0) otherwise.

We summarize the study variables in Table 1 by depicting the number of observations for each answer choices of each variable. Before discussing the results of Table 1, it is useful to gain an understanding of the m-banking landscape in Canada. According to Statista Consumer Insights [100], the distribution of banking methods among Canadian bank account holders in 2019 was as follows: 65% primarily conducted banking online via PC or laptops, 53% used mobile devices for m-banking, 48% of Canadians banked in-person, 12% used telephone banking, and 3% utilized other methods. By the last quarter of 2023, these preferences have shifted to the following: 60% of Canadians now primarily use m-banking, 51% use PC or laptops to conduct online banking, 42% bank in-person, 14% rely on telephone banking and 3% use other methods. This underscores a transition in Canadians' primary banking method from online to m-banking within the last few years. Fig 1 reflects the changes in banking methods used by Canadians over the years.

Table 1 Summary of study variables from the CIUS dataset

Variable	# of obs.	Variable	# of obs.
Mobile banking adoption		Social Media Use (SNS)	
1: m-banking adopter	8,965	1: social media user	8,129
0: otherwise	1,423	0: otherwise	2,259
Age Group (AGE)		Smartphone Dependent (SD)	
1: 15–24 years old	620	6: every 5 minutes	219
2: 25–34 years old	1,443	5: every 15 minutes	2,729
3: 35–44 years old	2,016	4: every 30 minutes	2,834
4: 45–54 years old	1,833	3: every hour	2,564
5: 55–64 years old	2,377	2: once or twice	1,494
6: 65+ years old	2,099	1: less than once a day	548
Income Quintile (INC)		Friendship Satisfaction (FRISAT)	
1: <=\$44,119	1,647	5: completely satisfied	5,247
2: \$44,120 - \$75,321	2,119	4: satisfied	3,316
3: \$75,322 - \$109,431	2,178	3: neutral	1,373
4: \$109,432 - \$162,799	2,320	2: dissatisfied	298
5: >=\$162,800	2,124	1: completely dissatisfied	154
Mental Health (MH)		Family Relation Satisfaction (FAMSAT)	
5: excellent	2,231	5: completely satisfied	5,280
4: very good	3,540	4: satisfied	3,255
3: good	3,101	3: neutral	1,341
2: fair	1,215	2: dissatisfied	348
1: poor	301	1: completely dissatisfied	164
Education Level (EDU)		Immigration Status (IMM)	
1: high school diploma	2,729	1: Immigrant	1,297
2: some college credits	3,894	0: Non-immigrant	9,091
3: university degree	3,765	Employment Status (EMP)	
Family Type (FAM)		1: Employed	6,610
1: with children < 18	2,939	0: Unemployed	3,778
2: without children < 18	5,014	Gender (SEX)	
3: single person	2,143	1: Female	5,454
4: other	292	0: Male	4,934

The results according to Table 1 align with the notion that more Canadian bank account holders use m-banking than not. We observe that 8,965 Canadians in this survey have used m-banking in the past three months (are m-banking adopters) compared to 1,423 who have not. In Table 2, the mean and standard deviation for each of the variables are depicted. Here, we see that m-banking (a binary variable with values of 0 and 1 for non-m-bankers and m-bankers) has a mean of 0.87, which is close to 1. This means that most individuals in the dataset are m-bankers.

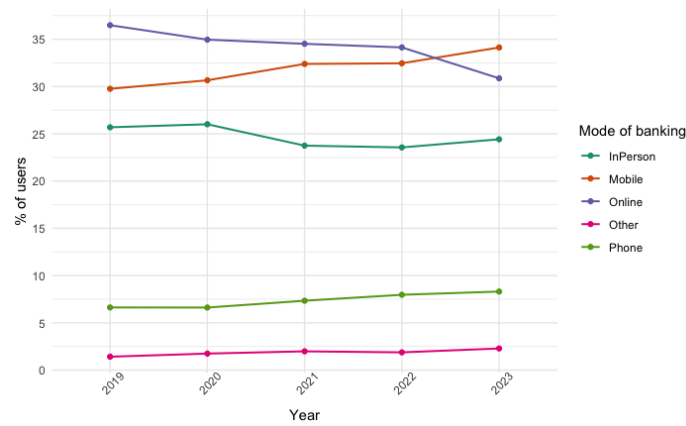


Fig 1 Canadian banking methods changes over the years (data from Statista Consumer Insights [100])

Most participants have high scores for MH, FAMSAT and FRISAT; indicating overall positive well-being. The majority of respondents use social media while only a small minority have high smartphone dependence scores.

Table 2 Descriptive Summary Statistics of main model variables

Variable	Abbreviation	Description	Mean	SD
Mobile banking adoption	m-banking	Adopter (1), otherwise (0)	0.87	0.34
Age Group	AGE	age groups (15 and over)	3.98	1.52
Income Quintile	INC	Income quintile according to 2019–2020	3.10	1.37
Education	EDU	Highest level of education obtained	2.10	0.78
Family Type	FAM	Household/family type ¹	1.98	0.78
Immigration Status	IMM	Immigrant (1), otherwise (0)	0.12	0.33
Employment Status	EMP	Employed (1), otherwise (0)	0.64	0.48
Gender	SEX	Female (1), Male (0)	0.53	0.50
Friendship Satisfaction	FRISAT	how satisfied are you with friend relationships? ²	4.28	0.90
Family Relation Satisfaction	FAMSAT	how satisfied are you with family relationships? ³	4.27	0.92
Mental Health	MH	In general, how is your mental health?	3.60	1.04
Social Media Use	SNS	user (1), otherwise (0)	0.79	0.41
Smartphone Dependency	SD	Frequency of checking smartphone (/day) ⁴	4.39	1.22

¹1: household with children under 18, 2: household without children < 18, 3: single person household, 4: other household types.

²On a scale of 1 (completely dissatisfied) to 5 (completely satisfied) how satisfied are you with the relationships with the following people in your life? Friends.

³On a scale of 1 (completely dissatisfied) to 5 (completely satisfied) how satisfied are you with the relationships with the following people in your life? Family/Relatives.

⁴6: every 5 minutes, 5: every 15 minutes, 4: every 30 minutes, 3: every hour, 2: once or twice, 1: less than once a day.

To understand the relationship between model variables, the correlation matrix (Fig. 2) is examined. Most of the study's variables are significantly correlated with one another with the strongest positive correlation exhibiting between FAMSAT and FRISAT and the strongest negative correlation between SD/SNS and AGE. People who are highly satisfied in their familial relationships are also highly satisfied in their friendships (the reverse is also true). Additionally, older adults are less dependent on their smartphones and are more likely to not use SNS. We add several demographic measures from the data to our models as control variables.

According to Fig. 2, FAMSAT and FRISAT are highly correlated. Including highly correlated independent variables in a model causes multicollinearity issues. FAMSAT and FRISAT measure similar ideas relating to relationship satisfaction, where the only difference is the type of relationship. Combining both variables into a single composite variable is strongly

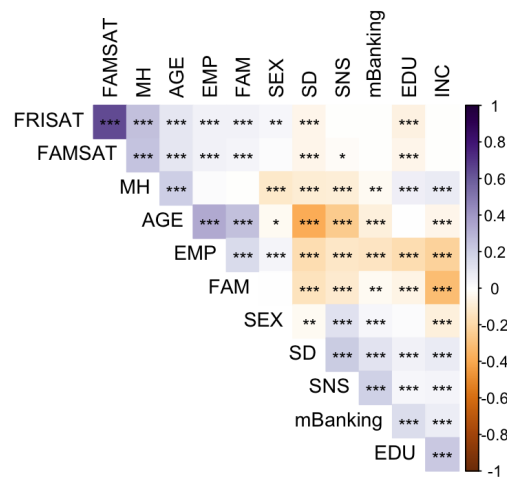


Fig 2 Correlation Matrix (p-values: *p<.1; **p<.05; ***p<.01)
Empty cells indicate non-significant correlation

recommended rather than omitting either or both from the model [101]. Thus, we add the values of FAMSAT and FRISAT together and present this summation in a new variable called Relationship Satisfaction (RS). Recall that FAMSAT and FRISAT take values of 1–5 where

a 1 indicates extreme dissatisfaction with the relationship and 5 extreme satisfaction. Following this, RS ranges from 2–10, where higher RS indicates higher relationship satisfaction. We test the validity of RS as the first step of our analysis, explained in detail in the next section.

4 Methodology and Model

We use logistic regression to test the hypotheses introduced in section 2. To decide on the exact model to fit the data, we follow three sequential steps: First, following the discussion on the composite variable RS from the previous section, to ensure that RS captures the essential information and the shared variance from FAMSAT and FRISAT, we run two versions of the same standard logistic regression model. The result of this step is a decision between having FAMSAT and FRISAT in the model or having RS in the model. Next, we choose a best approach to modeling from three different logistic regression models: standard logistic regression, and two versions of a mixed effect logistic regression model: fixed and random effect models.

From this analysis, we obtain the most optimal modeling approach, resulting in a singular, superior logistic regression model. In the last step, we run the best model with and without interaction terms to test the hypotheses. The results from the model without interactions and with interaction in tandem are used to test $H1$, while the results from the modeling with interactions are used for testing $H2 - H4$: The interaction term between MH and RS informs our decision on $H2$, the interaction term between MH and SD is used to test $H3$, and the interaction term between MH and SNS aids with the decision on $H4$. Before discussing the methodology in detail, we briefly note that considering MH, RS, and SD as numeric variables instead of categorical does not produce unreliable results. This is because we are not interested in predictions nor accuracy of the model, but simply testing hypotheses regarding associations of variables [102].

4.1 Variable Selection

The study's outcome variable, m-banking adoption, is binary and presented as $\mathbf{Y} \in \{0, 1\}$ where 1 indicates m-banking adoption (m-banking use within the last 3 months), and 0 otherwise. In the previous section, we explained the reason for considering a composite variable (RS). To validate the robustness of our approach using RS (instead of FAMSAT and FRISAT), we built two models: First, a model with RS as one of the independent variables and no FAMSAT and FRISAT. We name this model M_RS for easier reference later. Second, a model with FAMSAT and FRISAT as two of the independent variables (and no RS), named M_FSAT for reference. For comparisons, we only consider the standard logistic regression model. For simplicity, we only use the M_RS model's mathematical formula for the remainder of this section. The mathematical representation of the M_RS model is as follows ³:

$$\begin{aligned} \ln \frac{P(\mathbf{Y} = 1)}{1 - P(\mathbf{Y} = 1)} = & \beta_0 + \beta_1 \text{MH} + \beta_2 \text{SD} + \beta_3 \mathcal{D}_{SNS_0} + \beta_4 \text{AGE} + \beta_5 \mathcal{D}_{SEX_1} \quad (1) \\ & + \beta_6 \mathcal{D}_{EMP_0} + \beta_7 \text{EDU} + \beta_8 \text{INC} + \beta_9 \mathcal{D}_{FAM_1} + \beta_{10} \mathcal{D}_{FAM_3} \\ & + \beta_{11} \mathcal{D}_{FAM_4} + \beta_{12} \mathcal{D}_{IMM_1} + \beta_{13} \text{RS} + \varepsilon \end{aligned}$$

Where the β 's are regression coefficients (in log odds) of the independent variables, ε is the error term, and $\mathcal{D}$ is the dummy variable generated for categorical variables. $\mathcal{D}_{IV_t}$ is the dummy variable for independent variable IV where the level is t , for example, $\mathcal{D}_{SNS_0}$ is the dummy variable of $SNS = 0$. We verify the robustness of using RS as opposed to FAMSAT and FRISAT by comparing M_RS (eq 1) and M_FSAT (eq 1) using the Likelihood Ratio (LR) test [103]. The LR test compares the fit of these models to test the null hypothesis that the two models are the same. If the LR test shows a significant difference between the two models, we consider the fixed effects model to be a better model as it captures more information about the outcome variable by considering groupings.

³Full equation of M_FSAT is available in the Appendix 2, eq 1

4.2 Modeling Approach

Based on an initial exploratory data analysis, detailed in the appendix (Tables 1 and 2), we observe provincial variations in m-banking adoption across Canada. A visualization of the differences between provinces in terms of probability of m-banking adoption in Fig. 3 shows overlap for MH scores across the provinces for the most part with the exception of NL. Additionally but separately, we see variations in the effect of province on m-banking adoption (Fig. 1 in the appendix). This stems from the sampling methodology employed by Statistics Canada, which organizes data by provincial clusters [98]. We do not rely solely on visualizations for inference; nevertheless, we think it is crucial to incorporate the observed variation into our modeling approach to at least test for whether these variations are significant. We do this by comparing three distinct modeling approaches: one that discards both variations (standard logistic regression model), one that includes the province on m-banking variation (fixed effect logistic regression model) and one that includes that province variations in the effect of MH on m-banking (random effect logistic regression model).

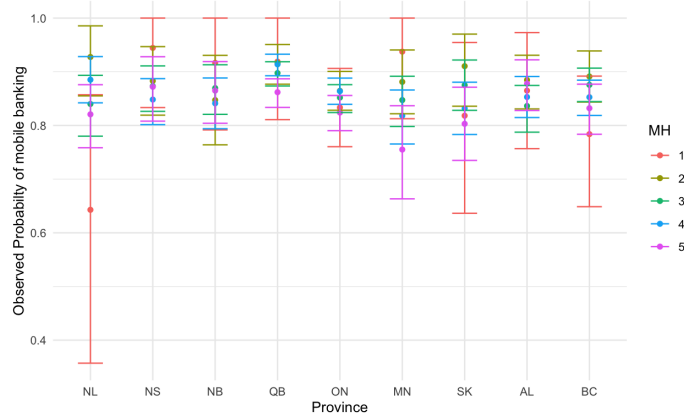


Fig 3 Probability of m-banking across different provinces

In the first model, we hypothesize that there is no significant inter-provincial variation in the effect of any model variables on m-banking adoption. Consequently, this model does not

account for provincial differences, assuming uniformity across all variables (standard logistic regression presented in eq 1). The second model posits that provincial variations directly influence m-banking adoption, but do not affect other variables. This model is a mixed effect logistic regression with fixed effects for all independent variables and a random effect term only for the intercept. We mathematically formulate this model as follows:

$$\begin{aligned} \ln \frac{P(\mathbf{Y} = 1)}{1 - P(\mathbf{Y} = 1)} = & \gamma_{0,j} + u_{0,j} + \beta_1 \text{MH} + \beta_2 \text{SD} + \beta_3 \mathcal{D}_{SNS_0} + \beta_4 \text{AGE} + \beta_5 \mathcal{D}_{SEX_1} \\ & + \beta_6 \mathcal{D}_{EMP_0} + \beta_7 \text{EDU} + \beta_8 \text{INC} + \beta_9 \mathcal{D}_{FAM_1} + \beta_{10} \mathcal{D}_{FAM_3} \\ & + \beta_{11} \mathcal{D}_{FAM_4} + \beta_{12} \mathcal{D}_{IMM_1} + \beta_{13} \text{RS} + \varepsilon \end{aligned} \quad (2)$$

Where index j is for the provinces in the data: Alberta, British Columbia, Manitoba, New Brunswick, Newfoundland and Labrador, Nova Scotia, Ontario, Quebec and Saskatchewan. In eq 2, the intercept coefficient in eq 1 is replaced by the following: $\gamma_{0,j} + u_{0,j}$ and that is the only difference between the two models. The constant $\gamma_{0,j}$ is the fixed effect component, and $u_{0,j}$ is the random effect where $u \sim N(0, \sigma^2)$ and is estimated differently for each of the provinces. The third model assumes significant inter-provincial differences in both the effect of independent variables on m-banking adoption and the differences in m-banking adoption itself. Again, we treat province as a grouping variable with substantial variation impacting both the decisions surrounding m-banking adoption and the influence of independent variables on it. Similar to the fixed effect model, we utilize a mixed effect logistic regression, but add a random effect term to independent variables and the intercept. We use a similar notation to eq 2 and construct the following for the last modeling approach:

$$\begin{aligned} \ln \frac{P(\mathbf{Y} = 1)}{1 - P(\mathbf{Y} = 1)} = & \gamma_{0,0} + u_{0,j} + (\gamma_{1,0} + u_{1,j}) \text{MH} + (\gamma_{2,0} + u_{2,j}) \text{SD} + (\gamma_{3,0} + u_{3,j}) \mathcal{D}_{SNS_0} \\ & + (\gamma_{4,0} + u_{4,j}) \text{AGE} + (\gamma_{5,0} + u_{5,j}) \mathcal{D}_{SEX_1} + (\gamma_{6,0} + u_{6,j}) \mathcal{D}_{EMP_0} \\ & + (\gamma_{7,0} + u_{7,j}) \text{EDU} + (\gamma_{8,0} + u_{8,j}) \text{INC} + (\gamma_{9,0} + u_{9,j}) \mathcal{D}_{FAM_1} \end{aligned} \quad (3)$$

$$\begin{aligned}
& + (\gamma_{0,0} + u_{10,j}) \mathcal{D}_{FAM_3} + (\gamma_{1,0} + u_{11,j}) \mathcal{D}_{FAM_4} \\
& + (\gamma_{12,0} + u_{12,j}) \mathcal{D}_{IMM_1} + (\gamma_{13,0} + u_{13,j}) \text{RS} + \varepsilon
\end{aligned}$$

The intercept term in eq 3 includes the fixed component of all independent variables' effects, indicated by $\gamma_{i,j}$ for the i th independent variable and j th province. The coefficient estimates dependent on the grouping variable (province) where $u_{i,j}$ is the random effect of independent variable i on m-banking adoption for province j . To decide on the best model, we first compare model of eq 2 with eq 1 using the LR test introduced previously. If the result from LR test shows a significant difference between the two models, we consider the fixed effects model to be a better model as it captures more information about the outcome variable by considering effects of province (as a grouping variable) on m-banking adoption. Next, to decide whether the addition of random effects to independent variables (eq 3) improves upon the fixed model, we use the Hausman test [104]. We test the following null hypothesis using Hausman: adding random effects to the fixed model is beneficial⁴. For both the Hausman and LR test, we report the χ^2 statistic. Under the null hypothesis, estimates are the same, therefore the test is based on the following contrast vector [105]:

$$H = [\mathbf{B}_{fix} - \mathbf{B}_{ran}]' [\mathbf{V}(\mathbf{B}_{ran}) - \mathbf{V}(\mathbf{B}_{fix})]^{-1} [\mathbf{B}_{fix} - \mathbf{B}_{ran}] \sim \chi_k^2$$

Where k is the number of independent variables in the model, $\mathbf{B}_{fix}$ is the matrix of coefficients in the fixed model, $\mathbf{B}_{ran}$ is the matrix of coefficients in the random model, and $\mathbf{V}$ is the variance-covariance matrix.

4.3 Hypothesis Testing

By this point in the analysis, we have chosen a best model to fit the data. What is left is to run the model and analyze the results. The goal is to test the study hypotheses discussed in section 2. To do so, we run the best model twice. The results of both runs are depicted in Table 4.

⁴The Hausman null hypothesis states that unique errors (individual effects) are not correlated with independent variables.

First, we run the best model as is, with no interaction terms to test $H1$: the effect of MH on m-banking adoption. Second, we add the interaction terms: $MH \times RS$, $MH \times SD$ and $MH \times SNS$. Each interaction term provides the necessary information for our hypothesis testing. By analyzing the coefficient estimate of $MH \times RS$, we test $H2$: whether the effect of MH on m-banking adoption stays consistent across values of RS. Using the coefficient estimate of $MH \times SD$ we test $H3$: whether the effect of MH on m-banking adoption stays consistent across values of SD. Lastly, the interaction term coefficient estimate for $MH \times SNS$ is used to test $H4$: whether the effect of MH on m-banking adoption stays consistent across values of SNS. The addition of interaction terms are to assess the change in the effect of MH across different values of RS, SD and SNS.

5 Results and Discussion

In this section, we discuss the results of our analysis. All values reported in Tables are log odds ratios (LOR). For easier communication, understanding and interpretation, we also represent odds ratios (OR) in text, which are simply e^{LOR} .

5.1 Model Selection

Following the discussion from section 4, we present the results of model comparison for both LR and Hausman tests for various tasks in Table 3. M_FSAT includes both FRISAT and FAMSAT while model M_RS includes only RS. According to the LR test's result, RS captures the same information as FRISAT and FAMSAT. Thus its use in the model as a substitute is warranted. The results indicate that the fixed model (eq 2) is preferred over standard logistic regression and random effects model (eq 3). Thus, the best model is M_FIX (eq 2) which will be referred to as the study's model from here onwards.

Adding the interaction terms for hypotheses testing, the model with interaction terms is as

Table 3 Model Comparisons using LR test and Hausman test

Model(s)	Description	χ^2_{LR}	$\Pr(> \chi^2_{LR})$	χ^2_H	$\Pr(> \chi^2_H)$
M_FSAT (eq. 1)	Standard Model with FRISAT & FAMSAT	0.055	0.815	—	—
M_RS (eq. 1)	Standard Model with RS ✓				
M_RS (eq. 1)	Standard Model with RS	22.549	< .001***	—	—
M_FIX (eq. 2)	Mixed (Fixed) Effects Model ✓				
M_RAN (eq. 3)	Mixed (Random) Effects Model	—	—	−0.054	< .001***
M_FIX (eq. 2)	Mixed (Fixed) Effects Model ✓				
Notes:	*p<.1; **p<.05; ***p<.01 ✓ indicates the model is preferred.				

follows:

$$\begin{aligned}
\ln \frac{P(Y=1)}{1-P(Y=1)} = & \gamma_{0,j} + u_{0,j} + \beta_1 \text{MH} + \beta_2 \text{SD} + \beta_3 \mathcal{D}_{SNS_0} + \beta_4 \text{AGE} + \beta_5 \mathcal{D}_{SEX_1} \\
& + \beta_6 \mathcal{D}_{EMP_0} + \beta_7 \text{EDU} + \beta_8 \text{INC} + \beta_9 \mathcal{D}_{FAM_1} \\
& + \beta_{10} \mathcal{D}_{FAM_3} + \beta_{11} \mathcal{D}_{FAM_4} + \beta_{12} \mathcal{D}_{IMM_1} + \beta_{13} \text{RS} \\
& + \beta_{14} \text{RS} \times \text{MH} + \beta_{15} \text{SD} \times \text{MH} + \beta_{16} \mathcal{D}_{SNS_0} \times \text{MH} + \varepsilon
\end{aligned} \tag{4}$$

5.2 Fixed Effects Logistic Regression

Table 4 depicts the results of fixed effect logistic regression modeling to test our hypotheses. We run the model once without including any interaction terms (mathematical formulation in eq 2), and once including the following interaction terms: $\text{MH} \times \text{RS}$, $\text{MH} \times \text{SD}$ and $\text{MH} \times \text{SNS}$ (mathematical formula eq 4). Starting with the results for the without interaction term model, we observe that a 1 scale point increase in scores of MH (towards better mental health outcomes) is associated with statistically significant lower log odds of m-banking adoption (-0.083 , $\text{OR} = 0.920$). This corresponds to an 8% decrease in likelihood of m-banking adoption for people with better mental health. In $H1$, we hypothesized that MH scores have no impact on (log odds of) m-banking adoption. Based on the results, we reject $H1$. Those with better mental health are less likely to adopt m-banking.

Table 4: Fixed effects Logistic Regression Results — outcome variable:
m-banking(yes/no)
to test Hypotheses *H1* (w/o interaction), *H2* (MH×RS), *H3* (MH×SD) and *H4* (MH×SNS)

Variable	Description	Model	
		w/o interaction	including interaction
		Coeff./s.e.	Coeff./s.e.
_cons	intercept	2.592*** (0.086)	2.592*** (0.086)
MH	Mental Health	−0.083*** (0.031)	−0.121*** (0.038)
SD	Smartphone Dependency	0.182*** (0.028)	0.181*** (0.028)
SNS	Indicator Variable (IV) = 1 if non user	−0.969*** (0.066)	−0.985*** (0.066)
RS	Relationship Satisfaction	0.025 (0.018)	0.025 (0.019)
AGE	Age Group	0.025 (0.024)	0.026 (0.025)
SEX	IV = 1 if Male	−0.110* (0.061)	−0.109* (0.061)
EMP	IV = 1 if Unemployed	−0.566*** (0.065)	−0.566*** (0.065)
EDU	Highest Education obtained	0.495*** (0.040)	0.495*** (0.040)

Continued on next page →

Variable	Description	Model	
		w/o interaction	including interaction
		Coeff./s.e.	Coeff./s.e.
FAM	IV = 1 if FAM= with children < 18	−0.219*** (0.082)	−0.217*** (0.082)
FAM	IV = 1 if FAM= single household	−0.057 (0.081)	−0.056 (0.081)
FAM	IV = 1 if FAM= other	0.040 (0.194)	0.038 (0.194)
IMM	IV = 1 if immigrant	−0.245** (0.095)	−0.242** (0.095)
INC	Income	0.044* (0.025)	0.043* (0.025)
RS × MH			0.001 (0.016)
SD × MH			0.017 (0.024)
SNS × MH	IV= 1 if non-user		0.122* (0.063)
<u>Group Level Effects</u>			
$\sigma(\text{intercept})$		0.148	0.148
95% confidence interval		[0.081, 0.279]	[0.081, 0.279]

Continued on next page →

Variable	Description	Model	
		w/o interaction	including interaction
		Coeff./s.e.	Coeff./s.e.
logLik		−3790.1	−3788.2
BIC		7718	7742
<i>Notes:</i>		* $p < .1$; ** $p < .05$; *** $p < .01$	

We see a significant increase in log odds of m-banking adoption due to SD ($OR = 1.200$). This corresponds to a 20% increase in likelihood of m-banking adoption for a 1 point increase in smartphone dependence scores. Those with a higher smartphone dependence have greater likelihood of m-banking adoption. With SNS, we observe that non users are statistically significantly less likely ($OR = 0.380$) to adopt m-banking. This means that non social media users are just over 6% less likely compared to SNS users to adopt m-banking. RS has a negligible, positive and non-significant effect on m-banking adoption ($OR = 1.025$, $p = 0.182$), which aligns with our expectations based on Fig. 2, where we saw a non-significant correlation between RS and m-banking adoption ($r = -0.01$, $p = 0.364$). Age has a similar non significant ($p = 0.307$) effect on m-banking adoption to RS. Men are less likely than women to adopt m-banking, but this difference is non-significant ($OR = 0.895$, $p = 0.071$).

Individuals who are unemployed are significantly less likely than those who have jobs to adopt m-banking ($OR = 0.568$). In other words, those without jobs are 43% less likely to adopt m-banking compared to those who are employed. Interestingly, income is slightly positively (log odds of 0.044) and non-significantly influential in m-banking adoption ($OR = 1.045$, $p = 0.079$). For family types, the reference level is $FAM = 2$, which corresponds to families without children under 18. Individuals from families with children (under the age of 18, $FAM = 1$) are statistically significantly less likely to adopt m-banking ($OR = 0.803$)

than those without children. However, the difference between single households ($FAM = 3$) and households of other types ($FAM = 4$) with families without children is non-significant.

Considering the family types, it appears that children under 18 are a dividing factor in m-banking adoption. Both singles and families with children are less likely to adopt m-banking compared to $FAM = 2$, while other household types ($FAM = 4$) are more likely to adopt m-banking compared to $FAM = 2$ ⁵. One reason for the significant difference between $FAM = 1$ and $FAM = 2$ might be due to the fact that the respondents in the $FAM = 1$ group are in fact the children between 15–18 years old, as CIUS is administered to persons over the age of 15. When we consider the interaction between MH and RS in model 6, we observe no changes to the model performance. The interaction term of MH and RS has no effect on m-banking adoption and is not statistically significant ($OR = 1.000$, $p = 0.993$).

In $H2$, we hypothesized that MH scores have no impact on (log odds of) m-banking adoption based on RS values. In other words, there is no impact on m-banking adoption due to the effect of MH that is caused by RS. Based on the results of the addition of the interaction between RS and MH, we observe that a unit increase in MH scores behaves the same regardless of the level of RS (log odds of $RS \times MH = 0.001$, $p = 0.975$). Since no significant differences in MH's effects on m-banking are present across RS, we fail to reject $H2$. In $H3$, we hypothesized that the probability of m-banking adoption is independent of MH across different levels of SD. When considering the interaction between SD and MH, we observe a larger impact compared to the MH interaction with RS (log odds of $SD \times MH = 0.017$) but this effect is not statistically significant ($p = 0.487$). Therefore, we do not have sufficient evidence to reject $H3$. Lastly, we consider the interaction of SNS and MH. Since SNS is a binary variable (0: does not use social media, 1: uses social media), the interaction term at each level will have the same absolute value with a different sign. That is, for non social media users, the effect of MH on m-banking is stronger (log odds = 0.122) than the same effect for social media users.

⁵StatsCan offers no further explanation or examples on what exactly constitutes other household type.

The interaction term for SNS and MH is positive for non SNS users ($OR = 1.130$), but not statistically significant at the 5% level ($p = 0.053$). The change in the log odds of MH from -0.083 to -0.121 between the two models ($OR = 0.920$ to $OR = 0.886$) is mostly due to the $SNS \times MH$ interaction term ($0.122 > 0.017 > 0.001$). However, we are not interested in the significance of this difference, because there is no change in the direction of the relationship (sign remains negative from one model to the next). Additionally, this difference is merely 4% (0.038 in log odds): In the model without interactions, a 1 point increase in MH scores is associated with an 8% decrease in likelihood of m-banking adoption (log odds = -0.083). Considering the interactions, a 1 point increase in MH scores is associated with 12% decrease in likelihood of m-banking adoption, a stronger negative effect.

Compared to SNS users, non SNS users are less likely to adopt m-banking (log odds = -0.985 , $OR = 0.374$). In other words, the likelihood of m-banking adoption is expected to significantly decrease by about 60% for non social media users (compared to users) holding all else constant. Compared to those that do not use social media, SNS users are statistically significantly more likely to adopt m-banking (log odds = 0.985 , $OR = 2.677$). That is, the probability of an SNS user also adopting m-banking is 0.728 or a 73% chance of a social media user adopting m-banking. For $H4$, we hypothesized that the the impact of MH on m-banking adoption remains constant across levels of SNS. That is, regardless of whether or not an individual uses SNS, MH's effects on m-banking remain the same. Based on the results of the regression analysis, we do not have sufficient evidence to reject $H4$.

5.3 Average Marginal Effects

According to our model, the average log odds of m-banking adoption across Canada is 2.59, i.e., people across the country are more inclined to adopt m-banking than not. However, only less than 1% of the variance in m-banking adoption is explained at the group level ($ICC = 0.007$). The standard deviations reported at the group level in Table 4 indicate the deviations in logistic regression slopes for the particular variable across groups. In our model, this is

only the intercept variation, which is the variation between provinces in terms of m-banking adoption likelihood. Numerical analysis from Table 4 shows that there is a statistically significant difference between the provinces in terms of m-banking adoption as the confidence interval for standard deviation of intercept (m-banking) at the group level does not include zero (0.081 to 0.279). Thus, we calculate the average marginal effect of all the independent variable in our model according to the grouping to better understand m-banking adoption.

Table 5 depicts the marginal effects of model variables across provinces on m-banking. Marginal effect is the change in log odds of m-banking that is expected for when an individual matching the attribute is added to the population. For example, an individual identifying as male, regardless of which province they live in, will on average have 0.012 lower log odds of adopting m-banking than women (this effect is not statistically significant, $p = 0.079$). Summarizing the statistically significant marginal effects we have: On average, those with better mental health outcomes are less likely to adopt m-banking. Those who have higher smartphone dependence are more likely to adopt m-banking, while non social media users are less likely than SNS users to adopt m-banking. Having higher levels of education is associated with higher likelihood of m-banking adoption. Compared to those without children, households with children are less likely to adopt m-banking. Unemployed (compared to employed), and non-immigrants (compared to immigrants) are all, on average, less likely to adopt m-banking.

5.4 Discussion of Results

The results of our study are summarized in text and in Table 6. In general, MH scores significantly influence m-banking adoption. Those with better MH outcomes are less likely to adopt m-banking. The effect of MH on m-banking adoption does not depend on RS and SD: MH's effect on m-banking adoption remains consistent across different levels of RS and SD. Social Media (SNS) use moderates the effect of MH on m-banking adoption: Depending on SNS use, the effect of MH on m-banking adoption differs significantly.

Table 5 Average Marginal Effects for Mixed Effects Logistic Regression

Variable	Margin	S.E.	<i>z</i>	Pr(<i>z</i>)	95% CI
MH	−0.009	0.003	−2.570	0.010	[−0.015, −0.002]
RS	0.003	0.002	1.325	0.185	[−0.001, 0.007]
SD	0.020	0.003	6.365	0.000	[0.014, 0.026]
SNS (ref: 1) = 0	−0.127	0.011	−12.002	0.000	[−0.147, −0.106]
AGE	0.003	0.003	1.083	0.279	[−0.002, 0.008]
EDU	0.054	0.005	11.552	0.000	[0.045, 0.063]
EMP (ref: 1) = 0	−0.064	0.008	−8.109	0.000	[−0.080, −0.049]
FAM (ref: 2) = 1	−0.024	0.009	−2.565	0.010	[−0.043, −0.006]
FAM (ref: 2) = 3	−0.006	0.009	−0.673	0.501	[−0.023, 0.011]
FAM (ref: 2) = 4	0.004	0.020	0.200	0.841	[−0.035, 0.043]
IMM (ref: 0) = 1	−0.028	0.012	−2.394	0.017	[−0.050, −0.005]
INC	0.005	0.003	1.747	0.081	[−0.001, 0.010]
SEX (ref: F) = M	−0.012	0.007	−1.759	0.079	[−0.025, 0.001]

Table 6 Summary of Hypotheses Testing Results

Hypothesis	Hypothesis Statement	Result
<i>H1</i>	The probability of m-banking is independent of MH scores.	Reject
<i>H2</i>	The impact of MH on m-banking remains constant across levels of RS.	×
<i>H3</i>	The impact of MH on m-banking remains constant across levels of SD.	×
<i>H4</i>	The impact of MH on m-banking remains constant across levels of SNS.	×
Notes:	×: Cannot Reject	

Evidence from various disciplines support our results: According to the Information Communication Technology (ICT) literature, digital divide (sometimes called Digital inequality) is one of the major issues of the information technology era [106]. This is the gap in digital literacy due to unequal access to technology, information and resources such as education for use of technology [107]. Technology adoption is moderated by information literacy and digital skills [107], and digital literacy is an important factor in m-banking adoption [108]. Discussions on digital divide are outside the scope of this study, but our results align with some components of digital divide. We highlight this connection to show support for our findings. Education is proven to be a key socioeconomic factor of innovation adoption in general [109]. In addition to relating to digital divide, education is also related to financial literacy [110], thereby strengthening its importance in studying m-banking.

In the realm of ICT, research has shown that immigrants are more likely to adopt and use new technologies driven by their need to communicate with friends and family back home [111–113]. Unemployment is significantly associated with a higher likelihood of being un-banked [114]. Hence, it's understandable that unemployed individuals exhibit lower m-banking adoption likelihood, given their higher likelihood of lacking bank accounts in the first place. Older adults are more likely to not use SNS [115] and less likely to be dependent on smartphones; However, SD is an issue among older adults as well [116]. Many previous studies have investigated the relationship between age, mental health, digital divide and technology adoption [117–119].

Older people have better MH outcomes compared to younger people [120], but many researchers are hesitant to claim this is a significant relationship because older adults are more likely to under-report MH problems [121]. Additionally, age is another indicators of digital divide [122], which might explain why non social media users (who are more likely to be older) are less likely to adopt m-banking while those who are more dependent on their smartphones (who are more likely to be younger) are more likely to adopt m-banking. There could be various reasons for the significant difference in m-banking adoption likelihood we observe between households with and without children.

One explanation is that individuals from households with children under 18 are less likely to adopt m-banking due to security concerns. Parents may be cautious about using an m-banking application because they children have access to their devices. Another reason might be the existence of joint bank accounts or more complex financial arrangements such as mortgage payments and setting up accounts for children for future which would require in-person visits to banks. Next, we discuss the implications of these results in theory and practice.

5.5 Managerial and Theoretical Insights

Here, we offer several recommendations to banks and managers according to our results. These practical suggestions would hopefully result in increased accessibility of products as

well as increased productivity of users. This will improve consumers' satisfaction related to m-banking products. First, we address the implication of *H1*, which states that those with poor MH outcomes are more likely to adopt m-banking. While this result may seem surprising, we find that it is indeed supported by various studies in psychology. Certain mental health challenges prompt individuals to seek m-banking as opposed to traditional in-person banking to avoid various undesirable outcomes. We consider social anxiety as an example to clarify the reason why our *H1* result is not surprising. Those with social anxiety prefer neutral, distant or anonymous relationships with businesses [123, 124]. A smartphone application such as m-banking fits all of these criteria. Socially anxious individuals are apprehensive about interacting with strangers or have a fear of verbal interactions with strangers [125–127].

A smartphone app that replaces the need to interact with people becomes an alternative that people with various anxiety types (social, general, and others) gravitate towards and benefit from [128]. These support the idea that those with social anxiety are more likely to adopt m-banking apps. However, social anxiety is just one aspect of mental health. There are various other underlying mental health challenges that would yield similar results. This result has significant implications for banks. By using our results, banks expand their consumer base. One way to do so is by targeted advertising campaigns or the integration of tailored strategies within m-banking applications. By demonstrating that banks are aware of the challenges facing those with mental health conditions, banks stand to enhance consumer engagement and trust. An important aspect of technology adoption is the User Experience paradigm [129]. Hence, it becomes imperative for banks to enhance their applications, ensuring optimal UX for users across the board, but especially those with specific mental health challenges. These enhancements do not need to be elaborate; rather, simple feature implementations that signal banks' awareness of the struggles these individuals face can be efficacious.

We offer two practical examples of such feature implementations: Individuals with Attention Deficit Hyperactivity Disorder (ADHD) face challenges with understanding bank

statements, banking protocols, evaluating financial problems and overall financial competence [130]. Designing applications that are specifically tailored to accommodate the needs of individuals with ADHD, while simultaneously benefiting a broader user base is one way that banks could use our study's results. Drawing from expert recommendations, applications that incorporate clear and easily understandable educational resources, timely reminders, and minimalist design elements to reduce distractions are best suited for those with ADHD [131]. A user-friendly app conducive to concentration and task completion enhances the experience for individuals with ADHD, making them more likely to become long term users. Another example feature to implement is regarding stress-induced decision-making tendencies which are exacerbated in individuals with high levels of anxiety.

Financial decisions are highly stressful [132], therefore features that are included to stop stress-based reactive decisions are likely to be useful to everyone, but in particular to those with a proneness to anxiety. These individuals tend to make risky decisions at times of heightened stress [133]. Banks could implement a protection feature in their app with this knowledge in mind, advertising this to consumers. This protection could be by way of adding a pop-up box message that asks the user for confirmation of a transaction twice before finalizing the transaction. Such a (protection) step where an action is delayed helps reduce the influence of anxiety and negative affects on decisions [134], directly benefiting the consumers. By implementing these strategies, banks show support and understanding for consumers that face such challenges on a daily basis. Businesses that support individuals with mental health problems can expect greater customer satisfaction in return [135–138]. Knowing what to advertise and to whom makes advertisement campaigns more effective, and cheaper to plan for and run.

We showed that social media use impacts m-banking adoption, but does not significantly alter the effects of MH on m-banking. Specifically, we found SNS users (compared to those who do not use social media) are more likely to adopt m-banking. This result offers valuable insights to banks. Using social media as a primary advertisement platform will reach

those individuals who are shown to be more likely to adopt m-banking. Therefore, social media marketing is an excellent avenue of investment if banks want to attract new m-banking costumers.

Various factors contribute to better mental health, which is outside the scope of this study. Businesses may want to invest in understanding groups that have better mental health outcomes, and make decisions based on these individuals' preferences. We showed how several demographic factors affect m-banking adoption: More educated individuals, those without children and immigrants are more likely to adopt m-banking. Neither of the results regarding effects of education and immigration are surprising, as they aligns with the consensus from the ICT literature. For family types, more studies need to be conducted to specify the exact reason for the differences. However, security concerns are a major contributing factor to decisions against adoption of m-banking (more on this later), therefore justifying the results for families with young children. Banks and financial institutions are able to use these results to understand the demographic that is more likely to become m-banking adopters, simplifying and focusing their advertisement strategies.

From a theoretical standpoint, our study contributes to the literature by determining factors that influence Mental Health (as an affective construct) in terms of its effect on m-banking. Theoreticians may use our discussions and results to develop models that incorporate mental well-being in the discussions of technology adoption to capture consumer decision-making more accurately and potentially developing new theories and models. Additionally, we contribute to the literature by showing how mental health (on its own) affects m-banking adoption, thus improving our understanding of users' mobile banking adoption decisions. We demonstrated how social media use and smartphone dependency directly influence m-banking adoption, but failed to show significant effects on MH's impact on m-banking adoption. We did not find sufficient evidence on the influence of relationship satisfaction on m-banking nor on mental health's impact on m-banking. Our results help researchers

better understand why some affective constructs (anxiety, joy, etc) impact technology adoption, specifically, m-banking. The results of this study can be extended to other technologies, however, some adjustments are required. To extend the results of this study, two major considerations are needed:

Firstly, it should be noted that financial decisions are one of the most stressful decision-making processes [139]. Disability and mental illness play important roles in financial health [140]. As such, studying behavioral and affective factors that relate to attitude and well-being are important in the context of technologies related to finance such as in our study (m-banking). Studying mental health, which is a proxy encompassing various affective constructs, in relation to financial technology is important and necessary. We clarify why this is the case. Mobile banking adoption is a behavioral decision paradigm [141, 142]. Behavior changes influence (behavioral) decision-making [143, 144]. Mental health factors are integrated into many behavioral change models [145–148]. This is because mental health conditions significantly impact an individual's mood and emotions [149]. In turn, these changes in mood(s) and emotional state(s) influence people's behavior [150].

Implementing this logic, we conclude that as a behavioral decision, m-banking is affected by behavior changes. Moreover, mental health is closely related and indicative of behavior changes. Therefore, there is a clear relationship (mediated by behavior changes) between mental health and m-banking adoption. Behavior changes is a broad term that might encompass anything having to do with behaviors that influence mental well-being of an individual, such as social media use. The reason SNS was not considered as a mediator between MH and m-banking is because our sample size is quite large and mediation analysis is highly susceptible to type I error [151]. Previous studies have confirmed the effects of mental health conditions on consumer behavior [152, 153]. This discussion highlights the importance of considering mental health of the users in relation to m-banking.

The second consideration for extending this study is about the risks associated with the specific technology. The majority of the risks associated with m-banking apps are related to

security [154]. One of the most important factors in not using mobile technologies (especially those related to finances) is attributed to anxiety, often presented as security concerns [4, 155–162]. Technologies that deal with sensitive information such as finances are more likely to induce anxiety due to security concerns. This is part of why our study is focused on m–banking and an affective construct such as mental health (which inherently includes anxiety and proneness to anxiety on an individual–level). Social Media Usage is another factor that is included in our study which relates to both security concerns and mental health [163, 164].

All in all, we content that while this study can be extended to understand other mobile technology adoption problems, one needs to carefully consider all dimensions of the specific application (technology). Other studies about technologies that have similar aspects such as anxiety and security concerns, might be able to extend the results of this study.

6 Conclusion

This study investigates the relationship between users’ mental health and adoption of m–banking. Additionally, we explore the potential influences of other constructs on this association. Drawing on foundational IS theories, we select key variables for our model, including affective constructs related to social well–being (relationship satisfaction) and smartphone use patterns, particularly smartphone dependency and social media use. Hypotheses corresponding to these variables were tested using logistic regression models. Our findings show significant impact of mental health on m–banking adoption. However, no significant relationships were found between mental health and social media use, smartphone dependency and relationship satisfaction. These findings suggest implications for banks and managers to prioritize consumers’ mental health in application design, advertising, and promotional strategies, as well as underscore the importance of considering customers’ demographics and backgrounds.

This study offers several noteworthy contributions to existing literature. Firstly, it pioneers the investigation of mental health in the context of m-banking adoption. Secondly, it examines various variables influencing mental health and its implications for m-banking adoption, thereby enhancing our understanding of this phenomenon. Financial institutions can leverage these findings to target demographics more inclined towards m-banking adoption in their promotional endeavors and optimize their m-banking application and advertising strategies accordingly. Consumers benefit from improved m-banking apps tailored to their constraints and preferences.

Our study is limited by the measurement scale employed for mental health assessment in the survey dataset. The scale used in the Canadian Internet Usage Survey lacks a clear midpoint, potentially leading to ambiguity in participants' responses. Future research endeavors should employ more robust measurement tools, such as tailored questionnaires designed to assess mental health accurately, thereby strengthening analytical outcomes. Additionally, our dataset captures only Canadian m-banking users' behaviors. Due to this geographical limitation, our results may not be generalizable to other countries that are significantly different from Canada. Lastly, our dataset was collected as the pandemic of COVID-19 was spreading in its earlier stages. Due to the rapid changes especially in the context of technology adoption in the post COVID-19 world, we recommend future researchers use data that captures the behavior in the post-Covid world to better represent the current state of m-banking adoption.

Declaration of Competing Interest

All authors state that there are no conflicts of interest.

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Appendix.

Differences across provinces as clusters of sampling. Here, we include a contingency table as well as a table of marginal effects for each province. In Table 1, we see the proportion

of m-banking adopters vs non adopters in each province as well as in each province based on their mental health score.

Table 1: Mobile banking based on the distribution of mental health scores across the provinces

Variable	# obs. m-banking		Mental Health	# obs. m-banking	
Group (code)	=No	=Yes	(MH)	=No	=Yes
Newfoundland and Labrador (10)	84	503	MH= 1	5	9
			MH= 2	5	64
			MH= 3	24	126
			MH= 4	24	185
			MH= 5	26	119
Nova Scotia (12)	94	613	MH= 1	1	17
			MH= 2	11	83
			MH= 3	27	186
			MH= 4	39	218
			MH= 5	16	109

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Variable	# obs. m-banking		Mental Health	# obs. m-banking	
Group (code)	=No	=Yes	(MH)	=No	=Yes
New Brunswick (13)	94	567	MH= 1	2	22
			MH= 2	11	61
			MH= 3	24	160
			MH= 4	37	196
			MH= 5	20	128
Quebec (24)	244	2,108	MH= 1	3	34
			MH= 2	17	186
			MH= 3	68	596
			MH= 4	73	774
			MH= 5	83	518
Ontario (35)	378	2,152	MH= 1	16	80
			MH= 2	45	287
			MH= 3	117	673

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Variable	# obs. m-banking		Mental Health	# obs. m-banking	
Group (code)	=No	=Yes	(MH)	=No	=Yes
			MH= 4	106	672
			MH= 5	94	440
			MH= 1	1	15
			MH= 2	12	89
Manitoba (46)	106	521	MH= 3	31	172
			MH= 4	38	171
			MH= 5	24	74
			MH= 1	4	18
			MH= 2	6	61
Saskatchewan (47)	98	541	MH= 3	24	168
			MH= 4	38	188
			MH= 5	26	106
			MH= 1	5	32

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Variable	# obs. m-banking		Mental Health	# obs. m-banking	
Group (code)	=No	=Yes	(MH)	=No	=Yes
			MH= 2	15	115
			MH= 3	47	240
			MH= 4	50	290
			MH= 5	22	158
			MH= 1	8	29
			MH= 2	16	131
			MH= 3	52	366
			MH= 4	65	376
			MH= 5	45	223
British Columbia (59)	186	1,125			

In Table 2, we see the marginal effect of each MH score across the provinces. This data confirms the validity of not considering a random effect for MH based on groupings (province). In other words, the effect of MH on m-banking does not vary significantly across provinces. Therefore, it is not useful to consider a random effect model.

Table 2: Marginal Effects of Mental Health on m-banking across different provinces

Mental Health (MH)	Predicted Marginal Effect	95% confidence Interval
Newfoundland and Labrador		
MH = 1	0.88	[0.86, 0.90]
MH = 2	0.87	[0.86, 0.89]
MH = 3	0.86	[0.85, 0.88]
MH = 4	0.85	[0.84, 0.87]
MH = 5	0.84	[0.83, 0.86]
Nova Scotia		
MH = 1	0.88	[0.86, 0.90]
MH = 2	0.88	[0.86, 0.89]
MH = 3	0.87	[0.85, 0.88]
MH = 4	0.86	[0.84, 0.87]
MH = 5	0.85	[0.83, 0.86]
New Brunswick		
MH = 1	0.88	[0.86, 0.90]
MH = 2	0.87	[0.86, 0.89]
MH = 3	0.86	[0.85, 0.88]
MH = 4	0.85	[0.84, 0.87]
MH = 5	0.84	[0.83, 0.86]
Quebec		
MH = 1	0.91	[0.89, 0.92]
MH = 2	0.90	[0.89, 0.91]

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Mental Health (MH)	Predicted Marginal Effect	95% confidence Interval
MH = 3	0.89	[0.88, 0.91]
MH = 4	0.89	[0.88, 0.90]
MH = 5	0.88	[0.87, 0.89]
Ontario		
MH = 1	0.87	[0.85, 0.89]
MH = 2	0.86	[0.84, 0.88]
MH = 3	0.85	[0.84, 0.87]
MH = 4	0.84	[0.83, 0.86]
MH = 5	0.83	[0.81, 0.85]
Manitoba		
MH = 1	0.87	[0.85, 0.89]
MH = 2	0.86	[0.85, 0.88]
MH = 3	0.85	[0.84, 0.87]
MH = 4	0.84	[0.83, 0.86]
MH = 5	0.83	[0.81, 0.85]
Saskatchewan		
MH = 1	0.88	[0.86, 0.90]
MH = 2	0.87	[0.85, 0.89]
MH = 3	0.86	[0.85, 0.87]
MH = 4	0.85	[0.84, 0.87]
MH = 5	0.84	[0.82, 0.86]
Alberta		
MH = 1	0.88	[0.86, 0.90]

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Mental Health (MH)	Predicted Marginal Effect	95% confidence Interval
MH = 2	0.87	[0.86, 0.89]
MH = 3	0.87	[0.85, 0.88]
MH = 4	0.86	[0.84, 0.87]
MH = 5	0.85	[0.83, 0.86]
British Columbia		
MH = 1	0.89	[0.87, 0.91]
MH = 2	0.88	[0.86, 0.90]
MH = 3	0.87	[0.86, 0.88]
MH = 4	0.86	[0.85, 0.88]
MH = 5	0.85	[0.84, 0.87]

To get an overall understanding of which provinces contribute the most to the variation in m-banking adoption, we visualize the random effects of province on m-banking in Fig. 1. Nova Scotia, Quebec, Ontario, Manitoba and British Columbia have the highest variations in m-banking adoption. This can be useful for policy makers and researchers who are interested in demographic as well as geographic differences in m-banking adoption. For example, one might want to understand why it is that m-banking across NS and AL is almost uniform but very volatile across QB. One reason might be social class differences, with provinces such as QB and BC having a larger gap between the upper and the lower classes.

Mathematical Formula for M_FSAT. In model M_FSAT, instead of RS we have two variables: FAMSAT and FRISAT. The mathematical formulation is as follows:

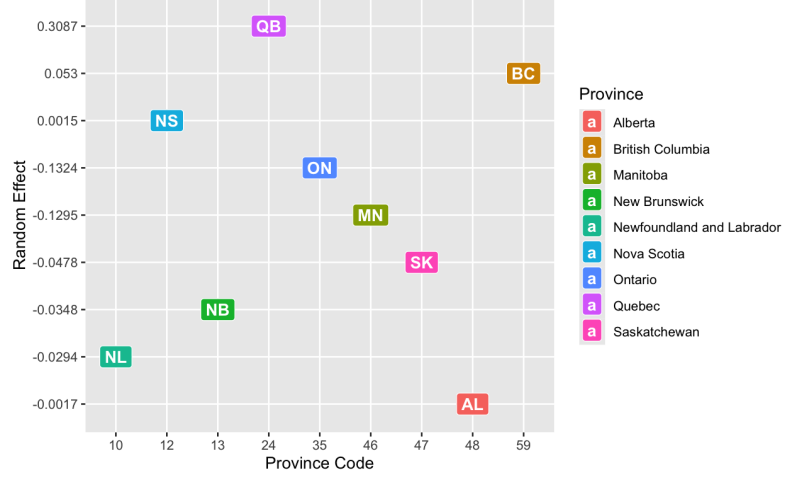


Fig 1 Variation in m-banking adoption attributed to each province

$$\ln \frac{P(\mathbf{Y} = 1)}{1 - P(\mathbf{Y} = 1)} = \beta_0 + \beta_1 \text{MH} + \beta_2 \text{SD} + \beta_3 \mathcal{D}_{SNS_0} + \beta_4 \text{AGE} + \beta_5 \mathcal{D}_{SEX_1} \quad (1)$$

$$+ \beta_6 \mathcal{D}_{EMP_0} + \beta_7 \text{EDU} + \beta_8 \text{INC} + \beta_9 \mathcal{D}_{FAM_1} + \beta_{10} \mathcal{D}_{FAM_3}$$

$$+ \beta_{11} \mathcal{D}_{FAM_4} + \beta_{12} \mathcal{D}_{IMM_1} + \beta_{13} \text{FAMSAT} + \beta_{14} \text{FRISAT} + \varepsilon$$