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Untapped Potential: Mobile Device Ownership and Mobile Payments in Canada

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Abstract

Mobile phones are ubiquitous around the world, making them obvious conduits for innovative payment technologies, or mobile payments. In Canada, five out of six adults regularly use a mobile phone. However, they have not started to use mobile payments at the same rate as other payment innovations, such as contactless card payments. In this paper, we present a two-stage model of mobile phone and mobile payment use.

An important feature of the model is that it controls for selectivity due to mobile device adoption. Controlling for selection into mobile phone usage reveals unobserved factors that have negative effects on mobile phone usage but a positive effect on the propensity to use mobile-type payments. These factors could be preferences or constraints.

We present empirical evidence that providing people without a mobile phone access to payments with features similar to mobile payments could result in usage rates exceeding the current use among mobile phone owners. Therefore, people who are unable to acquire or choose not to own a mobile device might have unmet payment needs.

Topics: Digital currencies and fintech, Econometric and statistical methods
JEL codes: C39, D12, E42

Résumé

Les téléphones mobiles sont omniprésents dans le monde, ce qui en fait le véhicule tout indiqué pour des technologies de paiement novatrices, soit les paiements mobiles. Au Canada, cinq adultes sur six utilisent un téléphone portable régulièrement. Cependant, les paiements mobiles ne se popularisent pas au même rythme que d'autres innovations du secteur, comme les paiements par carte sans contact. Nous présentons un modèle en deux étapes qui rend compte de l'utilisation des téléphones mobiles et des paiements mobiles.

L'une des forces de ce modèle est qu'il contrôle le biais de sélection attribuable à l'adoption des appareils mobiles eux-mêmes. Cela met en lumière l'existence de facteurs non observés, comme des préférences ou des contraintes, qui défavorisent la téléphonie mobile tout en favorisant le paiement mobile.

Nous démontrons de manière empirique que si les personnes sans téléphone mobile disposaient d'un mode de paiement assimilable au paiement mobile, les taux d'utilisation pourraient dépasser ceux actuellement observés parmi les utilisateurs de téléphone. Ainsi, il se pourrait que les personnes qui n'ont pas de téléphone mobile (que ce soit par contrainte ou par choix) aient des besoins non satisfaits en matière de paiements.

Sujets : Monnaies numériques et technologies financières, méthodes économétriques et statistiques
Codes JEL : C39, D12, E42

1. Introduction

Retail payments around the world have shifted to digital transactions, a trend that accelerated during the COVID-19 pandemic. Henry et al. (2022) document that the share of cash transactions in Canada fell from 54% in 2009 to 21% in 2021 while credit card transactions increased from 19% to 46%, which explains most of the shift. Numbers for the US in Foster et al. (2024) confirm a similar trend. China has also seen a dramatic move from a cash-intensive payments landscape to digital, and in particular mobile, payments (Ouyang, 2021; Ho, 2022).

Mobile phones have recently become form factors for innovative payment technologies, that is, mobile payments. These payments on or from a mobile device can take different forms. They can be made on a website, within an app, or in person at physical points of sale, and may also involve dedicated apps called digital, mobile, or virtual wallets. Mobile payments can consist of charging a payment card (credit, debit, or prepaid) or transferring funds, either from a bank account (Interac e-Transfer®) or from an online payment account.

Smartphone ownership in Canada is high, with Statistics Canada reporting that 84% of Canadians aged 15 and older have a smartphone for personal use.[1] Smartphone non-ownership is an obstacle to mobile payments for just about 16% of Canadians. Almost all Canadians, regardless of whether they live in an urban or rural area, can access mobile networks.[2] While mobile services are relatively expensive in Canada, large providers are required to offer and promote low-cost and occasional-use plans (CRTC, 2021).[3] A recent study by Technology Strategies International also reports that 70% of smartphones in Canada have built-in near-field communication (NFC) payment capability, allowing for in-person contactless payments from certain mobile payment apps

[1] Statistics Canada. Table 22-10-0143-01, "Smartphone personal use and selected smartphone habits by gender and age group."

[2] In 2022, 91.3% of Canadians had access to 5G networks and 99.5% of Canadians had access to LTE networks (Canadian Radio-television and Telecommunications Commission, Communications Monitoring Report).

[3] A recent price-comparison study among the G7 countries and Australia finds that Japan, Canada, and the US consistently have higher prices than other countries and that the lowest prices found internationally are often less than half the Canadian price (Wall Communication Inc., 2023). Following its most recent review of mobile wireless services in Canada, the Canadian Radio-Television and Telecommunications Commission (CRTC) determined that high prices are due to a lack of competition: Bell Mobility, Rogers, and Telus together exercise market power in the provision of retail mobile wireless services in all territories and provinces except Saskatchewan, where SaskTel holds and exercises market power (CRTC, 2021).

(Technology Strategies, 2023). In addition, most large Canadian payment card issuers support linking their cards to several mobile wallet apps.

Against this background, we observe that mobile payments have not gained widespread adoption in Canada yet. Statistics Canada reported that 10% of all Canadians above the age of 15 used a virtual wallet in 2020, and our data also suggest that only 16% of adults make mobile payments. These statistics hint that Canada may be lagging major markets, such as the US and China, in the diffusion of mobile payments. In the US, for instance, the share of mobile payment users doubled from 34.7% in 2018 to 69.5% in 2023 (Foster et al., 2024), with a critical turning point in 2021 (Lott, 2023).[4] The growing popularity of e-commerce and online shopping might explain much of the increase, as remote payments accounted for the majority of mobile payments in the survey results of Foster et al (2024). By contrast, in Germany, current mobile payment adoption rates are similar to that in Canada (around 15% in 2021), despite less favourable conditions. For example, while mobile wallets provided by Apple and Google are compatible with the cards issued by the largest Canadian banks, German banks are still overcoming their hesitancy to allow linking of their cards in mobile wallets (Deutsche Bundesbank, 2023).

In this paper, we present empirical findings regarding the adoption of mobile payments and digital wallets in Canada, based on a survey of Canadian consumers. Central banks monitor these technologies and their impact on payment behaviour closely for several reasons: First and foremost, because of the potential impact on the use of the banknotes (and coins) that they issue. Second, because central banks often play a role in overseeing payment systems and their efficiency. For instance, since 2022, the Bank of Canada has had the mandate of overseeing the growing industry of (digital) payment service providers, including digital wallets. In this role, the Bank's objectives are to ensure appropriate risk management as well as consumers' funds protection (Morrow, 2022, 2023, 2024).

In contrast to their relatively low usage of mobile payments, Canadians' use of contactless payments with a plastic card has grown rapidly over the last ten years. The latter combines attributes of cash, such as the speed of payment (Vallée, 2018), with those of cards, such as reward programs. Several studies have found that during the early stage of diffusion, contactless payments did not impact cash usage significantly (Chen et al., 2017; Trütsch, 2020). Felt (2020) finds that the adoption of contactless credit cards had only a small impact on

[4] We thank Kevin Foster for providing the 2023 statistics in advance of the publication of their report.

the transactional usage of cash in Canada at the intensive margin (how much is used) and none at the extensive margin (whether cash is used). Similarly, Brown et al. (2022) show that access to contactless debit cards increases the overall use of debit cards, especially for small-value payments, but barely affects cash usage. However, if mobile payments were to induce a shift from physical wallets to digital wallets, they could have a more significant effect on the demand for cash than contactless card payments.

Since the market for payments is two-sided (i.e., a method of payment can be used only if both consumers and merchants adopt or accept it), an important factor is whether mobile payments are accepted at the point of sale. Recent estimates suggest that acceptance is far from universal. Welte et al. (2024) report that slightly less than half (49%) of small and medium-sized businesses in the retail, restaurant, and services industries accepted mobile payments in 2023, an increase from 43% in 2021–22 (Welte and Wu, 2023). This compares with nearly 80% of them accepting contactless card payments.[5] Statistics Canada estimates that, in 2023, just over one-quarter of Canadian retailers (retail trade) accepted digital or electronic wallets for payments.[6] Empirical work by Rysman (2007) suggests a positive feedback loop between consumer usage and merchant acceptance, whereby more consumer usage attracts more merchants, which then attracts more consumers. Huynh et al. (2019, 2022) provide evidence that changes in the consumer adoption of a payment method might have a stronger effect on its overall usage than changes in merchant acceptance. Here, we focus on consumer usage and do not directly account for merchants' acceptance.

Consumers' demand for mobile payments is shaped by many factors, including their own constraints and preferences, information frictions, supply-side factors in the banking and wireless industries, as well as the acceptance of mobile payments by merchants. We model this demand at the extensive margin (whether mobile payments are used or not) and quantify how constraints on mobile device use affect mobile payments. In particular, mobile device non-users are constrained and their preferences for mobile payments are not revealed.

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[5] Merchants accepting contactless card payments need not accept contactless mobile ones. One reason for opting out of mobile payments could be higher fees. For instance, fees for mobile Interac debit payments are currently higher than for contactless Interac debit card payments. (Interac. "Understanding business fees." Accessed September 29, 2023.)

[6] Statistics Canada, Canadian Survey on Business Conditions. Table 33-10-0703-01, "Payment methods currently accepted or planned to be accepted over the next 12 months by businesses or organizations, third quarter of 2023."

A growing body of literature has been building a framework to study the economics of digital and mobile payments. They inform decision makers such as industry participants, oversight bodies, and competition authorities. In recent years, attention has turned to how mobile payments are positioned and integrated in a "stack" of digital platforms, creating interlinkages between several markets, such as those for mobile devices and apps, wireless services, the banking industry, non-bank payment services providers, online shopping platforms, physical retail stores, etc. Gomes and Lefouili (2023) develops a model of stacked payment and describes the inefficiencies that can arise when mobile wallet providers act as gatekeepers. For example, the model predicts underprovision of mobile payment services when consumers are charged a fee to access the platform. His results also call into question whether pro-competitive regulation would result in a more efficient outcome.[7]

In the work of Gomes and Lefouili (2023), the mobile payment platform generates its revenue from advertising. An important theme in the literature is also the flow of payment-related data to financial technology companies (fintechs) and the effect of this flow on financial inclusion. While fintechs can monetize this data, the payment flow data can also substitute for a traditional credit history. In the literature, those with limited access to financial services see the largest effects of this new type of financial profile. Ouyang (2021) uses data on Alipay, a leading mobile payment provider in China, to demonstrate that the app increases not only cashless payments, but also access to credit. In the model of Parlour at al. (2022), competition between traditional banks and fintechs have ambiguous effects on consumer welfare, but the previously underbanked benefit from the fintechs. Ho et al. (2022) empirically investigate the adoption of mobile payments based on a large panel data set. They show that preference for using mobile payments, socio-economic status, and price sensitivity are important adoption drivers. Our work complements these papers by investigating the role of access to a mobile device in addition to that of access to financial services.

This paper is organized as follows. Section 2 gives an overview of the Canadian mobile payments landscape and describes what is captured in the data. Section 3 presents a descriptive analysis of mobile device and mobile payment adopters. Section 4 proposes an econometric model using a two-stage

[7] A prominent case is the European Commission's Directorate General for Competition investigation of Apple Pay (European Commission, 2024). Apple is included on the regulator's list of "gatekeepers", owing in part to the gateway services that their platform provides within the digital ecosystem (European Commission, 2023).

Heckman probit model. Section 5 presents the estimation results and their implications.In Section 6, we discuss our findings. Section 7 concludes.

2. How Canadians use their mobile devices to pay

We use the Digital Wallet and Payment Trends survey (DWPT), a web survey of 3000 Canadians conducted by Ipsos each quarter since 2020, to monitor mobile payments. It covers the use and adoption of payment cards and other digital payment methods by the Canadian adult population.[8] For our main analysis, we use DWPT data from the first quarter of 2021 to the first quarter of 2023 for consistency of survey questions across time. All statistics are weighted using our own sample weights.[9]

2.1. The mobile payment landscape

In this section, we describe how the DWPT captures the mobile payment landscape in Canada. The survey considers retail payments (as opposed to wholesale payments) made by consumers, which can be consumer-to-business or consumer-to-consumer. When discussing mobile payments, we mean a payment that involves the payer's use of their mobile phone. Payment solutions that allow sellers or merchants to turn their smartphone into a payment acceptance device are not in scope.

All respondents indicate which methods of payment they have used in the last three months. In addition to the payment choices presented to all respondents, regular users of smart devices (smart phones and smart watches) are also asked whether they paid via scanning an image or barcode and whether they paid via a mobile payment app (examples provided are Apple Pay and Google Pay). If respondents indicate having used a mobile payment app, they provide details on the apps used on one of their mobile devices in the past three months.

Image scanning technologies use barcodes or quick response (QR) codes. When the payer presents the code on their phone, the payee scans it. The barcode can be obtained from a financial institution or generated by a prepaid card app, gift card app, or store app (e.g., Starbucks or Tim Hortons), or by a

[8] The DWPT is the successor survey to the Personal Cardholder Study (PCS). While the PCS focused on payment cards, the DWPT additionally surveys the adoption of other digital payment products. To qualify for the survey, respondents must have a bank account with a Canadian deposit-taking financial institution. This participation condition is unlikely to introduce a bias since bank account ownership is above 99% in Canada (CBA).

[9] In our analysis, we use sample weights to ensure that the final sample is representative of the target population. We construct these sample weights following Chen et al. (2018) and Felt and Laferrière (2020). Details are available in the Appendix.

mobile wallet app (Apple Pay, Google Pay). PayPal, Alipay, and WeChat, with the corresponding wallet apps, also offer payment with a QR code.[10] Therefore, QR codes are also a functionality of mobile wallet apps. However, mobile wallet apps, and mobile payment apps more generally, have a larger scope than image-scanning payments.

First, at the point of sale, some mobile wallet apps can use NFC chips integrated into the phone to communicate with the payee's payment terminal, for contactless payments. The mobile payment app will then charge the purchase amount to a payment card or account, the credentials of which the payer saved in the app. The main examples are Apple Pay, Google Pay, and Samsung Pay (hereafter AGS). In fact, only these three apps are currently supported by Canadian credit and debit card issuers for NFC mobile payments (see Table A1 in the Appendix). It is also necessary that the payee accepts contactless mobile payments from the card network of the linked card.[11] Sometimes, the payer authorizes the payment or authenticates themselves with a password or biometrics.

These contactless mobile payments at the physical point of sale may use tokens to encrypt the card information that is transmitted to the terminal. These tokens can be stored on the mobile device or generated by the mobile device. They can be used even when the payer's mobile device is not connected to the internet, similar to a contactless card payment. The AGS apps offer tokenization for in-store mobile payments.

Second, mobile payments can also be in-app on mobile devices. When the payer makes a purchase within another app, for example a music streaming service or a game, this app can access the payment information in the mobile payment app installed on the device.

Third, bank account management apps, or mobile banking apps, can also be used to make mobile payments. For example, Interac e-Transfers are a way to pay from a bank account management app. Furthermore, some Canadian banks provide wallet apps that can store gift cards and prepaid cards (e.g., TD Wallet).

Image scanning and mobile payment apps cover a wide range of mobile phone payments, but mobile devices can facilitate payments in other ways. For example, the Financial Consumer Agency of Canada also includes text message

[10] PayPal. "Pay touch-free with a QR code." Accessed September 29, 2023.

[11] According to element 11 of the Code of Conduct for the Debit and Credit Card Industry, a merchant can accept card-based contactless payments from a network but opt out of accepting mobile payments from the same network in case of differences in fees (Financial Consumer Agency of Canada, "Code of Conduct for the Debit and Credit Card Industry in Canada." Accessed September 29, 2023).

or email money transfers in their list of mobile payment options that may only require a basic mobile phone or email account. And more generally, many transactions that can be made online, including online banking and in-browser payments, can also be made on a mobile phone by using the web browser on the phone.

Conversely, payment apps can also be used without a smartphone, for example, on a computer or a tablet. When a user is logged into their Google account and makes an in-browser purchase in Google Chrome, Google Pay is available. The DWPT data does not capture this type of transaction, however.

2.2 Mobile payments in the DWPT data

This section uses only 2022 DWPT data, as the question asking which mobile payment apps were used remains unchanged over this period, with 13 apps listed. In 2022, 16% of Canadians were mobile payers: 15% of Canadians used mobile payment apps (where the examples provided were Apple Pay and Google Pay) and only 2% used image scanning payments; 1% used both types.[12]

As shown in Table 1, we observe in our data that AGS apps are the most used payment apps.[13] Of payment app users, 91% indicate that they have used at least one of these, while 51% used bank account apps to make a payment. The latter can be used to send Interac e-Transfer payments to merchants or peer-to-peer.

The bar chart in Figure 1 visualizes the various usage patterns observed in the data to reflect respondents' use of multiple mobile payment apps. Using more than one payment app, called "multihoming," is common (see Bakos and Halaburda, 2020). About one third of mobile payers (payment app and QR code payment users) use only AGS apps, and one fifth use only AGS and bank account management apps.

The next most popular mobile payment apps are payment account apps (such as the PayPal app), which allow payments from online payment accounts not affiliated with a financial institution, and store-branded prepaid card apps (such as the Starbucks app), which are digital equivalents of store-branded prepaid cards. They are used by 20% and 15% of mobile app users, respectively. Most of these users also use an AGS app.

[12] All statistics are weighted using our own sample weights.

[13] We caution that the framing of the question, i.e., providing Apple Pay and Google Pay as examples, could lead to an overrepresentation of the AGS apps in the data.

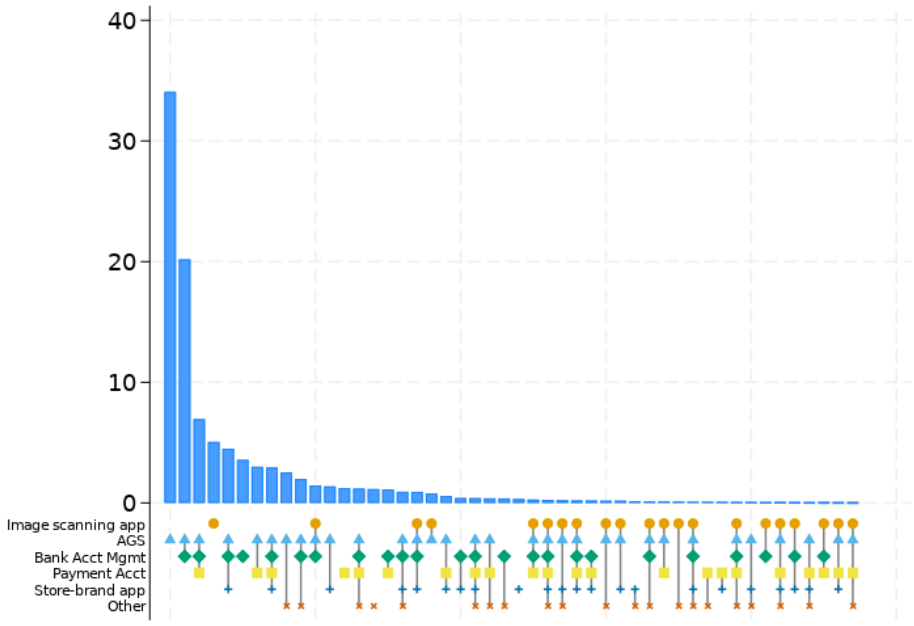
Many mobile payment apps can store credit or debit card information that can be accessed at the time of purchase. As explained in section 2.1, a special case occurs when this card information can be used for NFC contactless payment with a phone. In the DWPT, all mobile payment app users are asked whether they have linked a card for in-person contactless, or tap, payments. We find that 86% of them use this feature, linking a credit card (46%), a debit card (20%), or both types of cards (19%).

Table 1: How Canadians use mobile payments: Digital wallets and mobile banking apps are most popular

	% of adult Canadians
Mobile payments	16
Image scanning payments	2
Mobile payment apps	15
► **Payment apps used**	*% of mobile payment app users*
Apple, Google, or Samsung Pay (AGS)	*91*
Apple Pay	*61*
Google Pay	*31*
Samsung Pay	*7*
Bank account management apps	*51*
Payment account apps	*20*
Store-branded prepaid card apps	*15*
Other payment apps	*11*
► **Linked cards for in-person payments**	*86*
Only credit cards	*46*
Only debit cards	*20*
Credit and debit cards	*19*

Note: All values in this table are reported as percentages. Data are from the 2022 DWPT. Sample weights are used. Under *Other payment apps*, we compiled the remaining response options for payment apps, which are AliPay, MasterPass by MasterCard, Wealthsimple Cash, WeChat, Wise, Zoompass, and Other.

Figure 1: Adoption patterns among mobile payers: They often use more than one type of mobile payment



Note: The labels of each bar describe subsets of mobile payment types. The height of the bar represents the share of mobile payers who use each subset. Data are from the 2022 DWPT. Sample weights are used.

3. The demographics of mobile payers

How do mobile payment users differ from non-users? Although mobile payments require owning and using a mobile device, individuals may own a smart device and not pay with it. Therefore, in the remainder of the paper, we consider three types of individuals: those who do not use a mobile device on a regular basis (mobile non-users), those who use a mobile device on a regular basis but did not pay with it in the past three months (mobile users, non-payers), and mobile device users who paid with their mobile device in the past three months (mobile payers).

A mobile device is a smartphone or a smartwatch. Based on the variables in the DWPT data sets, mobile users may scan a QR code or use a mobile payment app for mobile payments.[14]

[14] Most smartwatches are not standalone and need to be paired with a smartphone to function. In the remainder of the paper, we use mobile/smart and device/phone interchangeably.

Table 2: Demographic profiles: Mobile payers have a higher representation of younger, more educated, and wealthier segments, recent immigrants

	Mobile non-users	Mobile users, non-payers	Mobile payers
Share of population	16	68	16
Age			
18–34	10	27	**49**
35–54	17	35	36
55+	**74**	38	15
Gender			
Male	50	49	52
Female	50	51	48
Education			
High school or less	**54**	41	35
College	27	31	31
University	19	28	**34**
Employment			
Employed	32	60	74
Unemployed	3	5	5
Not in labour force	**65**	36	21
Household income			
<$45K	**32**	21	17
$45K–85K	33	27	24
>$85K	34	52	**59**
Region			
Atlantic	7	6	7
Quebec	26	22	20
Ontario	37	39	41
Prairies	15	18	18
British Columbia	14	14	14
Locality			
Rural	**17**	14	10
Urban	83	86	90
Immigration			
Born in Canada	**89**	84	78
10+ years	10	12	12
<10 years	1	5	**9**
Ethnic origin			
North America	40	39	34
Europe	53	45	41
Africa, Latin America, and Caribbean	1	4	**7**
Asia-Oceania	5	12	**18**
Device used for survey			

Laptop/PC	85	56	43
Smartphone	7	40	54
Tablet	9	4	3
N=	4,242	18,131	4,256

Note: All values in this table are reported as percentages, except for the final row, which reports sample sizes. Proportions in each category and type add up to 100%, except for rounding errors. Data are from the 2021Q1–2023Q1 DWPT. Employment is missing for 268 observations, locality is missing for 1,653, and ethnic origin is missing for 2,108. Income is imputed for 1,825 missing observations. Sample weights are used.

Table 2 displays the proportion and demographic profile of each of the three types of users for 2021Q1–2023Q1. Use of mobile devices is high among adult Canadians; 84% are regular smartphone or smartwatch users.[15] Of these, only 19% use mobile payments, which amounts to 16% of the overall adult population. This result is in line with 2021 estimates derived from a Bank of Canada consumer diary in Henry et al. (2022). By contrast, 16% of adult Canadians do not use a mobile device on a regular (weekly) basis.

Users of mobile payments share traits with adopters of other payment innovations such as contactless cards (Chen et al., 2017). They tend, on average, to be younger, more educated, and earn a higher income than non-users. Mobile payers also have the largest representation of recent immigrants. A possible explanation is that recent immigrants are younger or that they come from places where mobile payments are already widely adopted, such as Asia or Africa (Han and Wang, 2021). Focusing on younger adults, Lusardi et al. (2018) also find that mobile payment users are more diverse, more educated, and have higher incomes than their non-user counterparts, but also demonstrate lower levels of financial literacy.

In contrast, individuals who do not frequently use a mobile device tend to be older, less educated, and have a lower income. Mobile non-users are more likely to be outside the labour force, to live in rural areas, or to be born in Canada.

The data set also provides information on the behaviour and preferences of respondents. Table 3 presents statistics regarding the payment behaviour of

[15] The Canadian Internet Use Survey estimates that 84% of Canadians aged 15 years or above had a smartphone for personal use in 2020 (Statistics Canada. Table 22-10-0143-01, "Smartphone personal use and selected smartphone habits by gender and age group"). More recent estimates indicate that 84% of Canadians had access to the internet through a mobile data plan for personal use in 2022, which implies the use of a wireless handheld device, such as smartphone or tablet (Statistics Canada, 2023).

the three types of individuals. The first panel shows the share of Canadians who used different methods of payment in the past three months. While two-thirds of them used cash, regardless of whether they use mobile payment technology, the types differ in how they used other payment methods.

Mobile payers have the most diverse payment mix. On average, they used seven different payment methods in a three-month period compared with 3.6 for mobile non-users and 4.4 for mobile non-payers. They have the highest proportions of credit card and debit card use, especially contactless and online usage. In addition to mobile payments, mobile payers also use other payment innovations more often, such as e-Transfers and cryptocurrencies. By contrast, cheque is the only payment method that mobile non-users apply more often than the other two types do. Mobile non-users also have the highest proportion of cash-only users, that is, those who exclusively paid with cash in the past three months.

As seen in other data sets, debit card ownership is almost universal in Canada (see, e.g., Henry et al., 2024) but slightly higher for mobile users. Credit card ownership is also slightly higher among mobile device users: 83% and 84% for mobile non-payers and payers, respectively, compared with 78% of mobile non-users. Table 3 shows that almost all mobile payers have shopped or ordered online on major retail websites and platforms in the past three months. They are also more likely to have credit card debt than other types. Similarly, adopting mobile payments is associated with costly or risky financial behaviour and linked to lower financial literacy (Meyll and Walter, 2019; Lusardi et al., 2018).

The remainder of Table 3 shows how respondents pay their utility bills. We indicate the share of individuals who pay for at least one utility (in a list of 9 items including gas, electricity, water, internet, etc.) using any given channel. Across all types, around two-thirds of individuals pay at least one utility bill via online banking. Mobile non-users pay in-person or by mail at a higher rate, while mobile payers rely relatively more on pre-authorized credit and mobile banking app payments.

We note that 8% of mobile non-users and 18% of mobile non-payers have used a mobile banking app to pay for utilities. Possible explanations are the use of mobile payment apps on tablets or access to online banking portals via the browser on a mobile device. Furthermore, while the questions about using mobile devices and making mobile payments have a well-defined time frame, that is, in the last three months, the bill payment questions ("Please indicate how you pay for the following bills") could be interpreted to mean whether the respondents had *ever* used mobile banking to pay the bills in questions.

Table 4 shows respondents' attitudes towards cash and other methods of payment. Survey respondents select up to three benefits of using cash. Similarly across all types, 85% see at least one benefit to cash. All types also agree that universal acceptance is an important benefit of cash, with 42% of mobile non-users and 37% of both mobile non-payers and payers selecting this feature. We observe variations across types for other attributes of cash. A higher share of mobile non-users perceive cash as safe, easy to use, and fast compared to mobile users. In contrast, more mobile payers view cash as helpful to control spending and like cash for the potential to be offered a cash discount. Their need to control spending and use a tangible measure of "money left in the pocket" might be tied to worries about their own financial behaviour. Liao and Chen (2021), Ahn and Nam (2022), Meyll and Walter (2019), and Lusardi et al. (2018) find that frequent users of mobile payments are more likely to demonstrate risky financial behaviour, including overspending. Our data confirm their findings since a higher percentage of mobile payers revolve on their credit card (see Table 3). Von Kalckreuth et al. (2014) and Hernandez et al. (2017) explain how cash can encourage financial responsibility by providing a spending cap and by amplifying the immediate "pain of paying" compared to the perceived gratification from the purchased good (Knutson et al., 2007).

The second panel of Table 4 presents stated preferences for paying. Respondents indicate which method of payment they find most convenient for in-store purchases below $100, assuming all options are available. Among each of the three types, a large majority considers contactless card payments the most convenient: three-quarters of mobile non-payers and two-thirds of mobile non-users and mobile payers. For both mobile non-users and non-payers, the remaining respondents view a combination of cash and card chip-and-pin as most convenient, with almost no one preferring the use of a mobile device for payment. In contrast, mobile comes second as the most convenient payment method among mobile payers. This highlights how the convenience of mobile payments, among those who adopt it, dominates over traditional payment methods.

Table 3: Payment behaviour: Mobile payers have a more diverse payment mix

	Mobile non-users	Mobile users, non-payers	Mobile payers
Method of payment used in the past 3 months (%)			
Cash only (no other MOP)	**5**	2	0
Cash	**69**	**67**	**69**
CC chip & PIN	50	57	63
CC contactless	49	59	**68**
CC online[a]	28	45	**62**
DC chip & PIN	35	45	57
DC contactless	26	42	**59**
DC online[a]	4	11	29
Prepaid CC	5	7	15
E-Transfer to a person	27	47	**73**
Online payment account	18	25	**44**
Cryptocurrency	0	1	5
Cheque	**25**	16	14
Gift cards	13	19	33
Money sent abroad	2	3	7
# of payment options used	3.6	4.4	**7.0**
Card ownership and usage			
DC owner (%)	96	98	99
# of DCs	1.2	1.3	1.4
CC owner (%)	78	**83**	**84**
# of CCs	1.9	1.9	2.0
Online shopping (%)	64	83	**93**
Revolver (%)	14	21	**31**
Channels used for utility bill payment (%)[b]			
Online banking	**63**	**68**	**66**
Pre-authorized – bank account	38	35	37
Pre-authorized – CC	29	34	**39**
Mobile banking app	8	18	**34**
Bank branch	**18**	13	12
Mail-in	**11**	7	6
Telephone banking	9	8	9
Provider website	8	9	13
Other	19	15	13

Note: The *Method of payment* section is the estimated proportion of adult Canadians who have used a given method of payment in the past three months. The *Cash only* row shows the proportion who reported using only cash in the past three months. DC and CC stand for debit card and credit card, respectively. *# of payment options used* is the average number of response options checked for the question on methods of payments used in the past three months. *DC owner* and *CC owner* are the proportion of Canadians with at least one credit or debit card, respectively. A respondent is defined as a debit card owner if they reported having a chequing account or a debit card. *# of DCs* and *# of CCs* are, respectively, the average number of debit

or credit cards per owner. *Revolver* indicates the proportion of credit card owners who currently carry outstanding balances on their credit cards. *Online shopping* is the proportion of debit or credit card owners who have shopped or ordered online in the past three months from the following sites or apps: Amazon, Best Buy, Canadian Tire, Costco, eBay, Etsy, HBC/Hudson's Bay, travel sites, Walmart, Wayfair, grocery delivery or pickup services, meal takeout, Kijiji, Home Depot. The *Channels used for utility bill payments* section contains the share of Canadians who use a given channel to pay for utilities. *Pre-authorized – bank account* and *Pre-authorized – CC* refer to pre-authorized payments charged on a bank account or a credit card, respectively. [a] data are from the 2022Q1–2023Q1 DWPT; [b] data are from the 2021Q1–2022Q3 DWPT; all other data are from the 2021Q1–2023Q1 DWPT. Sample weights are used.

Table 4: Perceived benefits and convenience of methods of payment: Contactless card payments dominate stated preferences

	Mobile non-users	Mobile users, non-payers	Mobile payers
Main benefits of cash (%)			
Universal acceptance	**42**	**37**	**37**
Safe/avoids identity theft	**34**	30	25
Easy to use	**39**	31	23
Faster payment method	**16**	12	10
Helps control spending	22	26	**28**
Cash discounts	9	13	**16**
Good for tipping	29	31	35
Anonymous payment	18	21	24
Other	2	2	2
No benefit	**13**	**13**	**14**
Most convenient method of payment at the point of sale (%)			
Cash	**18**	11	4
Card chip & PIN	17	12	6
Card tap & go	**64**	**74**	**69**
Mobile device	1	2	**21**
Reasons for choosing primary credit card (%)			
Only card I own	33	28	23
Convenience	**58**	**54**	**61**
Rewards	55	54	58
Low cost	**42**	33	30
Service	30	26	31

Note: All values reported in this table are reported as percentages, conditional on type. The *Main benefits of cash* section reports responses to the question "What are the benefits, if any, to using cash?" Respondents could choose up to three benefits of cash. The *Most convenient method of payment at the point of sale* section reports responses to "Which do you think is most convenient when paying for something under $100, in a coffee shop, store or other physical location, assuming any of the options below are available?" The section *Reasons for choosing primary credit card* reports stated reasons for using one's primary credit card for personal spending. Respondents could choose as many responses as they wanted from a list of almost 20 statements; we group them by theme. Data are from the 2021Q1–2023Q1 DWPT. Sample weights are used.

The remainder of Table 4 presents stated reasons for choosing one's primary credit card for personal spending. Over half of all types of individuals cite convenience, making it the top choice for all. Mobile non-users are more concerned with cost, mentioned by 42% of them compared with only one-third of mobile users.

4. A two-stage model of mobile device and mobile payment usage

We want to understand which factors encourage or impede mobile paying in the Canadian population. We view mobile payment use as a multi-stage technology adoption process. In the first stage, individuals decide whether to adopt a smart phone/device for regular use, and in the second stage, they decide whether to use the device for payments. Not accounting separately for mobile phone adoption may confound factors explaining mobile payment use with factors that affect device use. As a caveat, the design of the DWPT questionnaire, in particular the focus on AGS apps, could also lead to missing data (or underreporting of mobile payment adoption), which we cannot account for.

In econometric terms, a model of mobile *payment* use that fails to account for mobile *phone* use may bias population estimates. On the one hand, focusing on the subset of mobile users may create biasing sample selection. On the other hand, working with the whole sample but not distinguishing between mobile non-payers who own a mobile device and those who do not may confound the separate processes of mobile device adoption and mobile payment adoption.

Our empirical strategy is to estimate a flexible two-stage decision model where mobile device adoption is the first stage and mobile payment app adoption the second stage. Since both stages involve binary explained variables, we choose the bivariate probit model with sample selection of Van de Ven and Van Pragg (1981), adapted from Heckman (1979). Sample selection here refers to the fact that mobile non-users cannot make payments with a mobile device. Therefore, we do not observe their true choice whether to mobile pay, $mPay_i^*$.

We model mobile phone and mobile payment adoptions of individual i using probit models, as follows:

$$mUse_i = I(X_i\beta_1 + Z_i\gamma + u_{1i} > 0), \quad (1)$$

$$mPay_i^* = I(X_i\beta_2 + u_{2i} > 0), \quad (2),$$

where $I(.)$ is an indicator function that takes the value 1 if the term in brackets is true, X_i and Z_i are matrices of control variables for individual i, $u_1 \sim N(0,1), u_2 \sim N(0,1)$, and $\text{corr}(u_1, u_2) = \rho$.

The observed mobile payment adoption $mPay_i$ coincides with the latent, true adoption decision $mPay_i^*$ only for mobile users, that is, if $mUse_i = 1$. If ρ differs from zero, a standard estimation of Equation (2) based on mobile users will lead to biased estimates of β_2. Correcting for sample selection is required in such a

case. We implement the correction as proposed by Van de Ven and Van Pragg (1981) and obtain maximum-likelihood estimates of β, γ, and ρ.

Identification strategy

To make inferences from the bivariate model, it needs to be identified. The literature provides several sufficient assumptions for identifiability. First, the bivariate model is identified under the assumption that the errors u_1 and u_2 are jointly normal.

Second, in order not to rely only on this assumption for identification, the usual approach is to use an exclusion restriction, that is, include a set of variables $\boldsymbol{Z}$ in Equation (1) that impact mobile phone adoption but not the decision to use mobile payments once the device has been adopted. We use province-by-time fixed effects as instruments to capture changes and differences across Canadian provinces in terms of mobile phone carriers. These fixed effects could impact mobile phone adoption but not mobile payment use.

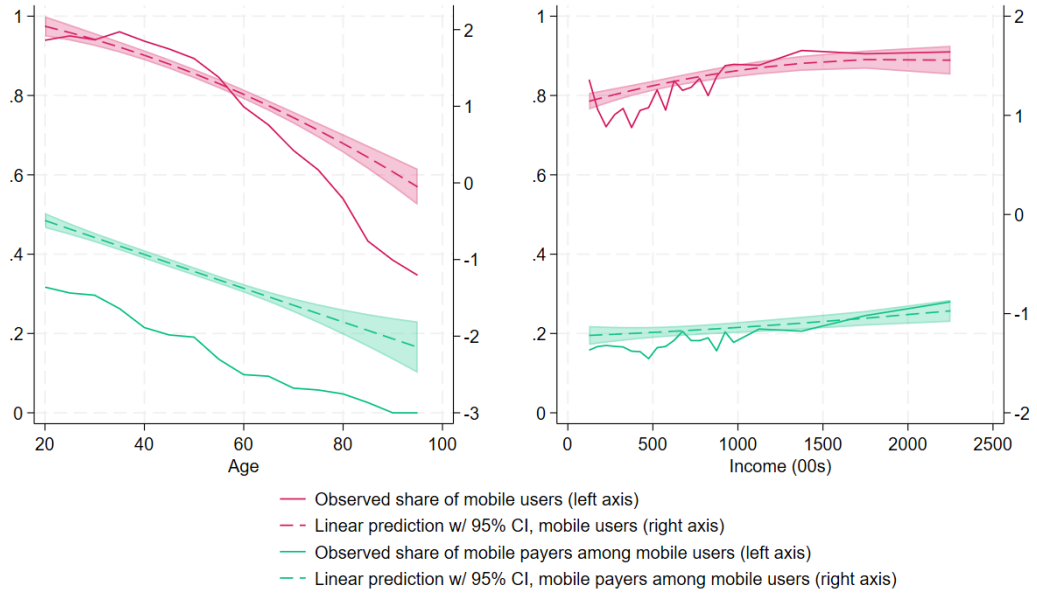
Third, identification can be obtained under functional form assumptions weaker than joint normality (see Lewbel, 2019; section 3.7). Dong (2010) and Escanciano et al. (2016), in the absence of exclusion restrictions, exploit non-linearities in how X enters the selection equation, Equation (1), to achieve identification. In our case, we observe that the probability of mobile use is non-monotone in age and income, while the probability of mobile payments monotonically declines in age and increases in income (Figure 2). We argue that capturing the non-monotone relationships requires higher-order terms (at least order 2) and that the monotonic relationships can be approximated linearly.

In practice, we add age squared and income squared to our instruments in Z, thereby combining different identification strategies, as recommended in Lewbel (2019). The same approach was recently taken in Balutel et al. (2022).

Survey data from Statistics Canada confirms that smartphone adoption is much lower among the elderly than among young or middle-aged Canadians.[16] Economically, this observation may relate to adoption cost. Older people may have higher financial costs (absolute or relative to consumption/income) as well as a steeper learning curve (see, e.g., Berenguer et al., 2016; Welte et al., 2023).

[16] For instance, Statistics Canada reports that among Canadians, 96% of 15–44 year olds and 87% of 45–64 year olds had a smartphone for personal use in 2020, compared with only 54% of 65 year olds (Table 22-10-0143-01, "Smartphone personal use and selected smartphone habits by gender and age group").

Figure 2: Age and income effects on mobile device and mobile payment usage: Non-linearity of mobile use in age and income provides identification



Note: The solid lines are observed shares of mobile users (red) and observed shares of mobile payers among mobile users (green). The dashed lines are linear predictions for mobile use (red) and mobile pay among mobile users (green), obtained from separate probit models, shown with their 95% confidence intervals. For better visualization, we show averages over five-year bins. Data are from the 2021Q1–2023Q1 DWPT. Sample weights are used.

While age still plays a role for mobile payment adoption among mobile users, the effects of age on mobile payment use do not accelerate as a person gets older. Other studies show similar results. For instance, Li and Luximon (2018) show that older smartphone users in Hong Kong quickly began using the advanced or smart features of their devices, in addition to basic calling and messaging features. Furthermore, older individuals who adopt smartphones may differ from their age-group peers who do not adopt such a device. The difference could be explained by observed or unobserved factors. Thus, explicitly modelling device adoption is important for modelling mobile payment choice.

Model specification

Except for the instruments that only enter the first-stage equation (age squared, income squared, and the province-by-time fixed effects), all explanatory variables are used in both equations.

We include standard demographic variables. We include revealed preferences for banking and payment choices as well as stated preferences that were available over the 2021Q1–2023Q1 period. We also use the type of device used to complete the DWPT questionnaire: a computer (laptop or PC), a smartphone, or a tablet. Finally, we also add a quarterly time trend in each equation.

In the following two sections, we relate the estimated demand model to consumers' observed and unobserved preferences and constraints. We also provide a counterfactual demand estimation where we remove the constraints to mobile device usage. As before, demand is taken to mean the extensive margin of mobile payments use, namely whether an individual used them or not. The intensity of use, i.e., how much the individuals use them, is not captured in our data.

5. Estimation results

Estimation results are provided in Table 5. The first two columns show parameter estimates while the last two columns show average marginal effects.

Table 5: Results from a bivariate probit with Heckman sample selection

	Model coefficients		Average marginal effects on	
	Mobile device use	Mobile payment use	Mobile device use	Mobile payment use
Age	-0.0086	-0.0198***	-0.0052***	-0.0044***
	(0.006)	(0.002)	(0.000)	(0.000)
Gender				
Female	0.0045	-0.1270***	0.0008	-0.0283***
	(0.031)	(0.031)	(0.006)	(0.007)
Education				
College	0.1008***	0.0721*	0.0188***	0.0159*
	(0.036)	(0.043)	(0.007)	(0.009)
University	0.0902**	0.0827**	0.0169**	0.0183**
	(0.040)	(0.044)	(0.008)	(0.010)
Employment				
Unemployed	0.0406	-0.0666	0.0072	-0.0147
	(0.089)	(0.080)	(0.015)	(0.017)
Not in labour force	-0.1386***	-0.0597	-0.0261***	-0.0132
	(0.037)	(0.043)	(0.007)	(0.009)
Household Income	0.0485***	0.0106***	0.0052***	0.0024***

	(0.011)	(0.003)	(0.001)	(0.001)
Region				
Quebec	-0.1689	-0.0072	-0.0179	-0.0016
	(0.118)	(0.074)	(0.013)	(0.017)
Ontario	-0.2067*	-0.0519	-0.0122	-0.0115
	(0.106)	(0.063)	(0.010)	(0.014)
Prairies	0.0781	-0.0223	0.0152	-0.0050
	(0.118)	(0.067)	(0.011)	(0.015)
British Columbia	-0.0378	0.0133	0.0091	0.0030
	(0.121)	(0.072)	(0.012)	(0.016)
Locality				
Urban	0.0597	0.1173**	0.0113	0.0252**
	(0.043)	(0.051)	(0.008)	(0.011)
Ethnic Origin				
Europe	0.0172	0.0547	0.0032	0.0122
	(0.037)	(0.037)	(0.007)	(0.008)
Africa, Latin America or Caribbean	0.2558**	0.0764	0.0441***	0.0172
	(0.105)	(0.076)	(0.017)	(0.017)
Asia	0.0956	-0.0569	0.0175	-0.0122
	(0.076)	(0.057)	(0.014)	(0.012)
Immigration				
>10 years	0.0540	0.0870*	0.0099	0.0198*
	(0.049)	(0.049)	(0.009)	(0.011)
<10 years	0.0701	0.1171*	0.0128	0.0270*
	(0.123)	(0.065)	(0.022)	(0.015)
Marital status				
Married	0.1088**	0.0321	0.0207**	0.0071
	(0.045)	(0.042)	(0.009)	(0.009)
Divorced or widowed	0.2354***	0.0663	0.0430***	0.0148
	(0.052)	(0.061)	(0.010)	(0.014)
# of kids <18				
1	0.1062	0.0358	0.0193	0.0081
	(0.067)	(0.047)	(0.012)	(0.011)
2	0.0805	-0.1057**	0.0147	-0.0226**
	(0.074)	(0.050)	(0.013)	(0.011)
3+	0.2263	0.0705	0.0393*	0.0161
	(0.141)	(0.090)	(0.023)	(0.021)
Device used for survey				
Smartphone	0.9945***	0.1565**	0.1530***	0.0353***

	(0.053)	(0.079)	(0.014)	(0.019)
Tablet	-0.0407	0.1617*	-0.0096	0.0365*
	(0.058)	(0.079)	(0.014)	(0.019)
Main benefits of cash				
Helps control spending	0.1252***	0.0682*	0.0227***	0.0154*
	(0.040)	(0.038)	(0.007)	(0.009)
Good for tipping	0.0751**	0.1048***	0.0138**	0.0237***
	(0.036)	(0.036)	(0.007)	(0.008)
Safe/avoids theft	-0.0086	0.0129	-0.0016	0.0029
	(0.034)	(0.035)	(0.006)	(0.008)
Anonymous	0.1298***	0.0735*	0.0235***	0.0166*
	(0.038)	(0.041)	(0.007)	(0.009)
Universal acceptance	0.0232	0.0264	0.0043	0.0059
	(0.035)	(0.034)	(0.007)	(0.008)
Easy to use	-0.0284	-0.0235	-0.0053	-0.0052
	(0.036)	(0.036)	(0.007)	(0.008)
Fast method of payment	0.0512	0.0387	0.0094	0.0087
	(0.047)	(0.051)	(0.009)	(0.012)
Cash discounts	0.1422**	0.1036**	0.0254***	0.0238**
	(0.057)	(0.046)	(0.010)	(0.011)
No benefit	0.1651***	0.1036*	0.0293***	0.0238
	(0.061)	(0.062)	(0.010)	(0.015)
Most convenient method of payment at point of sale				
Card chip and PIN	-0.0518	0.0193	-0.0105	0.0036
	(0.066)	(0.083)	(0.013)	(0.015)
Card tap and go	0.1181**	0.2498***	0.0226**	0.0517***
	(0.056)	(0.071)	(0.011)	(0.013)
Mobile	0.5203***	1.5346***	0.0857***	0.4639***
	(0.152)	(0.099)	(0.022)	(0.026)
Other	-0.0166	0.4493*	-0.0033	0.1017
	(0.241)	(0.245)	(0.048)	(0.065)

% monthly personal cash spending	-0.0027***	-0.0035***	-0.0005***	-0.0008***
	(0.001)	(0.001)	(0.000)	(0.000)
Revolver	-0.0168	0.2295***	-0.0031	0.0540***
	(0.046)	(0.037)	(0.009)	(0.009)
Debit card owner	0.2309*	-0.0633	0.0461*	-0.0144
	(0.118)	(0.147)	(0.025)	(0.034)
# of credit cards				
1	0.1463***	-0.2933***	0.0297***	-0.0637***
	(0.049)	(0.057)	(0.010)	(0.013)
2	0.2551***	-0.1120*	0.0501***	-0.0261*
	(0.054)	(0.058)	(0.011)	(0.014)
3+	0.4148***	0.1009	0.0773***	0.0254*
	(0.061)	(0.063)	(0.012)	(0.016)
Online purchase in past 3 months	0.3642***	0.2142***	0.0731***	0.0453***
	(0.034)	(0.056)	(0.007)	(0.010)
Primary financial institution				
Bank of Montreal	-0.0958	0.0790	-0.0186	0.0166
	(0.072)	(0.076)	(0.014)	(0.016)
Canadian Imperial Bank of Commerce	0.0644	0.1737**	0.0118	0.0379**
	(0.070)	(0.076)	(0.013)	(0.016)
Desjardins	0.0446	-0.0084	0.0082	-0.0017
	(0.083)	(0.090)	(0.015)	(0.018)
National Bank of Canada	0.1176	0.0976	0.0212	0.0207
	(0.107)	(0.116)	(0.019)	(0.025)
Royal Bank of Canada	0.0337	0.1851***	0.0062	0.0406***
	(0.064)	(0.068)	(0.012)	(0.014)
Scotiabank	0.0016	0.1611**	0.0003	0.0350**
	(0.071)	(0.076)	(0.013)	(0.016)
TD Canada Trust	0.0586	0.0789	0.0108	0.0166
	(0.064)	(0.070)	(0.012)	(0.014)
Direct banks	-0.0698	0.1690**	-0.0134	0.0369**

	(0.078)	(0.079)	(0.015)	(0.017)
Other FIs, excl. credit unions	0.0372	0.1257	0.0069	0.0269
	(0.106)	(0.119)	(0.020)	(0.026)
Time	-0.0061	0.0050	0.0029**	0.0012
	(0.020)	(0.006)	(0.001)	(0.001)
Age squared	-0.0002***			
	(0.000)			
Household income squared	-0.0012***			
	(0.000)			
Quebec x T	0.0183			
	(0.023)			
Ontario x T	0.0354			
	(0.022)			
Prairies x T	0.0019			
	(0.024)			
British Columbia x T	0.0221			
	(0.026)			
Constant	0.4835**	-0.7963***		
	(0.242)	(0.215)		
atanh ρ	-0.3303*			
	(0.197)			
ρ	-0.3188			
	(0.1768)			
Observations	23236		23236	

Note: Reference groups are Male (Gender), High school or less (Education), Employed (Employment), Atlantic (Region), Rural (Locality), North America (Ethnic origin), Born in Canada (Immigration), Single (Marital status), 0 (# of kids <18), Laptop/PC (Device used for survey), Cash (Convenience), 0 (# of credit cards), Other credit union (Primary financial institution). *Main benefits of cash*, *Revolver*, *Debit card owner*, and *Online purchase made in past 3 months* are binary variables. *Age*, *% monthly personal spending with cash*, *Household income*, and *Time* are continuous. CIBC is the Canadian Imperial Bank of Commerce. FIs are financial institutions. Estimation is implemented in Stata using the *heckprobit* module. Sample weights are used in these computations.

Factors that have the same directional effect on both stages

Many significant regressors have marginal effects with the same sign for both the selection equation and the outcome equation. In line with what we discussed earlier, both probabilities decrease with age and increase with income. A higher level of education is also correlated with a higher probability of mobile usage and mobile payment.

Stated preferences related to cash also show this pattern. Our baseline is a person who finds cash most convenient for in-store payments and considers cash beneficial, in particular, in terms of ease-of-use, safety, or acceptance. Compared to this baseline, the following preferences are positively associated with both mobile use and mobile payment: (i) rating contactless card payments or mobile payments most convenient for in-store payments, (ii) seeing no benefits to cash, and (iii) considering cash mainly as good for tipping, receiving cash discounts, controlling spending, or providing anonymity. Finally, both probabilities decline with the share of personal expenses paid with cash and increase for online shoppers.

Factors that have different directional effects on the two stages or are only significant in one stage

Other variables are significant in one stage and not the other. Employment and marital status matter significantly for mobile device use but not for mobile payment. Individuals not in the labour force are significantly less likely to use a mobile device than employed individuals. This is similar for singles relative to both married and divorced or widowed individuals. By contrast, male and female Canadians do not differ in terms of mobile use, but women make significantly fewer mobile payments than men.

Living in an urban versus a rural area also does not have a significant effect on whether an individual will use a mobile device, but it increases the probability of mobile payments. Higher merchant acceptance of mobile payments in urban areas could drive this result.

On the supply side, an individual's primary financial institution affects only mobile payment adoption. As documented in Table 1, financial institutions vary in their compatibility with AGS apps, and some of them also offer proprietary digital wallets that can be used to store digital versions of prepaid store cards. Furthermore, they may offer bank accounts and mobile management apps of differentiated quality.

We find that having a credit card is positively associated with smart device adoption. Explanations might be that signing up for a mobile phone plan is easier with a credit card and that post-paid mobile phone plans require a high

enough credit score.[17] Indeed, telecommunication companies commonly conduct credit checks before extending credit in the form of equipment and postpaid services. Several consumer advocacy groups view credit checks as social barriers (hence constraints) to wireless service access for some Canadians (CRTC, 2021, pp. 98–100). Conversely, mobile use can affect an individual's credit score, as mobile phone payments can be included in one's credit report, and payments made on time as well as late or missed payments can affect one's credit score (FCAC, 2016).

The relationship between credit card ownership and mobile paying reveals that mobile payments may be a substitute for credit cards for those without a credit card, while complementing credit cards for credit card owners. Owning one or two credit cards (as opposed to none) is significantly *negatively* correlated with mobile paying. Even though mobile payers own and use on average more credit cards (see Table 3), we thus obtain that, all else being equal, individuals who do not own a credit card are more likely to make mobile payments than individuals with one or two credit cards. However, among credit card owners, owning a greater number of credit cards is associated with using mobile payments. This can be seen by the increasing coefficients of the indicator variables for owning one, two, or at least three credit cards. A similar result is obtained from the model in Parlour et al. (2021). They find that fintechs benefit consumers who have barriers to accessing traditional banking services because these consumers gain access to electronic payments.

Mobile payments seem, therefore, to serve as substitutes for a first credit card, while they complement second and additional credit cards. As an explanation, individuals without credit cards might use online payment accounts or prepaid cards for online payments on their phone. They may also make in-store purchases with store-branded prepaid card apps. In the data, we indeed observe that they are more likely to hold and use prepaid cards than credit card owners. Owners of a single credit card might stick to conventional credit card usage, and multiple credit card owners may be interested in mobile payments.

Exclusion restrictions

As explained above, we follow Escanciano et al. (2016) and use differences in functional forms as an identification mechanism. In particular, we exploit non-linearities of the mobile use regression in age and income to identify our model (see Figure 2). Our results indicate that age squared and income squared

[17] We do not include credit ratings in the regression because they are not available over the whole observation period (2021Q1–2023Q1). However, we present credit ratings by consumer types in Table 7.

significantly affect mobile use, with the expected signs. We also confirm that, when included in the mobile payment regression, their coefficients are not significantly different from zero.

Figure 2 highlights the non-linear effects of age and income. We see that age is not constraining for mobile device access for individuals younger than 40. In other words, mobile device adoption rates do not change when comparing users who are 20 years old and 40 years old, but change significantly when comparing users who are 40 years old and 60 years old. Similarly for income: mobile adoption rates increase with incomes below $100,000 and are quite flat for higher incomes.[18]

Positive selection on observables

Overall, our results indicate a *positive* selection on observables. Observed characteristics of mobile device users tend to make their adoption rates of mobile payments *higher* than the potential adoption rates of mobile non-users. This can be seen in Figure 3, which shows the distribution of the predicted marginal probabilities of using mobile payment $\Phi(X_i\hat{\beta}_2)$ for mobile users (in blue) and non-users (in red). The predicted adoption rate of mobile payments for mobile non-users is 8.2% on average, compared with 20.5% for mobile users.

Negative selection on unobservables

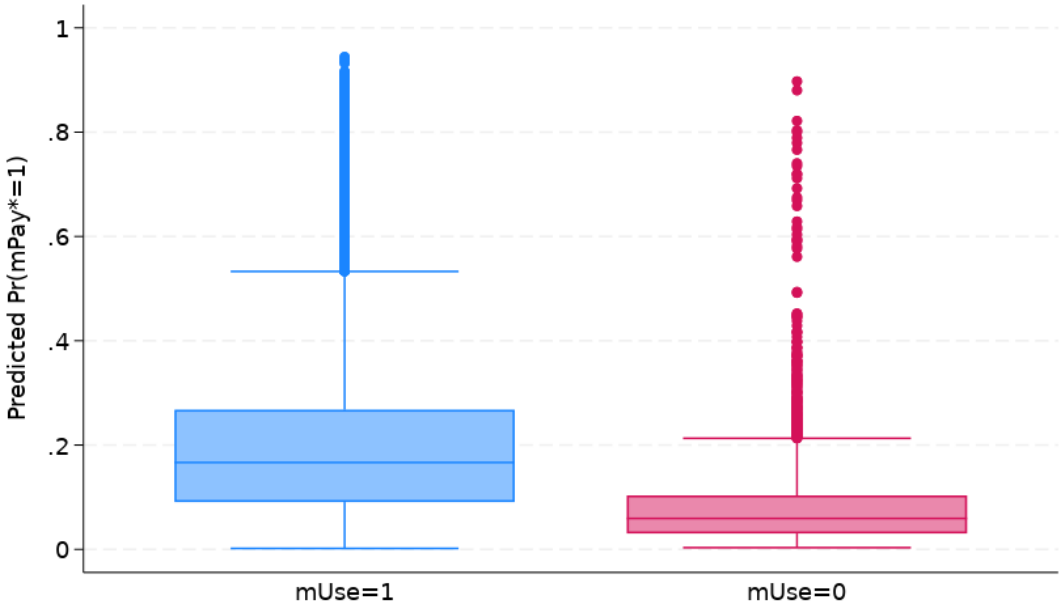
Our regression results also indicate significant negative selection on unobservables, given the negative correlation parameter ρ.

The parameter ρ measures the correlation between the unobserved error terms that affect mobile phone usage and mobile payment. In the maximum likelihood estimation, ρ is not directly estimated. The directly estimated parameter is atanh ρ, which has the same sign as ρ. Our estimation results indicate a significantly negative atanh ρ at the usual levels of significance.

We perform several robustness checks that confirm negative selection. That is, all else being equal, the propensity of individuals who use mobile phones to make mobile payments is *lower* than the hypothetical propensity of mobile non-users, had they a phone or another mobile payment enabling device.

[18] A plot of predicted probabilities corresponding to the fitted values in Figure 2 is available in the Appendix (Figure A1).

Figure 3: Predicted propensities of mobile users and non-users to make mobile payments: Observable characteristics of mobile non-users tend to lower their potential adoption rates of mobile payments



Note: Boxplots of the predicted probability of mobile payment adoption $\Phi(X_i\hat{\beta}_2)$ from the model with sample selection, over individuals with $mUse_i = 1$ (mobile users, in red) and with $mUse_i = 0$ (mobile non-users, in blue). Data are from the 2021Q1–2023Q1 DWPT. Sample weights are used.

Negative sample selection hints at characteristics of individuals, such as their preferences or the constraints they face, that we do not (fully) account for in our regression analysis and that have negative effects on their mobile phone adoption but a positive effect on their propensity to adopt mobile-type payments. Put differently, if two people with the same predicted probability of mobile adoption differ in the sense that one has a smartphone and the other one does not, the person without a smartphone is likely to have a stronger inclination to use mobile payments.

Negative selection is often found in the literature on technology adoption. Kongaut and Bohlin (2016) find negative values for ρ when modelling the use of smartphones for a specific purpose such as listening to music or using social networks, conditional on adopting a smartphone. Michels et al. (2020) also find a negative ρ when modelling mobile device adoption and mobile internet adoption. In the literature on payment choice, it is also common to find a negative sample selection in the empirical analysis of the adoption (extensive

margin) and usage (intensive margin) of a given method of payment (see, e.g., Lippi and Secchi, 2009; Schuh and Stavins, 2010; Hayashi and Stavins, 2012).

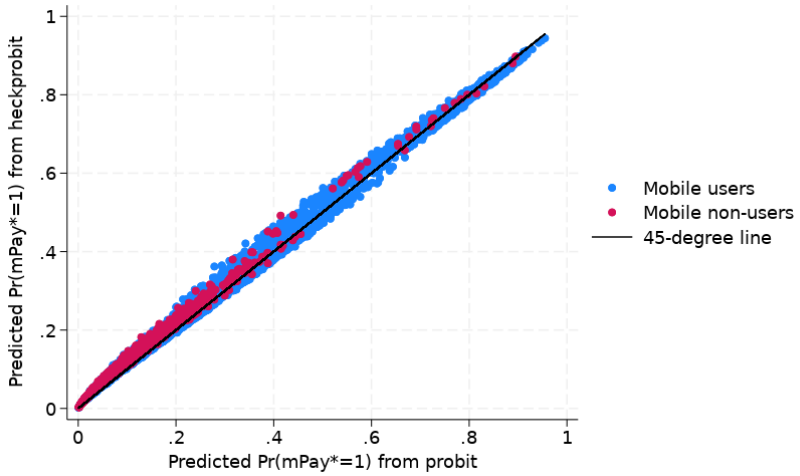
The implications of accounting for sample selection

Due to negative sample selection, ignoring the selection mechanism would lead to underestimating the propensity of mobile payment adoption in the Canadian population. On the one hand, accounting for sample selection corrects the parameter estimates of the mobile payment adoption equation (β_2 in Equation (2)). On the other hand, the non-zero correlation between the two equations brings differences between the unconditional and the conditional probability to mobile pay (conditional on the mobile-use status of individuals).

Figure 4 shows the predicted marginal probabilities of mobile payment adoption from our model with sample selection correction ($\Phi(\mathbf{X}\ \widehat{\boldsymbol{\beta}}_2^{heckprobit}$) on the y axis, against the predicted probabilities from a probit regression (estimated on mobile users), which does not account for selection ($\Phi(\mathbf{X}\ \widehat{\boldsymbol{\beta}}_2^{probit}$), for mobile users (in blue) and non-users (in red). The difference between the two models is that the estimated probit model holds for mobile users only, while the estimated model with sample selection holds for all individuals, whether mobile users or non-users.

The dots are scattered in a narrow band along the 45-degree line, indicating that the overall correction of the β estimates is small. Still, they are more concentrated above the 45-degree line, indicating that correction increases the estimated propensity to adopt mobile payments for most individuals. It is on average 20.5% and 8.2% for mobile users and non-users based on the heckprobit estimates, compared to 19.2% and 6.5% based on the probit estimates.

Figure 4: Predicted probabilities of adopting mobile payments with and without selection. Correcting the parameter estimates for selection increases the estimated propensity of adopting mobile payments for most individuals.

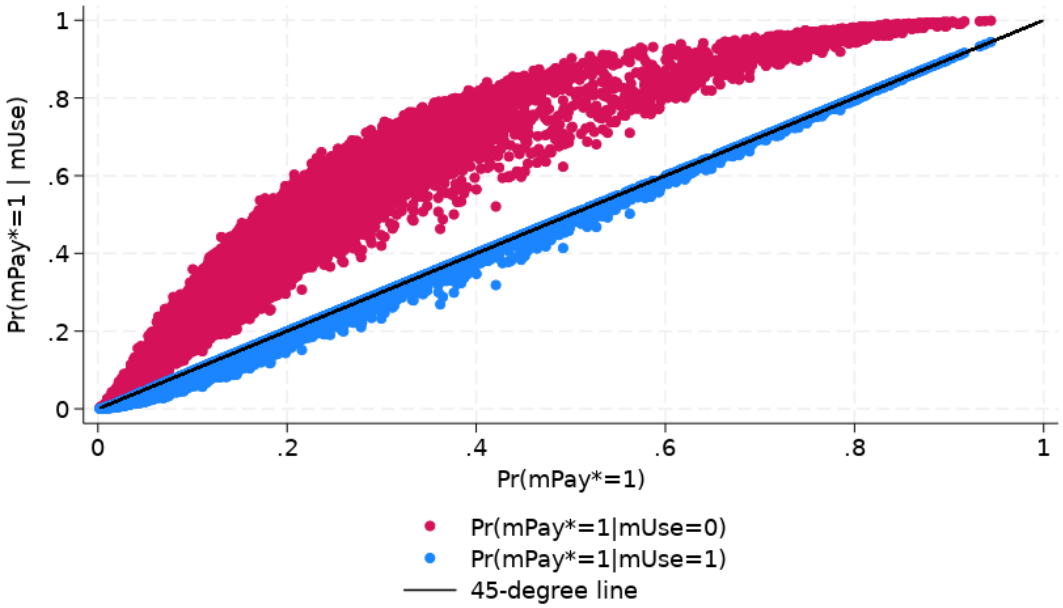


Note: This figure plots the predicted propensities of mobile payment adoption from the heckprobit model with selection ($\Phi(\mathbf{X}\ \widehat{\boldsymbol{\beta}}_2^{heckprobit})$ on the y axis against the predicted propensities of mobile payment adoption from a standard probit model estimated on mobile users ($\Phi(\mathbf{X}\ \ \widehat{\boldsymbol{\beta}}_2^{probit})$.

The probabilities in Figure 4 are marginal probabilities, $\Pr(mPay^* = 1)$, that differ only because of differences in the parameter estimates, $\widehat{\boldsymbol{\beta}}_{heckprobit}$ and $\widehat{\boldsymbol{\beta}}_{probit}$. By contrast, in Figure 5 we compare the predicted marginal probabilities of mobile payment and the conditional probabilities $\Pr(mPay^* = 1|mUse)$, which also account for the mobile usage status (mobile users or non-users).

Figure 5 clearly reflects negative sample selection: conditional probabilities of mobile payment are smaller than the unconditional ones for mobile users (in blue) and vice versa for mobile non-users (in red). The graph illustrates the size of the adjustment when we condition on mobile use status, due to the significant non-zero correlation term. The correction is also asymmetric: the red dots corresponding to the propensity to use mobile payments conditional on mobile non-use, $\Pr(mPay^* = 1|mUse = 0)$, are spread out far above the 45-degree line, while the blue dots corresponding to the propensity to use mobile payments conditional on mobile use, $\Pr(mPay^* = 1|mUse = 1)$, are spread along the line and just beneath it. This result demonstrates that important factors that explain the behaviour of mobile non-users are missing from the model.

Figure 5: Predicted propensities of adopting mobile payments with and without conditioning on the mobile use status: Mobile device non-users have a higher propensity to adopt mobile payments than mobile users, all else being equal



Note: This figure plots the predicted propensities of mobile payment adoption conditional on mobile use on the y axis against the predicted marginal propensities of mobile payments. All predictions are from the model with sample selection. Sample weights are used.

Table 6 presents the observed and predicted propensity of mobile users to use mobile payments, as well as the predicted propensity of mobile non-users to use mobile payments. We also compute the resulting predicted propensity to use mobile payments in the Canadian population by combining the observed adoption rates of mobile users and the predicted propensities of mobile non-users.[19] We also consider the scenario in which mobile non-users are considered to have zero propensity to use mobile payments; this is equivalent to using the observed mobile payment adoption $mPay_i$ instead of the predicted adoption $mPay_i^*$. We compare predictions obtained with and without sample selection correction for the entire population and specific demographic segments.

First, we observe that for mobile users, the predictions of our two-stage model as well as the probit model are close to observed adoption rates. For mobile

[19] A similar approach is used to compute true HIV prevalence rates in the presence of survey non-response (see, e.g., Bärnighausen et al. (2011)).

non-users, probit predictions and conditional heckprobit predictions differ noticeably. The former account only for selection on observables, while the latter also account for selection on unobservables.

On average, the predicted adoption rate among mobile non-users is 14.7%, slightly lower than the observed adoption rate of 19.5% among mobile users. This outcome results from the two opposite effects described above: mobile non-users have observables characteristics that make them relatively less likely to use mobile payments (due to positive selection on observables), and unobservables characteristics that make them relatively more likely to use mobile payments (due to negative selection on unobservables).

The heckprobit predictions are highest for mobile non-users in the 18–34 age category (44.6%), who are recent immigrants (46.6%), and who originate from Asia-Oceania (32.1%). For these segments, the predicted adoption rates of mobile non-users are much higher than the observed or predicted adoption rates of mobile users.

As a result, the average predicted adoption rate is 2.4 percentage points higher than the observed adoption rate in the Canadian population. By segment, the difference is large for individuals who are cash-only (4.6 pp), who do not own a debit card (4.3 pp), or who do not own a credit card (3.4 pp).

The breakdown by age is particularly relevant: For all three age groups considered (18–34, 35–54, 55+), the predicted adoption rates of mobile non-users are higher than the (observed or predicted) adoption rates of mobile users. Given this finding, we further explore differences between users and non-users by age segments in the next section.

Table 6: Observed and predicted propensities of mobile payment adoption: Without selection, we understate mobile payment adoption among mobile non-users

	Among mobile users			Among mobile non-users		In the population		
	Observed	Predicted without sample selection	Predicted with sample selection	Predicted without sample selection	Predicted with sample selection	Observed	Predicted without sample selection	Predicted with sample selection
Overall	19.47	19.21	19.23	6.55	14.73	16.36	17.61	18.79
Age								
18–34	30.18	30.89	**30.71**	23.64	**44.62**	28.51	29.93	30.71
35–54	20.05	20.74	**20.93**	10.01	23.06	18.40	19.37	20.26
55+	8.62	8.46	**8.45**	4.29	10.32	6.05	7.39	9.10
Gender								
Male	20.47	20.48	20.51	8.01	17.27	17.12	18.63	20.00
Female	18.51	17.99	17.99	5.06	12.14	15.61	16.61	17.61
Education								
High school or less	16.98	16.17	16.20	5.35	12.15	13.51	14.83	16.08
College	19.56	19.64	19.64	7.05	15.89	16.80	17.97	19.09
University	22.84	22.85	22.86	9.18	20.28	20.27	21.45	22.58
Employment								
Employed	23.07	23.01	23.00	11.40	24.45	21.00	22.17	23.18
Unemployed	20.23	20.52	20.54	8.16	18.66	18.15	19.19	20.10
Not in labour force	12.57	12.05	12.10	4.27	10.12	9.15	10.43	11.94
Household Income								
<$45K	16.19	15.13	15.08	4.91	11.11	12.37	13.83	15.13
$45K-85K	17.53	16.61	16.62	5.76	13.18	14.16	15.45	16.76
>$85K	21.67	21.89	21.93	8.82	19.54	19.31	20.41	21.46
Region								
Atlantic	20.10	20.11	20.11	5.30	12.49	16.69	17.78	18.91
Quebec	17.99	18.04	18.09	6.03	13.64	14.66	15.96	17.25
Ontario	20.10	19.70	19.70	7.37	16.07	17.03	18.37	19.55
Prairies	19.69	19.48	19.48	6.40	14.65	16.97	18.07	19.08
British Columbia	19.46	18.99	19.00	6.21	14.51	16.29	17.48	18.72
Locality								
Rural	14.40	14.42	14.45	4.46	10.82	11.56	12.52	13.72

Urban	20.20	19.96	19.97	6.99	15.54	17.04	18.25	19.51
Immigration								
Born in Canada	18.49	18.31	18.32	6.36	14.30	15.35	16.62	17.84
10+ years	20.65	20.72	20.72	6.98	16.03	17.67	18.92	20.06
<10 years	31.42	31.57	**31.55**	22.53	**46.62**	30.31	31.22	31.77
Ethnic origin								
North America	17.49	17.51	17.53	6.49	14.42	14.53	15.69	16.99
Europe	17.87	17.68	17.69	5.65	13.15	14.52	15.64	17.01
Africa, Latin America, and Caribbean	28.08	28.48	28.49	10.90	24.86	26.49	27.15	27.90
Asia-Oceania	26.13	26.16	**26.16**	15.91	**32.13**	24.43	25.51	26.49
Cash-only	0.00	10.85	10.88	5.21	11.85	0.00	1.87	4.26
Debit card non-owner	15.90	16.87	17.04	8.10	16.75	11.46	14.20	16.09
Credit card non-owner	19.03	19.92	19.97	7.74	16.24	15.18	17.16	18.57
Low digital literacy[a]	12.22	13.34	13.40	4.55	11.23	9.09	10.33	11.98

Note: All values in this table are reported as percentages. The *Observed* columns present adoption rates as observed in the data. The *Predicted without sample selection* columns present predictions from a standard probit model estimated on mobile users. The *Predicted with sample selection* columns present predictions from the heckprobit model; we use predictions conditional on the mobile use status. [a] Data are from the 2022Q3–2022Q4 DWPT. All other data are from the 2021Q1–2023Q1 DWPT. Sample weights are used.

6. Discussion

In this section, we propose several mechanisms that might explain the negative selection. In other words, we assess why mobile non-users do not use a smart device on a regular basis and why they might like to mobile pay. It should be noted that if we had reliable measures of the factors that inhibit smartphone adoption and facilitate mobile-like payment adoption in the DWPT data, we would have included them in the model. In Table 7 we present supporting empirical evidence based on additional variables from the data, which were not included in the regression because they are only available for part of the observation period.

Table 7: Additional evidence on differences between non-mobile users and mobile users, by age category: Younger non-users have financial constraints; older non-users have low affinity

		Age: 18–34		Age: 35–54		Age: 55+	
	Overall	Mobile non-users	Mobile users	Mobile non-users	Mobile users	Mobile non-users	Mobile users
Education							
High school or less	*42.3*	**59.1**	43.6	**42.6**	33.4	**55.9**	43.7
College	*30.4*	20.1	24.6	31.4	36.2	26.6	31.8
University	*27.3*	20.7	31.8	25.9	30.4	17.5	24.4
Household Income							
<$45K	*22.1*	**38.7**	25.5	**31.1**	15.4	**32.1**	19.9
$45K-85K	*27.6*	28.4	26.6	30.5	22.2	34.5	31.2
>$85K	*50.3*	32.9	48.0	38.4	62.3	33.5	48.9
Access to payment cards (%)							
Cash only (no other MOP)	*2.0*	**12.9**	1.9	8.8	1.4	3.5	0.9
DC owner	*97.9*	**88.3**	96.9	94.8	98.6	97.8	99.2
CC owner	*82.6*	**48.6**	75.0	**67.0**	84.2	84.4	90.8
Stated credit rating (%)[a]							
Poor	*3.8*	3.3	4.6	3.6	5.2	2.2	2.1
Fair	*6.1*	9.8	7.9	6.0	8.9	2.1	3.0
Good	*14.2*	17.6	19.6	14.0	17.1	7.7	8.6
Very good	*20.0*	22.7	24.4	17.3	20.4	17.0	16.8
Excellent	*43.4*	27.3	27.3	38.6	39.7	56.4	58.6
Not sure	*12.4*	**19.3**	16.2	**20.6**	8.6	**14.7**	10.9
Credit card debt and debt-to-income (DTI) ratio							
Revolver (%)	22.1	**32.9**	25.4	17.1	29.2	12.5	16.1
Average debt-to-income ratio	1.6	**3.0**	1.6	1.6	1.6	1.3	1.5
Perceived liquidity and debt (scores out of 10)[b]							
I have sufficient savings to cover emergencies.	*6.6*	**5.8**	6.3	6.1	6.0	7.3	7.3
I have sufficient savings to cover 6 months of living expenses.	*6.2*	5.8	5.7	5.9	5.4	7.3	7.0
I plan ahead on major expenses because I don't like to take out a loan.	*7.5*	**6.5**	7.1	7.5	7.2	8.2	8.1
Perceived technology literacy (scores out of 10)[c]							
People often ask me for my recommendations on new technology.	*4.5*	6.1	5.7	4.2	4.8	**2.7**	3.6
Perceptions regarding security/privacy							

How trustworthy is open banking to you? (scores out of 10)[d]	*3.9*	5.7	4.9	4.6	4.0	**2.8**	3.0
Benefits of cash:							
- Safe/avoids identity theft (%)	29.9	20.2	25.3	**32.1**	27.8	**36.1**	34.1
- Anonymous payment (%)	21.1	**19.4**	22.7	**19.0**	22.3	**17.2**	20.4
Online activities (%)							
Online shopping (with DC or CC)	*81.9*	87.1	91.0	77.3	87.0	**59.2**	77.5
Online banking	*66.9*	57.3	59.8	64.2	71.8	**63.2**	70.8
Allocation of monthly spending across telecom services (%)[c]							
Wireless service (total HH)	*40.5*	30.5	46.5	30.4	46.2	21.1	36.7
Home internet	*29.7*	**35.3**	30.4	31.2	29.9	31.3	27.9
Home phone	*7.2*	12.8	6.4	9.9	4.8	**14.0**	7.6
TV service	*19.1*	15.4	11.4	21.9	15.9	**31.4**	25.4
Home security/ automation	*3.5*	6.0	5.3	6.5	3.2	2.1	2.5
Household's wireless service providers[c]							
Bell, Rogers, Telus	*50.3*	39.8	44.9	49.6	53.5	49.9	52.3
Budget (chatr, Fido, Koodo, Lucky, PC, Public, Virgin)	*33.4*	**50.8**	37.6	36.1	30.2	33.9	32.2
Other regional (Eastlink, Fizz, Freedom, SaskTel, Shaw, Videotron, Xplore, Other)	*16.2*	9.3	17.5	14.2	16.3	16.2	15.5

Note: The *Stated credit rating* section reports percentages of responses to the question "How would you describe your current credit rating?" The average debt-to-income ratio is computed as the monthly debt payment of respondents who have debt divided by one twelfth of the midpoint of their annual income range. The *Perceived liquidity and debt (scores out of 10)* and *Perceived technology literacy* sections report average levels of agreement with each statement, where 1 is "Disagree strongly" and 10 is "Agree strongly." The question "How trustworthy is open banking to you? (scores out of 10)" reports average levels of trust, where 1 is "Not at all trustworthy" and 10 is "Extremely trustworthy," excluding "Don't know" responses. The *Allocation of monthly spending across telecom services* section is the household monthly spending across 5 telecom services, reported in proportions that add up to 100%, except for rounding errors. The *Household's wireless service providers* section reports the respondents' main provider, in percentages. [a] data are from 2022Q1–2023Q1; [b] data are from 2023Q1 only; [c] data are from 2022Q3–2022Q4; and [d] data are from 2022Q1–2022Q2. All other data are from the 2021Q1–2023Q1 DWPT. The latter variables, not available forthe entire observation period, were left out of the regression model. Sample weights are used.

The age distribution of mobile non-users is heavily skewed toward older individuals (Table 2 and Figure 2). As shown in Table 7, younger and older mobile non-users have in common a higher representation of less educated and lower income individuals. In all age categories, mobile non-users compared with users are also more likely to be cash-only individuals (have used no other payment method besides cash in the past three months) and less likely to own a bank account/debit card or a credit card.

Cash-dependent individuals, those with limited access to financial services, and financially constrained consumers may have difficulty obtaining a smartphone and a phone plan. Their credit history or the lack of it may play a role in their access to mobile services since most wireless carriers require a credit check for postpaid plans. Although prepaid plans have less stringent requirements, consumers may see disadvantages to them, such as untransparent billing and the expiry of unused balances (CRTC, 2021, p. 98). In Table 7, we do not observe major differences between the stated credit ratings (from poor to excellent) of mobile users and non-users. However, mobile non-users are more likely to answer that they do not know/are unsure of their credit rating, which could indicate a limited engagement with financial services (Collins et al., 2023) or privacy concerns. Individuals who are financially constrained may face additional affordability barriers due to the (still) high cost of mobile services in Canada.[20] Low-income Canadians spend a much higher share of their income on communication services than Canadians with higher income (CRTC, 2019).

Next, we discuss how different age segments may have different main reasons for not using a mobile device, as well as different reasons for wanting to use mobile payments.

Younger mobile non-users: Financially constrained with limited access to payment cards but digitally savvy and active

We find that for younger individuals, mobile non-users and users differ markedly in their payment choices and financial characteristics. Cash dependency is more pronounced among younger mobile non-users. For instance, in the 18–34 age category, 12.9% of mobile non-users are cash-only relative to 1.9% of mobile users. By contrast, in the 55+ years old category only 3.5% of mobile non-users are cash-only relative to 0.9% of mobile users. Likewise, the difference in the credit card ownership rate between users and non-users is 26.4 percentage points in the 18–35 category compared with only 6.5 percentage points in the 55+ category.

[20] See "Telecom services still too expensive, industry minister says."

As shown in Table 7, only younger mobile non-users appear more financially constrained than mobile users in the same age category: if they own a credit card, they are more likely to carry a revolving debt, and borrowers in this category have higher debt-to-income ratios. They are also less at ease with their level of indebtedness and savings. We observe that the youngest mobile non-users (18–35 years) significantly more often live in a household where the wireless service is provided by a budget carrier, as opposed to one of the large national telecommunication companies (Bell, Rogers, and Telus).

Young mobile non-users, on average, appear at ease with technology and do not exhibit security or privacy concerns. In fact, they are active online, and their first area of expenditure in terms of telecommunication technologies is internet at home. As shown in Table 6, we predict that mobile non-users in the 18–34 age category would massively adopt mobile payments if they had a phone: Their adoption rate would be around 45%, compared with an adoption rate of 31% observed among mobile users of the same age range. Once they have a phone, they may want to use it for in-store or online payments, at no additional cost. These individuals may benefit from mobile-like payments that do not require a bank account or a credit card, especially to make online payments. Indeed, as mentioned before, mobile payments might substitute for a first credit card.

Older mobile non-users: Low digital technology affinity or trust, with potential accessibility challenges

We find that for older individuals, mobile non-users and users differ markedly in their reported abilities and preferences. In the older age categories, mobile non-users rate themselves as being less tech savvy than mobile users (Table 7; "People often ask me for my recommendations on new technology"). This is especially true for individuals in the age category 55+, with an average rating of 2.7 (out of 10) for mobile non-users compared with 3.6 for mobile users. Older mobile non-users are also more concerned about safety or security. In Table 7, their lower rating of the trustworthiness of open banking could reflect this concern. They are also more likely to mention as a benefit of cash that it is safe/avoids identity theft. By contrast, mobile non-users in the 18–34 age category do not seem to share these security concerns. Mobile non-users of all ages do not report anonymity as an important feature of cash payments.

Older mobile non-users compared to older mobile users, are also significantly less likely to shop online or use online banking to pay for bills. Their first area of expenditure in terms of telecommunication technologies are TV services. They are also relatively more likely to have a home phone. Statistics Canada

research finds that being a senior is the strongest predictor of being a "non-user" or a "basic user" of the internet, after accounting for education and other characteristics that could confound the relationship between age and internet use (Wavrock et al., 2021). This could demonstrate both lower (digital) technological sophistication and/or low trust in the security of online transactions. Recent research by the Office of the Privacy Commissioner of Canada (2023) found that Canadians over 55 were more concerned about privacy than their younger counterparts. However, they were also among the least likely to actively protect their privacy online, which could reflect lower technological or digital knowledge.

Seniors could also face accessibility challenges due to physical, cognitive, and financial factors. Seniors are almost twice as likely to have a disability than are people of working age, and aging is typically accompanied by some cognitive decline (see, e.g., Agarwal et al., 2007). Even if mobile service providers offer accessibility related service and products, persons with disabilities and seniors can face challenges obtaining them (CRTC, 2023). Finally, while the population aged 55+ has higher net worth and a higher share of credit card owners, affordability barriers may amplify factors such as low technology affinity for low-income seniors who are at high risk of being marginalized by the digital divide (CRTC, 2019).[21]

As shown in Table 6, we predict that mobile non-users in the 55+ age category would moderately adopt mobile payments if they had a phone: Their adoption rate would be around 10%, thus slightly higher than the 8.5% adoption rate observed among mobile users of the same age range. Henry et al. (2023) provide evidence that technologically less savvy people may have access to a range of methods of payment, including payment cards, and yet have limited access to online payments. Older mobile non-users may therefore be interested in mobile-like online payments using a device suited to their personal needs and capabilities. Also, mobile payment apps could mitigate some of the limitations of individuals with cognitive challenges or disabilities. For example, Google Pay and Apple Pay contain accessibility features such as auditory navigation when selecting a card for payment and engaging in the payment, as well as a vocal payment amount confirmation. Voice-authenticated payments may also be more accessible for individuals with mobility disabilities compared to traditional authentication methods (Payments Canada, 2023).

[21] Identified as particularly vulnerable, low-income seniors are now eligible for special programs that provide access to low-cost Internet plans as well as computers.

Mobile non-users who are concerned that mobile devices pose a privacy risk because of tracking and lack of data protection could value the security or privacy offered by mobile payments through authentication procedures (including passwords and biometric identification) and tokenization. Chen et al. (2021) also suggest that privacy-concerned users may gradually develop digital demands and concerns about data privacy at the same time as they learn about these concepts.

Note that the unobserved sample selection could also, at least partly, arise from missing data. While some people might not use smartphones, they could use mobile payment apps or image scanning on PCs or tablets. The questionnaire does not capture this because only smartphone and smartwatch users are asked about mobile app payments. Consumers who print QR codes for use at the point of sale or use text messages on older-generation mobile phones would also not be observed in the DWPT data.

Additionally, we might not control for some supply-side constraints. For instance, there may be compatibility issues between bank account apps and the devices' operating system. Also, in 2022, 30% of mobile users (or about one quarter of the adult population) had a device without the NFC technology that is necessary for contactless mobile payments at the point of sale. In the DWPT data, advanced features of the mobile device such as the operating system or an integrated NFC chip, are unobserved, however.

Modelling these latent choice constraints might be possible if we had shifters for the demand for mobile devices (Agarwal and Somaini, 2022) such as variation in the market structure across time or region. Indeed, in the first stage of the model, region is a significant factor in mobile device use: residents of Ontario use mobile devices significantly less, especially compared with those living in the Prairie provinces (Table 5).[22] Accordingly, in 2017, the Canadian Competition Bureau (2017) found evidence for regional variation in the supply side of mobile services, namely that mobile wireless prices were lower in two of the Prairies provinces (Saskatchewan and Manitoba) compared with other regions (such as Ontario). This was attributed to greater competition in these two provinces.

[22] We thank Michael Sullivan (Western University, Ontario) for drawing our attention to the geographical variation in the structure of the wireless market across Canada,

7. Conclusion

Payments and payment-adjacent services are one of the most active areas of financial technology (BIS, 2017). Piggybacking on widespread adoption of mobile technology and a large population of the cohort known as digital natives, mobile phones have played an important role in the dispersion of fintech. At the same time, concerns arise about whether financial technology can be truly inclusive if those without mobile phones or lower technology affinity cannot access it.

In our regression analysis, controlling for selection into mobile phone adoption reveals unobserved preferences and/or characteristics that work against having a mobile phone and towards mobile paying. We present empirical evidence that providing access to payments with features similar to mobile payments to those without a mobile phone would result in usage rates exceeding the current use among mobile phone owners. Therefore, people who are unable to acquire or choose not to own a mobile device might have unmet payment needs. Providers and developers of payment innovations might therefore consider providing alternative channels in addition to smartphone apps. What is more, some mobile non-users (such as cash-dependent individuals) may be particularly affected if cash were to disappear (Henry et al., 2023).

In Canada, five out of six adults use a smartphone regularly. However, they have not started to use mobile payments at the same rate as other payment innovations such as contactless cards. Han and Wang (2021) observe that the US also lags many developing countries in using mobile payment innovations. They suggest that in countries where card payments are widespread, the incremental improvement introduced by the current mobile payment technology may not justify the costs of switching for consumers. In a recent study of US consumers, almost half of respondents found physical cards easier to use than cards in digital wallets (J. D. Power, 2023). The same study observes that emergence of contactless payments at the point of sale seems to work in favour of physical cards rather than digital wallets. However, Foster et al. (2024) report that US consumers use their mobile devices for payments at rapidly increasing rates and attribute this to online payments. In a study of Chinese consumers, Ho et al. (2022) show that steering mobile non-payers towards mobile paying at the point of sale might require substantial incentives, pointing to high switching costs.

Despite the potential of mobile payments, we find that their use is still in the early stages in Canada. Their impact on the Canadian retail payment landscape remains to be seen. We find that mobile wallets compete with other digital payments. However, if mobile payments induce a shift from physical wallets to

digital wallets, they could have a more significant effect on the demand for cash than contactless card payments alone.[23] It is, therefore, important to continue monitoring trends as the market and technologies develop.

[23] Using 2012 data from the US, Trütsch (2016) finds evidence that mobile payments do not replace physical payment cards but substitute for paper-based payment methods such as cash and cheques.

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Appendix

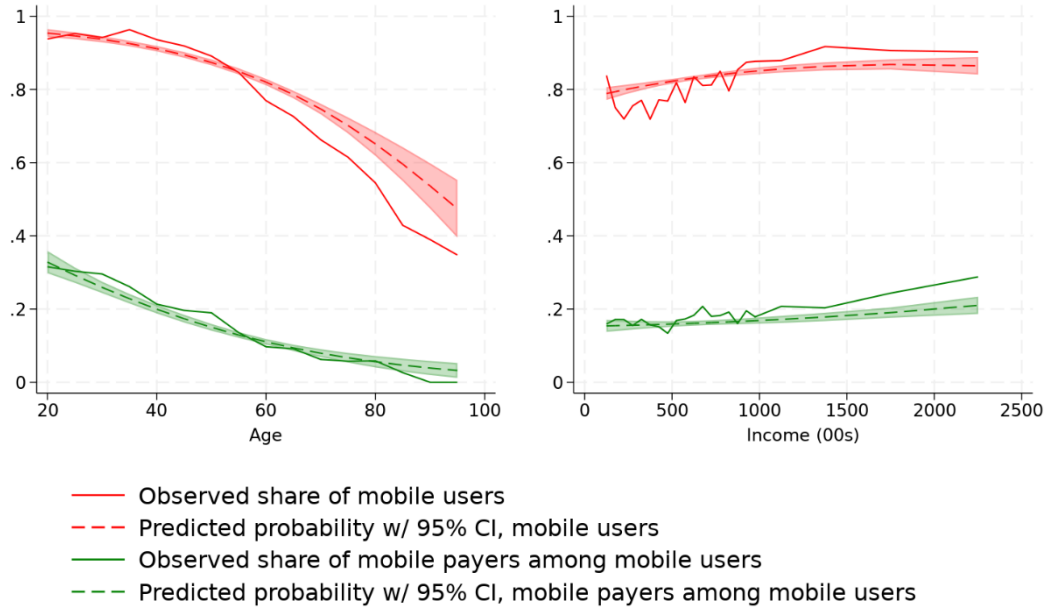
A. Table A1: Compatibility of major credit and debit card issuers with open mobile wallets (as of April 2023)

	Apple Pay	**Google Pay**	**Samsung Pay**
Credit and debit card issuers			
Royal Bank of Canada	Interac debit, credit cards	Interac debit cards, Mastercard credit cards, Visa debit cards	Interac debit, credit cards
Canadian Imperial Bank of Commerce	Interac debit, credit cards	Interac personal debit cards, any personal or small business Visa or Mastercard credit card, unless otherwise indicated, Simplii Financial Interac personal debit cards (excludes corporate, Petro-Points Mastercard, prepaid Visa cards)	Interac debit, credit cards
Bank of Montreal	Interac debit, credit cards	BMO personal debit cards, BMO Mastercard personal credit cards, Visa credit (excludes prepaid travel Mastercard, small business cards, Diners Club)	No
Bank of Nova Scotia	Interac debit, credit cards	Interac debit cards, Visa consumer credit cards, Visa prepaid cards, American Express credit cards (excludes Mastercard credit, Visa debit, Visa small business)	Interac debit, credit cards
National Bank of Canada	Interac debit, credit cards	Mastercard credit cards and debit cards (excludes prepaid and commercial cards)	No
Desjardins	Desjardins Access Card (Interac debit card), Visa and	Desjardins Access card (Interac debit card), Visa and Mastercard	No

	Mastercard credit cards, Visa prepaid cards (excl. commercial and business cards, Visa US cards)	credit cards, Visa prepaid cards (excludes commercial and business cards, Visa US cards)	
Toronto Dominion Bank	Interac debit, Visa credit cards	Yes (Since Oct 2023)	Interac debit, credit cards
Credit unions (e.g., Servus, Meridian, Coastal)	Interac debit	No	No
Credit card issuers			
PC Financial	Mastercard debit and credit cards	Mastercard debit and credit cards	No
Capital One	No	No	No
Peoples Trust	Yes	Mastercard consumer credit cards, prepaid, and rewards prepaid	No

Sources: ApplePay: https://support.apple.com/en-ca/HT204916; GooglePay: https://support.google.com/wallet/answer/12150258?visit_id=638182497041411740-1222005568&rd=1; SamsungPay: https://www.samsung.com/ca/support/apps-services/which-canadian-banks-and-credit-unions-are-supported-on-samsung-pay/.

Figure A1: Observed adoption and predicted probabilities by age and income



Note: The solid lines are observed shares of mobile users (red) and observed shares of mobile payers among mobile users (green). The dashed lines are predicted probabilities for mobile

use (red) and mobile pay among mobile users (green), obtained from separate probit models, shown with their 95% confidence intervals. For better visualization, we show averages over five-year bins. Data are from the 2021Q1–2023Q1 DWPT. Sample weights are used.

B. Calibration

In all our analysis, we use raking ratio weights to ensure that the final sample is representative of the target population. The weights are constructed following Chen et al. (2018) and Felt and Laferrière (2020).

We obtain the final weights by raking each quarterly sample on gender, age, region, education, marital status, and household income. The target population is Canadians aged 18 and older in the 10 provinces. We use 2020 population estimates from Statistics Canada as targets for gender, age, and region.[24] Remaining targets are from the 2016 Canadian census.

[24] Statistics Canada. Table 17-10-0005-01 "Population estimates on July 1st, by age and sex."