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Empirical Evaluation of CBDC in Cambodia

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Abstract

Cambodia is one of the two first countries that adopted retail CBDCs in October 2020. We conducted a survey in the summer of 2022, roughly two years after the introduction of the CBDC, called Bakong. Bakong is offered in two currencies, Khmer Riel and the US dollar, as Cambodia has been highly dollarized. We propose simple predictions on the usages of Bakong from the viewpoints of three kinds of substitutions: substituting paper money, bank deposits, and international currencies. While the first and the second effects are common to any CBDCs, the third one is specific to Bakong. Unlike typical local currency CBDC, US dollar Bakong may substitute Khmer Riel more. In our survey, we found some evidence for all these predictions.

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I. INTRODUCTION

A retail CBDC may substitute three existing "money," i.e., paper money, bank deposits, and foreign currencies. Depending on which substitution occurs, a retail CBDC could bring either benefits or costs to a country. We empirically investigate these substitution effects of a retail CBDC using an actual retail CBDC introduced in a prototypical developing country, Cambodia. Such empirical research exists few, if not none, to the best of our knowledge, at the time of our survey conducted in mid-2022, but designed in late 2021, about a year after Cambodia introduced its CBDC.[1]

Many seems to start with a naïve view on CBDC: Compared with paper money (M0), a retail CBDC is expected to lower the costs of issuing (or printing) for the authority once it is developed with some sunk costs. For the citizens, a CBDC should also bring more convenience to carry around, though anonymity and privacy may be lost depending on legal protections. Overall, a retail CBDC should be beneficial from the viewpoint of substituting paper money.

Compared with bank deposits (M1), a retail CBDC in practice asks people to possess transaction-purpose liquidity accounts at the central bank. This option of having a very safe central bank account should be quite attractive for a depositor who has such a liquidity account (e.g., a checking account) at a private sector bank, in particular, during a period of financial turmoil.

However, this would create a problem in both short and long run. In the short run, rapid money transfers from private sector banks to the central bank would create a massive banking crisis (Brunnermeier and Niepelt 2019; Keister and Sanches 2018). In the long run, a financial system without private sector banks implies, either the economy would lack any bank loans or rely on loans from the central bank (or the government).[2] If the former happens, the economy would result in lower growth with little financing for long-term investments (Diamond and Dybvig 1983). If the latter happens, the economy would resemble

[1] Due to COVID-19 pandemic, our implementation of survey was delayed at least a half year.
[2] Fernández-Villaverde et al. (2020) conder that the central bank can monopolize deposits and then let money lenders and investment funds take care of corporate finance, though I doubt if the social welfare is maximized in such a system. Chiu et al. (2019) argues in a country like Canada where a few big banks seem to enjoy oligopolistic rents, CBDC could be a good competitor in the market to lower such inefficiency.

that of the Soviet Union, which was quite inefficient. This concern about a retail CBDC substituting bank deposits seems a sufficient condition for preventing introduction of a retail CBDC, at least directly issued by the central bank.[3] More recent argument is to place CBDC as a part of all decentralized finance (DeFi), which is digital, distributed ledger, based finance system (Aquilina et al. 2023).

The third substitution could happen against foreign currencies. This is especially important for a small open developing country. As a typical developing country still relies substantially on seigniorage as a part of its fiscal revenue (Khan et al. 2023), keeping its local currency is important for the welfare of its citizens. This monetary sovereignty issue seems indeed well recognized in many countries when Facebook tried to issue Libra, and especially in Asian countries when China is experimenting with its retail CBDC with Alipay, which is a Chinese payment network, already set up in many Asian countries.[4] If it is threatened by the competition from a foreign currency (or a crypto-currency), a country could benefit from issuing a retail CBDC to defend its monetary sovereignty and keeping seigniorage.

Cambodia is a typical developing country, perhaps except that it has been suffering from de facto dollarization. While Bahama, the other country that adopted a retail CBDC around the same time, October 2020, uses Bahamian dollar (called Sand dollar in its CBDC form) that is pegged to the US dollar (i.e., a sort of de jure dollarization), Cambodia does not make its local currency, Khmer Riel, hard-pegged to the US dollar. Hence, Cambodia's case is de facto dollarization and interesting to see the CBDC's effects on substitution between the local currency and the international hard currency. Also, while Bahama is a small island country relying on tourism, Cambodia is a more typical developing country, which has been rapidly growing since the 1990s by industrialization though tourism seems also sizable (Figure 1).

The intrusion of the US dollar into Cambodia is quite large compared to any other South-East Asian country, or any other countries, which do not adopt the US dollar as the official

[3] Stable coins backed by the bank deposits, which is insured by the deposit insurance and (somewhat) by the lender of last resort function of the central bank, could be considered as an indirect retail CBDC as protected by the authority. This indirect retail CBDC would preserve bank deposits.
[4] Alipay is run under a private sector company, Alibaba. However, it has been said that a Chinese authority gained substantial control power on Alibaba in recent years.

currency.[5] This is perhaps due to the prolonged political and civil unrest. The unrest may be traced back in the late 1960s and ended only in the late 1990s. It brought the UN and international NPO activities coupled with the US dollars into the country.

By 2020, in Cambodia, about 80 percent of bank deposits are contracted in US dollars (USD, Figure 2). Anecdotal evidence suggests loans are also made in US dollars about the similar percentage. By the way, salaries are also mostly paid in US dollars by relatively large firms and foreign firms, while those are paid in the local currency, Khmer Riel, for government employees and small business workers (Hay 2020).

More importantly, in our survey in 2022, payments are also more than 60 percent done in US dollars. In an earlier survey conducted in the Autumn of 2020 in a similar manner (Hay 2020), the use of the local currency, Khmer Riel, is mostly concentrated in small transactions. It is implied by the prices quoted in KHR is relatively cheap in the survey for shops in Phnom Penh, the capital city (Figure 3). This is because the USD paper money (larger than or equal to one dollar) is circulating in Cambodia but not the USD coins. Still, there are many things that are sold under one US dollar. For those items, people need to use Khmer Riel.[6]

Here, we see one specific substitution effect of a retail CBDC, unique to Cambodia Bakong: Bakong may eliminate the use of the local currency, Khmer Riel, even more. The perverse effect of Cambodia Bakong stems from the fact that Bakong is issued in two currency units, KHR and USD. People can use USD Bakong even for smaller denominations than one dollar, for example, 25 cents. While we explain more about Bakong in the next section, we believe it important to note here that this specific substitution is opposite to the typical motivation of a small open country to issue a retail CBDC to defend its local currency against the US dollar, or any foreign currencies and cryptocurrencies.

In summary, we have three hypotheses, two of which are common to all the retail CBDCs, and one is unique to Cambodia's Bakong.

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[5] One of the authors of this paper, Hay, summarized well about Cambodia's de facto dollarization in his Ph.D. thesis (Hay 2020) under the supervision of the other author, Ueda. The description and figures on dollarization are largely based on it.

[6] Note that there is at least one other reason to use Khmer Riel lies in the supply side: The salaries of government employees are paid in Khmer Riel. As for the private sector, foreign firms and big local firms pay salaries in US dollars, while small local firms pay in Khmer Riel as described above already (Hay 2020).

- H1: Retail CBDC substitutes M0, paper money.
- H2: Retail CBDC substitutes M1, bank deposits (or more broadly private sector payment tools like debit cards and QR code-based payments)
- H3: Bakong substitutes Khmer Riel against the US dollar.

We find supporting results for all the hypotheses in logit analyses using our own survey. Note that those predictions, especially H1 and H2, are consistent with key theoretical papers described above as well as with many policy-oriented documents and academic reviews when the discussions became popular in 2018 to 2020 (e.g., Adrian and Griffoli 2019; Auer and Boehme 2020; BIS 2018, 2019; Boar, Holden and Wadsworth 2020; Griffoli et al. 2018; Townsend 2020; Yanagawa and Yamaoka 2019) and the discussions still continue (e.g., Khan et al. 2023; Aquilina et al. 2023; Ueda 2022). As for H3, again, it is specific to Cambodia. In any case, when we start the survey in October 2022, we do not find any empirical papers on wide-use retail CBDC based on a field survey.

II. BAKONG

The National Bank of Cambodia (NBC) officially launched the CBDC, called Bakong, on October 28, 2020. NBC began its CBDC project in 2016 with the inauguration of the Project Bakong, named after a temple of the ancient Khmer Empire. In 2017, the NBC selected Hyperledger Iroha, a blockchain platform that Soramitsu, a private company of Japan, maintains and develops for its retail CBDC.[7] The NBC and Soramitsu team collaborated for three years to implement the project Bakong.

The Bakong system is designed to upgrade a legacy interbank transfer system (FAST) by replacing its relational database with the Iroha distributed ledger, which is resilient by design against hardware failures, tampering, and cyberattacks.[8] In this sense, Bakong is also a wholesale CBDC, not only a retail CBDC. Note that a wholesale CBDC refers to a payment system used in interbank transfers. Traditional payment systems (of any countries) are known

[7] Soramitsu is led by founder Kazumasa Miyazawa, who spend many years in Sony and developed a contactless payment system (FeliCa), now widely used in Japan (e.g., SUICA) as well as worldwide (e.g., Apple's iPhone). However, Bakong is a QR code-based system, not a FeliCa based system.
[8] Iroba distributed ledger is developed by Soramitsu and donated to Hyperledger Project, which is a collection of open source blockchain applications.

to be costly and to take substantial time to complete a transaction. However, if using blockchain-based technology, it could transfer money rapidly and securely with little cost.[9]

Three official objectives of the Cambodian CBDC are listed as follows when it was introduced: (1) promoting the use of Cambodian Riel and reducing dollarization; (2) preventing the spread of COVID-19; (3) promoting financial system efficiency, resilience, and inclusion. They were mentioned by Chea Serey, director general of central banking at the NBC, during the launching ceremony as follows: "I hope the official launch of Bakong system today will help to promote social welfare and also prevent the spread of that disease through facilitating e-payment from person to person seamlessly without involving cash."

People who have smartphones can download the Bakong App at home to store digital KHR and/or digital USD wallets if they have (1) a national identity card; (2) a telephone number; (3) a current selfie photo to put in the system. Users of this mobile app can make payments and transfer money from their e-wallets by scanning QR codes or tapping their phone numbers.

By the way, many commercial banks in Cambodia had already introduced their own smartphone apps, similar to the Bakong App. People can use those private sector banks' apps to pay at shops. Also, people can use those private sector banks' apps to transfer money to other banks. For example, ABA bank has its own ABA App. People can use their smartphones to transfer money from ABA bank to another bank such as Acleda bank. In this case, the interbank transfer portion can be done through the wholesale part of Bakong, if chosen by senders over the traditional interbank transfer system (FAST). Cambodia introduced this wholesale Bakong at the same time of the retail Bakong.

From the retail users' point of view, Bakong App has 4 main functions. *Send, Receive, QR Pay,* and *Deposit*, in either KHR or USD.

a) *Send*: is used for transferring money to a receiver's Bakong account, by using the receiver's phone number.[10]

[9] Evaluating specific technology is beyond the scope of this paper and, as such, we cannot say this is always true.

[10] The fee structure of sending money is the following as of May 2023. No fee is charged for sending money from a Bakong account to another Bakong account. A fee of 0.5 USD is charged if the money transfer between 50 USD and 500 USD is done from an ABA bank account to a Bakong account. The fee varies by banks and

b) *Receive*: is used for receiving money from a sender. A receiver needs to show only his/her own QR code to the sender for making a transaction.
c) *Deposit*: is used for transferring money from a Bakong account to a bank account if the bank partners with the Bakong App system.
d) *QR Pay*: is used for paying money to the receiver by QR code by scanning the QR code of the receiver.

Among above four functions, (a), (b), and (c) are categorized as money transfers, which may use wholesale Bakong even by a transfer between the two commercial banks (i.e., (c) function). In this sense, users of Bakong, including the wholesale portion, is considered to be quite large. Indeed, it reached to half the population by the time of our survey (Nikkei Asia, January 4, 2022).[11]

However, its actual usage related to payments at retail shops (i.e., (d) function) is less known. Below, our analysis based on our own field survey focuses on the actual use of Bakong as a retail payment tool. By the way, functions (a) and (b), money transfers between two Bakong accounts can be also considered as retail CBDC. Later, we also investigate Bakong usage as a retail money transfer tool.

Note that, regarding the USD wallet of Bakong, NBC seems as if issuing the US dollar. Indeed, theoretically, it is creating USD liquidity in the same way as a commercial bank in the US, getting deposits of paper US dollars and giving depositors USD units in deposit accounts. Only a fraction of the received US dollars by a US commercial bank are deposited in the US Federal Reserve System as bank reserves ("fractional reserve banking"), and the USD deposit amounts less bank reserves are considered to be created by the commercial bank ("inside money"). NBC appears to operate the same way regarding the USD wallet of

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increases with the amount of money to be transferred. If the amount of money to be transferred is 700 USD from an ABA account to a Bakong Account, the fee is 1 USD. But, the fee is zero if the amount is less than or equal to 50 USD. Between two commercial bank accounts, for example sending money from ABA to Phnom Penh Commercial bank via the wholesale Bakong, a fee of 0.5 USD is charged if the amount is less than 500 USD. This fee increases with the amount of money to be transferred. If the amount is 600 USD to be transferred from ABA to Phnom Penh Commercial bank, the fee will be 1 USD.

[11] Recent figures do not show much difference. Most major financial institutions, namely 46 institutions, including commercial banks, specialized banks, microfinance institutions and payment service providers, have launched the Bakong payment system (Khmer Time, March 20, 2023). About 8.5 million accounts have been using Bakong e-wallets (The Phnom Penh Post, February 22, 2023). This is about half of the country's population, which is the same as Nikkei Asia (January 4, 2022), a year ago.

Bakong. The only difference seems that it has foreign reserves (presumably mostly in US treasury bonds) in its own hands, rather than bank reserves at the US Federal Reserve System.

Obviously, NBC is not a customer of the US Federal Reserve System, which plays the role of the lender of last resort, nor a member of the US FDIC. This implies a USD Bakong is not likely as stable as US commercial bank deposits. On the other hand, getting USD paper money in the hands of NBC, as much as it can do, may be regarded as a way of eliminating de facto dollarization in Cambodia, especially if the trust in USD Bakong eroded sometime in the future. However, these issues are beyond the scope of this paper, which focuses on the empirical evaluation of acceptance of the retail CBDC in Cambodia. For those interested in the above-mentioned stability issues, please see the companion paper (Ueda 2023).

III. SURVEY

Between July 2022 to August 2022, we conducted an online survey (though with some face-to-face interviews) for individuals, solicited through SNS services, mainly Facebook.[12] Survey includes many questions, on the use of Bakong App and other digital or electronic payments, as well as characteristics of individuals. The total sample size was 827.

By design, this is not a random sampling. Those who surveyed need to have access to the internet and are most likely to own smartphones. Those surveyed also need to understand what digital payments and Bakong are. They need to connect to major SNS services. Those requirements, perhaps, easy for people living in any advanced countries, but not so easy for those in developing countries like Cambodia.[13]

We ask 46 questions in the survey for individuals. Not all questions got many answers, especially detailed ones. For this paper, we utilize about a dozen questions which got

[12] The survey questions are jointly written by two authors, Ueda and Hay. The survey was managed by Hay with employing interviewers, who were mostly students at the National University of Battambang. By the way, we also conducted direct interviews with shop owners between March 2022 to April 2022, but we do not utilize much this portion in this paper. Note that, due to COVID-19 pandemic, these interviews were delayed from our original research plan.

[13] Besides the restrictions due to COVID19 pandemic, this was also one of reasons that we did not design our survey as random sampling.

sufficient amounts of answers. Table 1 shows definition of our variables. Table 2a shows key statistical summary of those variables and Table 2b shows correlations among them.

Notably, more than 1/2 of our sample has college degree (*Education* in Table 2a).[14] However, Cambodia as a whole, only about 10 percent of the population have college degrees according to the World Bank database.[15] This implies that our sample are quite skewed towards highly educated people, and thus that our results are likely biased towards more acceptance of any digital payment systems than population average. At the same time, if we selected sample randomly, sizable portion of them might not have access to financial services as well as to the internet, and also have difficulties to understand our questions regarding the use of digital payments and transfers.

Table 2a shows that those who prefer to pay in digital (*Digital Preference*) are about 30 percent, while those who have ever experienced to pay in digital (*Digital Experience*) are about 60 percent. Overall, 20 percent of our sample ever used *Bakong* for the retail payments. Again, this is likely to overestimate the use of *Bakong* in retail payments.

Note that our survey on shops, conducted separately in earlier 2022, shows that only 0.3 percent of 359 retail shops in Phnom Penh accepts Bakong Pay, the smallest among any digital payments. On the other hand, ABA Pay is most widely accepted at about 80 percent of shops and Acleda Pay is the second at about 40 percent of shops.[16] Any credit cards acceptance comes the third, at about 16 percent of shops, while Alipay is at the penultimate at 0.8 percent of shops.[17] Overall about 20 percent of shops do not accept any digital or electronic payments.

These results of the shop survey reflect that each "Pay" service usually requires a different QR code of the same shop shown at the store counter. For a typical traditional small shop, the

[14] Hereafter *capitalized and italicized* words are used for variables we used.
[15] At data.worldbank.org, we look at the variable named "Educational attainment, at least completed short-cycle tertiary, population 25+, male (%) (cumulative) – Cambodia," which is available for 2014 (8.5 percent) and 2015 (9.4 percent), originally comes from UNESCO Institute for Statistics. The tertiary school enrollment in 2021 is about 13 percent according to data.worldbank.org. Note that we accessed the World bank data site on May 25, 2023.
[16] ABA bank is a Canadian bank operating in Cambodia, while Acleda bank is a domestic bank.
[17] Alipay is provided by Ant Financial, a Chinese firm, a part of Alibaba group. We also include Apple Pay provided by Apple, an American firm, and Pay Pay provided by Softbank, a Japanese firm, as both are supposed to be active in Cambodia. However, no shops in our sample replied to accept those two payment tools.

counter is so small that can show only a few QR codes. On the other hand, a shop in a modern shopping mall could show more QR codes at its counter. Those modern shopping malls sell higher-priced goods compared to traditional markets or roadside shops, and thus may select naturally certain types of customers (e.g., richer and more educated).

In any payment tools, including paper money, those who are more likely to use the US dollar (*USD user* in Table 2a) compared to Khmer Riel is about 60 percent in our sample. This seems consistent with our shop survey, which reveals that about 40 percent of shops show price tags only in USD, about 30 percent in KHR, and about 30 percent in both USD and KHR.

Note that the *Bakong_USD* variable also captures USD users but only when using Bakong. Bakong USD users are about 2/3 (=0.134/0.197) of Bakong users. This is a bit higher than the general USD users (60 percent) described above. This is consistent with hypothesis H3, a perverse substitution effect of KHR over USD by Bakong.

Other variables in Table 2a show the characteristics of individuals. Due to our survey design, most people, about 80 percent, live in the capital city, *Phnom Penh*, an urban area. Others can be regarded as living in a rural area. *Male/Female* is self-explanatory, as well as *Age* variable. *Working* (about 70 percent) includes full-time students with paid jobs and excludes retired people. Again, the online questionnaires are disseminated originally from the university, full-time students (i.e., unemployed if without paid jobs) are likely overrepresented. *Public servants* are about 10 percent, excluding those who work for NPOs. While workers at (mostly international) NPOs and large companies are paid in US dollars, public servants are paid in Khmer Riel, naturally preferring retail payments in Khmer Riel.

IV. Logit Analysis on Retail Payments

A. Hypothesis H1 on Paper Money

Regarding hypothesis H1 (substitution of paper money by CBDC), although with quite a biased sample, we investigate if actual usage of any digital payments is different from preference and if Bakong users give more tendencies towards actual usage.

We first look at the preference to use digital payments by conducting the following logit model (H1.a). Table 3 column (1) shows the result.

Prob(Digital Preference) = Logit(Bakong users, USD users, Individual characteristics)

Then, we also look at whether the actual use of *Bakong* is associated with the use of any digital payments by conducting the following logit model (H1.b). Table 3 column (2) shows the result.

Prob(Digital Experience) = Logit(Bakong users, USD users, Individual characteristics)

In Table 3 column (1), most of our samples reply to those basic questions to construct the variables here, so 805 samples out of 827 are utilized. As predicted, *Bakong* users are more likely to prefer to use digital payments. This seems remarkable given the fact that Bakong is not accepted at many shops in our shop survey.

Table 3 column (2) shows the result with almost the same sample size, 800. Note that, we cannot directly test hypothesis H1. Instead, to assess hypothesis H1, we compare this result column (2) against column (1).

Like in Table 3 column (1), *Bakong* use is associated positively with digital payment *Experience* (column 2). Same as in column (1), the result seems consistent with a policy objective: Bakong can facilitate cashless transactions. However, we have to be aware that reverse causality may be a possibility, that is, people with a stronger *Preference or Experience* of digital payments use *Bakong* more (with likely other kinds of digital and electronic payments). The coefficient is almost twice stronger for *Experience* (column 2) than for *Preference* (column 1), so Bakong is likely to promote the actual use of any digital payments. Still, directly testing H1 is difficult.

However, an interesting picture emerges comparing *Preference* (column 1) and *Experience* (column 2) results by looking at individual characteristics. In Table 3 column (1), those who are *Educated, Working,* and *Public Servants* are more likely to prefer to use digital payments. *USD users* are especially fond of using digital payments as predicted. But, Table 3 column (2) show mostly similar but a slightly different result. Although *Educated, Working*, and *USD*

users are more likely to have *Digital payments Experience*, *Public Servants* are no longer the case. Also, younger (less *Aged)* people have more *Experience* to use any digital payments though no *Age*-dependent difference in *Preference*. In other words, older generations appear to feel some barriers to start using digital payment systems.

More importantly, living in *Phnom Penh* is strongly associated with the *Experience* of digital payments, though it does not affect the *Preference*. This implies the existence of some frictions in rural areas to financial inclusion regarding digital and electronic payments. As the economy develops and urbanization progresses, people in the current rural area are expected to use cashless payments much more than now when they see more shops accepting digital payments.

B. Hypothesis H2 on Private Sector Banking

Regarding hypothesis H2 (substitution of bank deposits by CBDC), as discussed already, we cannot investigate bank deposits directly but can look into the use of other payment tools that are linked to commercial bank deposits. Here, we investigate how Bakong users are different from users of any other digital payments that are led by ABA Pay and Acleda Pay.

Here, we focus on those who are using any digital payment tools. This gives us a smaller sample size of 484. Among them, some people use Bakong. Table 3 column (3) shows the result.

Prob(Bakong users in digital payment users) = Logit(USD users, Individual characteristics)

To assess hypothesis H2, we compare the column (3) results to column (2) results. Similar to any digital payment experience (column 2), more *Educated* people use *Bakong* more though *Working* status no longer matters in column (3). Also, *Age* dependency shows the opposite association. Older people tend to use Bakong more among digital payment users (column 3), although younger people are more likely to have experience using any digital payment tools (column 2) as described above.

More importantly, *Phnom Penh* dummy has a negative sign, though at a 10 percent level of significance, in column (3). This is also the opposite of column (2), experience with any

digital payment tools. In other words, among those who are already using (and able to use) digital payment tools, *Bakong* is more widely used in rural areas. For rural areas where fewer digital payment tools are available at shops, the Bakong payment system has been likely to be installed. Perhaps, there is less network externality established by ABA Pay or other private sector payment methods, and QR codes on shop counters are not so crowded in rural areas.

Overall, older people and rural people seem to use digital payments because they use Bakong. This result fills the gap between column (1) and (2) described already, that is, older as well as rural people do have similar preference to use digital payments but have less experience of actual usage. The result is consistent with a view that obtained in the previous section (discussion on hypothesis H1): older people and rural people tend to trust the central bank more than the private sector. Introduction of Bakong appear to encourage those people to use any digital payment tools. This is consistent with the policy agenda of financial inclusion regarding digital payments.

Yet another important result here is that USD users are not significantly associated with Bakong users among those who are already using any digital payment tools. USD users thus appear indifferent using Bakong or other digital payment tools.

C. Hypothesis H3 on US Dollar

In the end of discussions on hypothesis H2, we noticed that, among digital payment users, USD users treat Bakong indifferently among any other digital payment tools. A further question is that, if we focus on Bakong users only, whether USD users have different characteristics or not. We investigate this below as looking into hypothesis H3 (substitution of KHR by USD Bakong). As we focus on Bakong users only, sample size shrinks to 148 in the logit analysis below. The result is shown in Table 3 column (4).

Prob(USD Bakong users among Bakong users) = Logit (Individual characteristics)

Note that any tendencies we found for USD Bakong users may be just the same as USD users of any digital payment tools, like ABA Pay. So, to assess hypothesis H3, we conduct a companion logit analysis as below, focusing on those who have ever used digital payments,

the same focus group as in column (2) with sample size of 484. The result is shown in Table 3 column (5).

Prob(USD users) = Logit (Individual characteristics)

Importantly, *Phnom Penh* dummy has a significantly positive sign in both columns (4) and (5) of Table 3, thought the effect is somewhat stronger for *Bakong USD users*. However, unlike more general digitization of payment systems (discussion in H2), USD usage is difficult to predict from the coefficient on *Phnom Penh* dummy here.

The positive sign on *Phnom Penh* should reflect supply and demand effects. Firms in Phnom Penh may pay in US dollars more likely than in the rural area. This apparently creates more supply of USD liquidity for Phnom Penh citizens. It is difficult to predict if this tendency of paying wages in USD continues or not. However, this tendency, after correcting for other individual characteristics, should be theoretically the same for both Bakong USD users and general USD users.

As for the demand side, it may be likely to reflect the fact that more shops accept Bakong or any digital payments like ABA Pay in Phnom Penh than in rural areas. Many shops sell cheap items, which are priced below one US dollar. Also, a combined pay of several US dollars plus several hundred KHR is not an exception. As such, without digital payment tools, people need to use Khmer Riel paper money and coins, but with digital payment tools like Bakong and ABA pay, people can pay all in US dollars. This creates demand for USD-denominated Bakong and any other digital payments like ABA Pay more than USD paper money.

Table 3 column (4) shows that *Age* and *Education* are not significant, while column (5) shows their significantly positive coefficients. In other words, older and more educated people tend to use US dollars in general, but no such differences are found for Bakong USD users. This might be consistent with a policy objective: The introduction of Bakong might lower USD usage in the future. However, it is likely the opposite in a detailed look of the results. Younger and less educated people are using Bakong USD more than they do other payment methods. After all, Table 2a shows, as discussed already, that Bakong users tend to pay in USD more (68 percent) than the whole sample (60 percent USD users).

Note that wealth might be an issue here. Although *Working* status is controlled and thus income somewhat, wealth is not controlled due to no available data. As such, the young and less educated perhaps correlated with less wealth and, accordingly less use of US dollar bank accounts. Bakong accounts, unlike private sector banks like ABA bank and Acleda bank, may promote unbanked people to use more digital payment tools. However, it is not the case at least for education regarding general use of digital payments as well as Bakong as shown in column (2) and (3) of Table 3. Though somewhat true for younger people for general digital experience (column 2), but it is not the case for Bakong (column 3). As such, the wealth effect is difficult to be confirmed and applied to explain the USD usage.

One anomaly is a significantly negative association found for the *Public Servant* dummy for *Bakong USD users* (column 4 of Table 3). This might seem consistent with the fact that public servant wages are paid in Khmer Riel. However, if so, we should see such a significant coefficient for general USD users (column 5) and perhaps also for Bakong users, regardless of USD or KHR, (column 3). But, they are both insignificant. Together with the only positive significant coefficient is digital payment *Preference* (column 1), not *Experience* (column 2), public servants may indeed want to promote Bakong, especially KHR Bakong. But, why it appears only in Bakong usage, not in other digital payments (columns 2 and 5) is a puzzle.[18]

D. Looking at Differences

Unfortunately, we did not conduct a randomized experience on allocating Bakong, nor have panel data before and after the introduction of Bakong. However, *Digital Payment Preference* can be used as a reference point for actual *Digital Payment Experience* since their correlation is only about 0.5 (Table 2b).

Table 4 column 1 shows the result of a Logit estimation using the difference of *Experience* minus *Preference* as the dependent variable. The independent variables are the same as in Table 3 columns 1 and 2 described in the previous section. Notably, the use of *Bakong* is not significantly explaining the difference between *Experience* and *Preference*. However*, Phnom*

[18] One possible conjecture is that, perhaps, public servants might be more careful on selecting KHR when using Bakong than when using private sector payment methods. Note that, as described already, a Bakong account is linked to a national identity card.

Penh, Age, and *Working* are significant factors, as they would be expected by comparing the results of Logit regressions separately conducted for *Preference* (Table 3 column 1) and *Experience* (Table 3 column 2).

In other words, for Hypothesis 1, the overall results stay the same. Specifically, relative to the preference of using digital payments, living in *Phnom Penh* and *Working* fosters more actual uses of digital payments while *Age* seems a barrier to adopting digital payments. Here, *Bakong* does not appear influencing the actual use of digital payments beyond preference.

To see more carefully the effects of *Bakong* on the use of digital payments, presumably against paper money, we conduct a similar Logit analysis but now include interaction terms of all the independent variables and *Bakong*. Table 4 column 2 shows the result. For non-interaction terms, the results are essentially the same as in column 1 explained above. Two interaction terms are significant, *USD user*Bakong* and *Public Servant*Bakong*. Because *Bakong* users, by definition, have *Digital Payment Experience*, the negative coefficients of the interaction terms imply that they do prefer digital payments (the negative sign before *Preference* should be flipped with a negative coefficient). In other words, *Bakong* users who are also *USD users* prefer digital payments more. The preference for digital payments is also stronger for *Bakong* users who are *Public Servants*. In other words, *Bakong* appears to promote the use of digital payments, in particular among public servants and among USD users.

Regarding H2, substituting private financial services, we now look at only those who preferred to use digital payments. Among them, the question is who are actually using digital payments, especially Bakong. To be comparable to Table 4 column 2, we define the independent variable as *Experience – Preference* again, and show the result in Table 4 column 3. In this restricted sample, *Age* remained negative, though at 10 percent significance level, keeping showing an age barrier to adopt digital payment technology. *Phnom Penh* and *Working* are no longer significant while *Public Servant* turns positively significant at 10 percent level.

Importantly, among the interaction terms, *Age*Bakong* is the only variable that is significantly positive though at 10 percent level. This implies that *Bakong* promote older

people's use of digital payments against the age barrier found for digital payments tools in general. This is consistent with findings in the section B on H2.

Lastly, regarding H3 (substitution of KHR), we restrict the sample to those who use digital payments, and then look at the difference between *Bakong USD* users and general *USD users* for any payment tools. Note again that *Bakong USD users* are defined as those who use Bakong for payments, more often with USD wallets than with KHR wallets. We find one significant variable, which is *Phnom Penh*. This is consistent with section C above. However, other variables, that is *Age, Education*, and *Public Servants*, do not explain the difference between general USD users and Bakong USD users. Hence, *Phnom Penh* variable is more likely to be interpreted as a shortage of shops accepting *Bakong*, relative to other forms of digital payments, in rural areas, rather than wages payments.

V. LOGIT ANALYSIS WITH MONEY TRANSFERS

Our survey also includes questions about money transfers, similar to those about retail payments. The retail money transfer function may be more utilized because it is closer to the wholesale function of Bakong, which is undoubtedly successful as explained in the introduction. Indeed, the descriptive statistics (Table 2a) show about 25 percent of our sample use Bakong for retail money transfers while about 20 percent use Bakong for retail payments. As such, the retail payment function may be used with some delays by those who become accustomed to money transfers using Bakong directly.

Here, we test the following additional hypothesis regarding the effects of Bakong use in retail money transfers on Bakong use in retail payments:

- H1': Bakong use in retail money transfers accelerates H1 (retail CBDC to substitute M0, paper money).
- H2': Bakong use in retail money transfers accelerates H2 (retail CBDC to substitute M1, bank deposits)
- H3': Bakong USD use in retail money transfers accelerates H3 (Bakong to substitute Khmer Riel against the US dollar).

Regarding H1' and H2' on retail payments, we add the variable, *MTBakong*, which takes one if a person uses Bakong for money transfers. The result is shown in Table 5 columns 1 and 2. *MTBakong* is not significant in column 1 (H1) but it is positive at the 10 percent significance in column 2 (H2). Other coefficients are essentially not changed, except that Public Servant in column 2 (H2) becomes insignificant (from positive 10 percent significance).

In other words, H1' is rejected. People use Bakong more when transferring money, but they are not affected by these experiences when deciding to use Bakong in retail payments in general.

However, H2' is supported. The experience of Bakong in money transfers appears to persuade people to use Bakong more in retail payments for those who prefer to use any digital payment tools.

Regarding H3' on payments in USD versus KHR, we add the variable, *MTBakongUSD,* which takes one if a person uses USD Bakong more than KHR Bakong when transferring money. Again, we restrict the sample to those who use digital payments, and then look at the difference between *Bakong USD users* and general *USD users* for any payment tools. Note that the, among Bakong users in money transfers, USD is the dominant currency choice as it is chosen by 3/4 (=0.186/0.245) according to Table 2a.

Table 5 column 3 shows that *MTBakongUSD* is negative and statistically significant. So, H3' is rejected. Bakong USD in money transfers does not increase USD usage in retail Bakong payments. This may show a substitution effect in *Bakong USD* use between money transfers and retail payments. For example, those who (need to) transfer money to relatives in rural areas in USD Bakong may have less USD Bakong in hand to pay for retail shopping. By the way, as for other variables, before including *MTBakongUSD,* only one is significant, which is *Phnom Penh,* but now, *Working* and *Education* also become positive and significant to explain the difference between general USD users and Bakong USD users.

VI. CONCLUSION

We have three hypotheses, two of which are common to all the retail CBDCs, and one is unique to Cambodia's Bakong.

- H1: Retail CBDC substitutes M0, paper money.
- H2: Retail CBDC substitutes M1, bank deposits (or more broadly private sector digital and electronic payment tools)
- H3: Bakong substitutes Khmer Riel against the US dollar.

Although we could not test them with clear identification, we conducted logit analysis based on our own field survey conducted in summer of 2022. Sample size is about 800. It is not random and skewed towards Phnom Penh residents, highly educated, and those who have access to internet and SNS services. Still, we could say that we found some supportive evidence for all the above hypotheses.

Hypothesis H1 seems to hold: Bakong appears to promote digital payments against paper money. Experiences of any digital payment tools are skewed towards Phnom Penh and younger people, while preferences are not. Hence, some frictions are suspected regarding inclusion to digital payment systems, in particular, for older population and in the rural area. In such an environment, Bakong usage is strongly associated with digital payment experiences twice as much as preference, consistent with our conjecture that Bakong promotes digital payments. Moreover, Bakong users have more digital payment experience relative to their preference, if they are public servants or are customed to pay in US dollars in any forms.

Hypothesis H2 seems to hold: Bakong appears to appeal to those who are not typical users of other (private sector) digital payment tools. This is implied by our finding that characteristics of Bakong users are quite different from those who have used any forms of digital payments. In particular, among those who have ever used any forms of digital payments, Bakong reaches more to rural areas and older populations, easing frictions to inclusion. Even after considering preference for digital payments, the age barrier to actually use digital payments is lowered with Bakong.

Hypothesis H3 is difficult to reject: Regarding dollarization, Bakong does not seem improving the situation. The usage of USD Bakong relative to KHR Bakong is higher than the general tendency of USD usage in any retail payments. In particular, USD Bakong are used by the young and less educated, who are not typical users of US dollars.

A puzzle remains that the public servants use USD Bakong much less than general population. This may not be a puzzle given their salaries are paid in Khmer Riel. However, they do not show any difference from other populations in choosing US dollars in other forms of retail payments.

However, Phnom Penh appears as the only significantly positive factor to explain differences between Bakong USD users and general USD users in any digital payment tools. Hence, a shortage of shops accepting *Bakong*, relative to other forms of digital payments, in rural area, is acting like a barrier rather than wages payments. In other words, more acceptance of Bakong by shops would accelerate more usage of US dollars.

Bakong is said to be used widely in wholesale interbank transfers. It is thus not surprising that Bakong is used (a bit) more also in retail transfers. And, we find evidence that such Bakong use in money transfers seem to accelerate the adoption of Bakong in retail payments against other digital payment tools, provided by private financial institutions. However, Bakong USD use in money transfers does not accelerate dollarization in Bakong retail payments.

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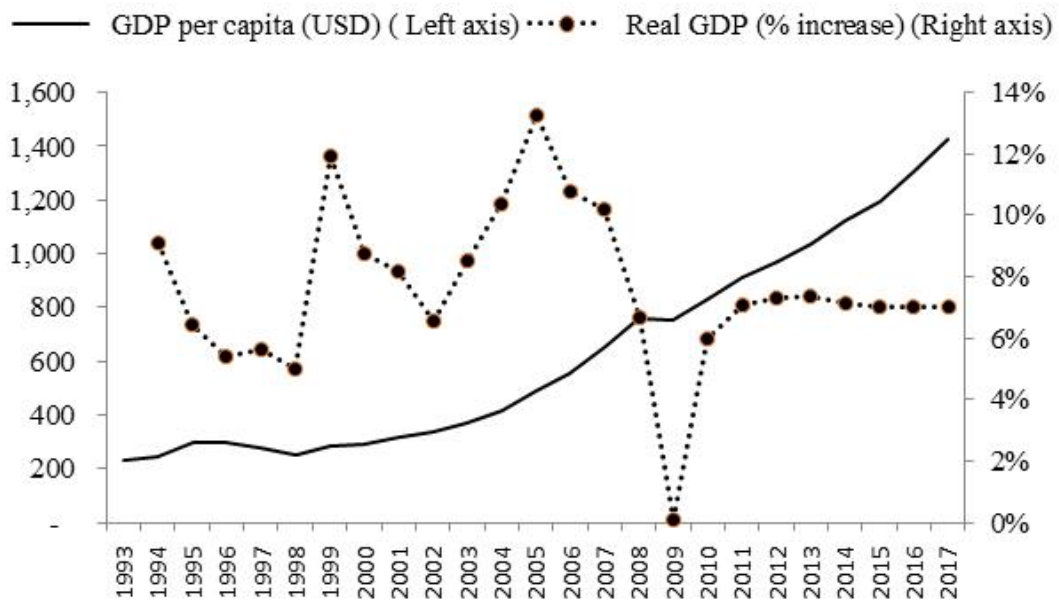
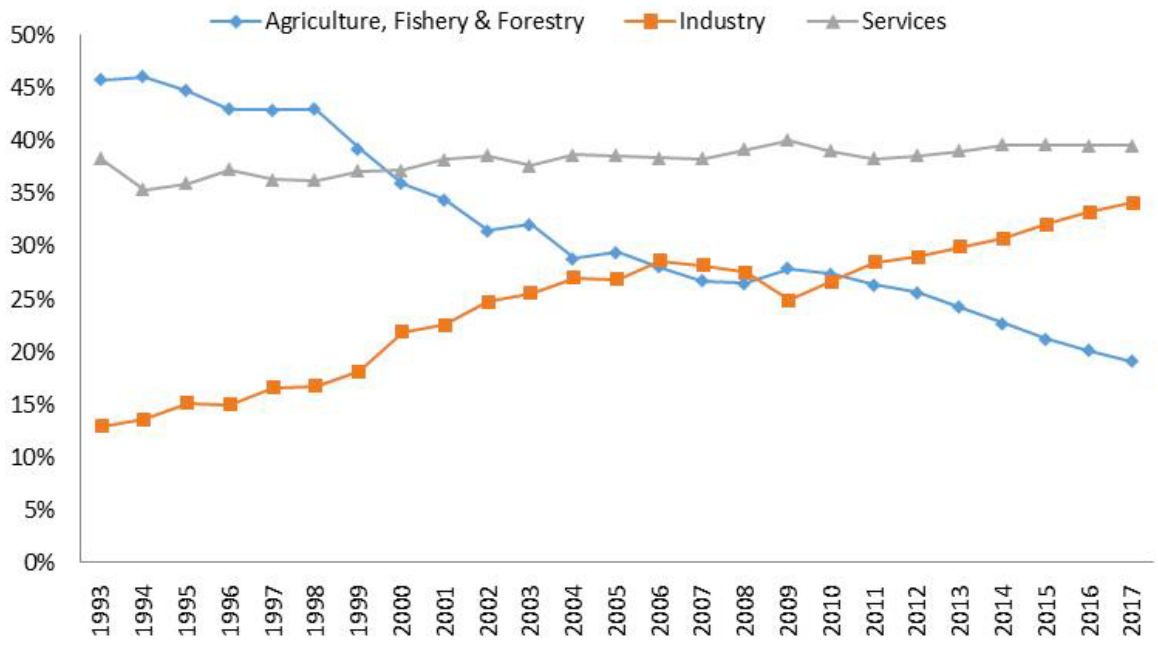
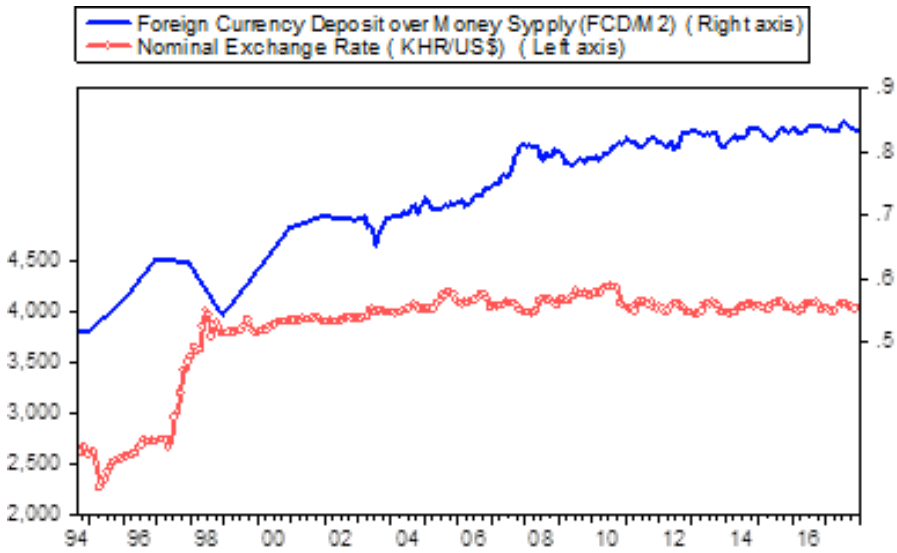
Figure 1. Cambodia's GDP per capita, Real GDP Growth, and Industry Shares in GDP





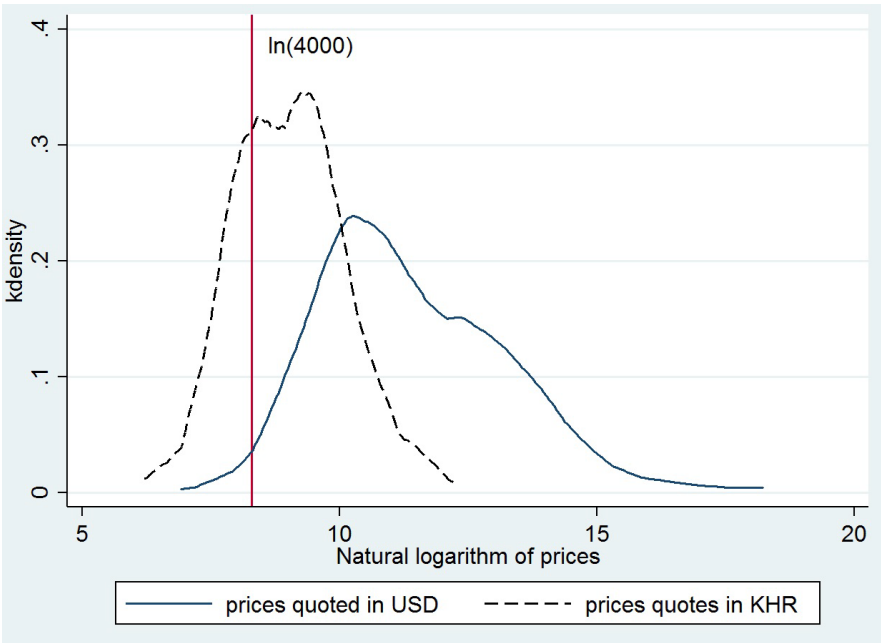
Source: Ministry of Economy and Finance, Cambodia

Figure 2. Dollarization and exchange rate



Source: The National Bank of Cambodia

Figure 3. Prices quoted in USD and KHR in Shops in Phnom Penh



Source: Hay (2020).

Note: The red line shows 4000 KHR, which is about one USD.

Table 1 Definition of Variables

Name	Definition
USD user	*Dummy, defined "1", USD or Equally convenient; "0" Khmer Riel.*
Digital Preference	*Dummy, defined "1" if respondent prefer digital payment; "0" for cash or indifference.*
Digital Experience	*Dummy, defined "1" if purchasing goods and services, ever used digital payment; "0" otherwise.*
Bakong	*Dummy, defined "1" Bakong users any response for questions on currency preference; "0" otherwise.*
Bakong USD user	*Dummy, defined "1", Bakong users who perfer USD; "0" otherwise.*
MTBakong	*Dummy, defined "1" Bakong uses any response for questions on currency preference in money transfers; "0" otherwise.*
MTBakongUSD	*Dummy, defined "1" Bakong users for money transfer in USD; "0" otherwise.*
Phnom Penh	*Dummy, defined "1", if respondent identifies a place he/she stays as a "Phnom Penh" (used as a proxy for urban area identification); "0" - "Not in Phnom Penh" (rural).*
Male/Female	*Dummy, defined "1" for male and "0" for female.*
Age	*Actual value variable defines age of respondent. It ranges between 16-72.*
Working	*Dummy, defined "1", for all categories of respondents who has paid job, including: Paid employee or worker, Employer or Manager, Self-employed or business owner, Full time student with paid job, Farmer; "0" for all other categories.*
Public Servant	*Dummy, defined "1", Public Institutions; "0" otherwise.*
Education	*Dummy, defined "1", if respondent hold PhD, master or Bechelor Degree; "0" otherwise.*

Sourse: Survey on dollarization and digitalization in payment in Cambodia

Table 2a Statistical Summary of Variables

	Obs	Mean	Std. dev.	Min	Max
USD user	826	0.613	0.487	0	1
Digital Preferences	817	0.297	0.457	0	1
Digital Experience	813	0.592	0.492	0	1
Bakong	827	0.197	0.398	0	1
Bakong USD user	827	0.134	0.341	0	1
MTBakong	827	0.245	0.431	0	1
MTBakongUSD	827	0.186	0.390	0	1
Phnom Penh	827	0.819	0.386	0	1
Male/Female	826	0.414	0.493	0	1
Age	822	31.082	11.761	16	72
Working	825	0.728	0.445	0	1
Public Servant	827	0.104	0.305	0	1
Education	821	0.553	0.497	0	1

Sourse: prepared by author, based on the survey on dollarization and digitalization in payment in Cambodia.

Table 2b Correlation of Variables

	USD user	*Digital Preference*	*Digital Experience*	*Bakong*	*Bakong USD user*	*MTBakong*	*MTBakong USD*	*Phnom Penh*	*Male/ Female*	*Age*	*Working*	*Public Servant*
USD user	1											
Digital Preference	0.2603*	1										
Digital Experience	0.3255*	0.4750*	1									
Bakong	0.1675*	0.3385*	0.3357*	1								
Bakong USD user	0.1895*	0.3437*	0.2975*	0.7947*	1							
MTBakong	0.1749*	0.3284*	0.3002*	0.7627*	0.6079*	1						
MTBakongUSD	0.2403*	0.3026*	0.3342*	0.7078*	0.6773*	0.8387*	1					
Phnom Penh	0.2280*	0.0507	0.1852*	0.0202	0.0749*	0.057	0.0720*	1				
Male/Female	0.0336	0.0602	0.1240*	0.0958*	0.0291	0.1082*	0.0835*	0.1218*	1			
Age	-0.0291	-0.1036*	-0.2301*	-0.0611	-0.0312	-0.1087*	-0.0526	-0.1295*	-0.0930*	1		
Working	0.0695*	0.0746*	0.1381*	0.0136	0.0711*	-0.001	0.0809*	-0.1253*	-0.0357	0.1098*	1	
Public Servant	0.0730*	0.2256*	0.1834*	0.2096*	0.1099*	0.1831*	0.0914*	-0.0144	0.0874*	0.0824*	0.0704*	1
Education	0.2547*	0.3771*	0.4283*	0.3577*	0.2889*	0.3809	0.3359*	0.2220*	0.2050*	-0.4320*	-0.2129*	0.2251*

* indicates 5 percent level of significance

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Table 3. Logit on Retail Payments – Benchmark

	Digital Preference	*Digital Experience*	*Bakong*	*Bakong USD*	*USD users*
	(1)	(2)	(3)	(4)	(5)
Bakong	1.048***	1.942***			
	(4.911)	*(5.459)*			
USD user	0.878***	0.911***	0.330		
	(4.180)	*(4.977)*	*(1.243)*		
Phnom Penh	-0.186	0.722**	-0.791*	1.553**	1.258***
	(-0.708)	*(2.923)*	*(-2.392)*	*(2.915)*	*(4.105)*
Male/Female	-0.103	0.039	-0.001	-0.646	-0.298
	(-0.560)	*(0.211)*	*(-0.005)*	*(-1.571)*	*(-1.335)*
Age	-0.004	-0.0257**	0.0379*	0.041	0.0592***
	(-0.429)	*(-2.789)*	*(2.572)*	*(1.488)*	*(3.552)*
Education	1.597***	1.452***	1.933***	0.549	0.972***
	(6.491)	*(6.298)*	*(5.608)*	*(0.766)*	*(3.626)*
Working	0.721***	1.534***	-0.163	1.141*	0.733**
	(3.339)	*(6.724)*	*(-0.604)*	*(2.424)*	*(2.723)*
Public Servant	0.768**	0.782	0.446	-1.597**	(-0.628)
	(2.727)	*(1.896)*	*(1.527)*	*(-3.237)*	*(-1.823)*
const.	-3.046***	-2.127***	-2.980	-2.084	-2.711***
	(-6.567)	*(-4.829)*	*(-4.839)*	*(-1.770)*	*(-4.313)*
Obs.	*805*	*800*	*484*	*148*	*484*
Prob > chi2	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*
Pseudo R2	*0.217*	*0.285*	*0.108*	*0.156*	*0.086*

*z statistics in parentheses: * p<0.05, ** p<0.01, *** p<0.001*

Table 4. Logit on Retail Payments – Looking at Differences

	Digital Experience − Preference	*Digital Experience − Preference*	*Digital Experience − Preference (for Preference=1)*	*Bakong USD user − USD user*
	(1)	(2)	(3)	(4)
Bakong	-0.070	1.188	-19.180	
	(-0.335)	*(1.036)*	*(-2,026.000)*	
USD user	0.147	0.352	-1.414	
	(0.843)	*(1.812)*	*-(0.878)*	
Phnom Penh	0.817***	0.809**	-0.363	0.917**
	(3.311)	*(2.827)*	*-(1.353)*	*(3.159)*
Male/Female	0.251	0.266	0.070	0.069
	(1.565)	*(1.450)*	*-(0.869)*	*(0.361)*
Age	-0.0320***	-0.0335***	-0.158*	0.008
	(-3.563)	*(-3.348)*	*-(0.094)*	*(0.660)*
Education	0.289	0.274	-	-0.380
	(1.419)	*(1.238)*		*(-1.628)*
Working	0.651**	0.838***	1.591	0.176
	(3.285)	*(3.625)*	*-(1.243)*	*(0.729)*
Public Servant	0.028	0.404	1.679*	-0.143
	(0.102)	*(1.126)*	*(-0.940)*	*(-0.506)*
*USD user * Bakong*		-1.379**	-1.100	
		(-2.908)	*(-1.799)*	
*Phnom Penh * Bakong*		0.023	16.260	
		(0.038)	*(-2,026.000)*	
*Male/Female * Bakong*		-0.246	0.201	
		(-0.609)	*(-1.669)*	
*Age * Bakong*		0.021	0.233*	
		(0.838)	*(-0.139)*	
*Education * Bakong*		0.038	-	
		(0.053)		
*Working * Bakong*		-0.770	-2.874	
		(-1.586)	*(-2.093)*	
*Public Servant * Bakong*		-1.162*	-	
		(-1.967)		
const.	-1.316**	-1.561***	1.101	-0.591
	(-3.235)	*(-3.356)*	*(-2.308)*	*(-1.160)*
Obs.	*792*	*792*	*177*	*484*
Prob > chi2	*0.000*	*0.000*	*0.156*	*0.124*
Pseudo R2	*0.0562*	*0.073*	*0.1918*	*0.0218*

*z statistics in parentheses: * p<0.05, ** p<0.01, *** p<0.001*

Table 5. Logit on Retail Payments – including Bakong Use in Money Transfers

	Digital Experience − Preference	*Digital Experience − Preference*	*Digital Experience − Preference (for Preference=1)*	*Bakong USD user − USD user*
	(1)	(2)	(3)	(4)
Bakong	0.018	1.240	-21.108	
	(0.060)	*(1.070)*	*(-0.012)*	
USD user	0.150	0.353	-1.147	
	(0.860)	*(1.820)*	*(-1.269)*	
MTBakong (Bakong Use in Money Transfers)	-0.114	-0.090	1.608*	
	(-0.410)	*(-0.320)*	*(1.688)*	
MTBakongUSD (Bakong USD Use in Monety Transfers)				-1.005***
				(-4.870)
Phnom Penh	0.820***	0.812**	-0.793	0.893***
	(3.320)	*(2.840)*	*(-0.567)*	*(4.450)*
Male/Female	0.253	0.267	0.054	0.043
	(1.570)	*(1.450)*	*(0.060)*	*(0.280)*
Age	-0.0320***	-0.0336***	-0.180*	0.008
	(-3.570)	*(-3.350)*	*(-1.849)*	*(1.150)*
Education	0.299	0.282	0.000	0.639***
	(1.460)	*(1.260)*	-	*(3.330)*
Working	0.653***	0.839***	1.282	0.360*
	(3.290)	*(3.630)*	*(1.041)*	*(2.070)*
Public Servant	0.031	0.410	1.419	0.052
	(0.110)	*(1.140)*	*(1.469)*	*(0.200)*
*USD user * Bakong*		-1.373**	-1.232	
		(-2.890)	*(-0.670)*	
*Phnom Penh * Bakong*		0.022	16.417	
		(0.040)	*(0.009)*	
*Male/Female * Bakong*		-0.243	0.270	
		(-0.600)	*(0.009)*	
*Age * Bakong*		0.021	0.247*	
		(0.840)	*(1.725)*	
*Education * Bakong*		0.049	0.000	
		(0.070)	-	
*Working * Bakong*		-0.770	-2.514	
		(-1.590)	*(-1.204)*	
*Public Servant * Bakong*		-1.171*	0.000	
		(-1.980)	-	
const.	-1.317**	-1.559***	1.823	-1.374***
	(-3.240)	*(-3.350)*	*(0.743)*	*(-3.770)*
Obs.	*792*	*792*	*177*	*484*
Prob > chi2	*56.230*	*72.920*	*19.562*	*52.950*
Pseudo R2	*0.0564*	*0.0732*	*0.223*	*0.047*

*z statistics in parentheses: * p<0.05, ** p<0.01, *** p<0.001*