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The Journey to Less-Cash Society: Thailand's Payment System at a Crossroads

by

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Abstract

Digital technology is changing the way we transact and pay each other, but cash usage remains dominant in many countries. In Thailand, it remains a question whether and to what extent electronic payments (e-payment) can replace cash. What is the role of a central bank amid challenges and opportunities at this crossroads? The paper explores global trends in cash and e-payment and outlines Thailand's existing retail payment landscape. Both physical and IT/ICT infrastructure are assessed at micro-level with regard to Thailand's readiness to move away from cash. However, given coexistence of cash and e-payment at present, we explore ways in which efficiency of cash management process can be improved. Data on cash distribution by geographical area are utilized to illustrate usage of Thai consumers and identify costs and inefficiency associated with cash management. On the other hand, adoption of e-payment can play a critical role in moving toward a less-cash society, if not a cashless one. The paper highlights the latest data on e-payment behavior in Thailand, especially PromptPay transactions as well as mobile/internet transactions after the transfer fee reduction in March 2018.

Keywords: Cash, payment transactions, cashless
JEL classification: D12, E42, G28, O33

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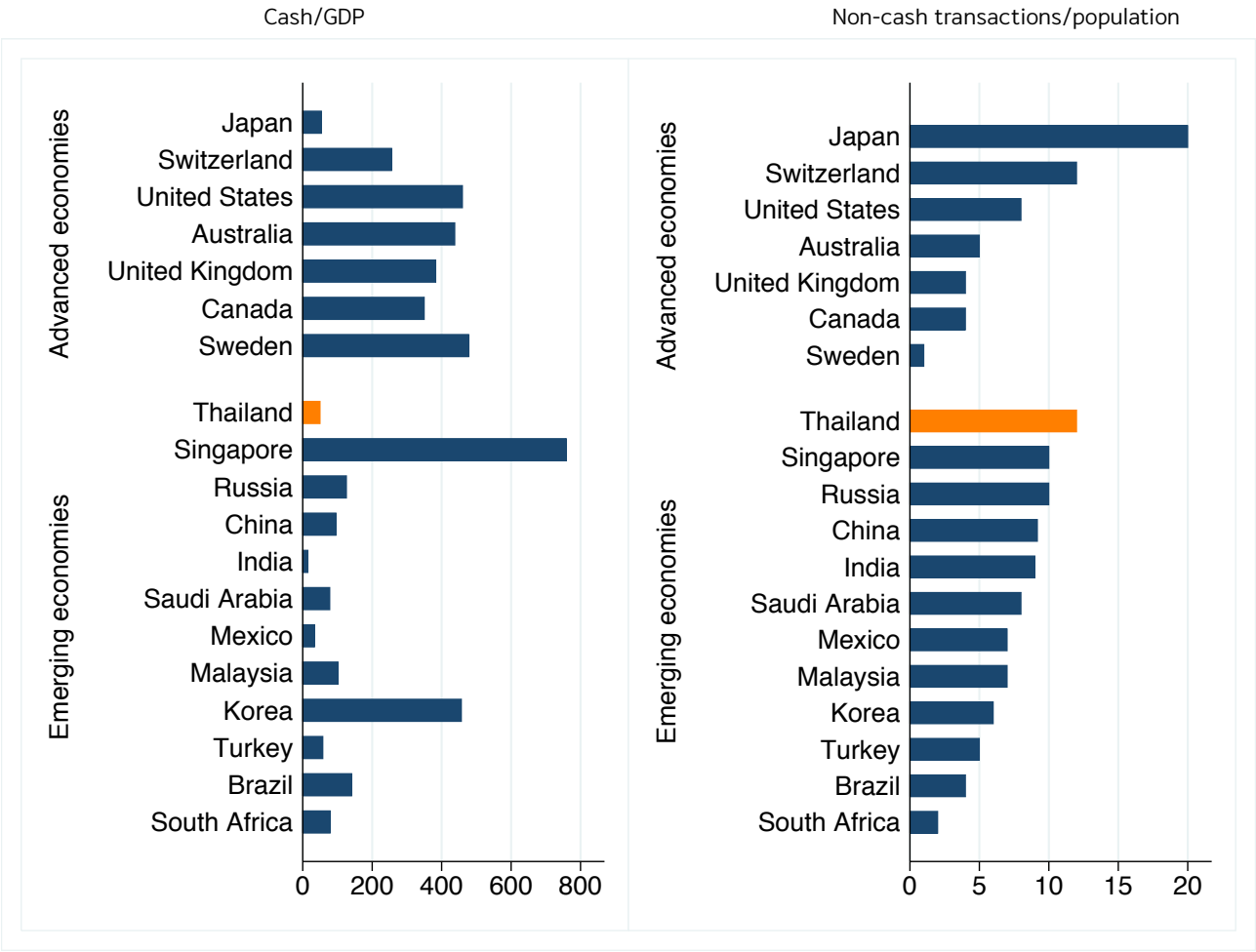
1. Introduction

Throughout history, technology has shaped and advanced the way we transact and pay each other. Digital technology currently puts the payment system at a new crossroads featuring a choice between cash[1] and a wide range of electronic payment methods. Globally, the trend toward cashless society is led by Sweden as its cash to GDP ratio reached the lowest point in history of 1.4 in 2016 (Figure 1). In other countries, nonetheless, the relationship between levels of cash and e-payment remains ambiguous. While e-payment has increased over the past 10 years, it is not obvious that cash has fallen (Bech et al, 2018 and Figure A1 in Appendix).

In Thailand, cash still dominates despite impressively high growth rates of e-payment. In 2016, Thailand's cash to GDP ratio stood at 11.6, highest among 12 emerging countries, while non-cash transactions only amounted 50 transactions per person in one year. The objective of this paper is to illustrate Thailand's existing landscape of retail payment and discuss its journey toward less-cash society. We ask two main questions: where are we now and where are we going? We employ various data sets on cash and e-payment such as daily cash distribution from the Bank of Thailand, locations of cash points from Google Maps, survey data on payment behavior in Thailand, and administrative data on electronic fund transfers. Due to data availability, e-payment in this paper largely refers to mobile/internet banking as it is used as cases in our analysis.

Figure 1: Cash and e-payment around the world



Note: Non-cash transactions include direct debit, credit transfers, checks, card payments, e-money (but excluding checks for China).
Source: BIS, BOT, PBOC, and BNM

[1] Cash, paper currency and banknotes are used interchangeably in this paper.

The paper contributes to our understanding of Thailand's retail payment in three ways. First, we offer data-driven analyses on inefficiency of banknote distribution at present. Patterns and seasonality are illustrated with high-frequency daily data and location points. We identify inefficiencies associated with the current cash system and propose an estimated cost of cash per transaction. Second, we assess Thailand's infrastructure readiness if we are to shift away from cash. Infrastructure of financial services, both physical and IT/ICT, are examined by geographical areas. The existing infrastructure still leaves 8.9% of villages without convenient access to either physical or digital financial services. Our findings suggest that cash still must coexist with other electronic payments in the near future.

Third, we provide stylized facts on profile of electronic-banking users through cases of the new centralized payment infrastructure (PromptPay) and the fee reduction of electronic fund transfers. The two cases marked milestones in Thailand's journey to less-cash society. We explore the extent to which observable characteristics can explain e-payment usage, while there remain other behavioral factors that underpin consumer behavior. As cash and e-payment will likely coexist at least for sometime, we propose possible solutions to increase efficiency in the current cash distribution system while promoting adoption of less-costly e-payment as an alternative to cash.

The findings obtained in this paper can be used to better understand the landscape of Thailand's retail payment at present before envisioning and designing the future of payments. Because money touches our lives in various ways—some concrete and some extraordinarily abstract—the move toward less-cash society will certainly involve collaboration of a wide range of stakeholders. The journey ahead of us may not just be choices between forms of fiat money, either cash or e-payment, but a variety of new payment technology such as blockchain and virtual currencies. Their implications on monetary policy, financial institutions and society must not be understated.

The paper is organized as follows. Section 2 describes the overview and recent trends in Thailand's retail payment. Section 3 assesses efficiency and costs of cash distribution management. We also compare cost of cash to that of an electronic fund transfer. Section 4 evaluates current challenges on moving toward less-cash society in terms of infrastructure and consumer behavior. Section 5 discusses Thailand's journey to less-cash society through cases of PromptPay and the transfer fee reduction as well as discussing the central bank's role on this endeavor. Section 6 concludes with some final thoughts.

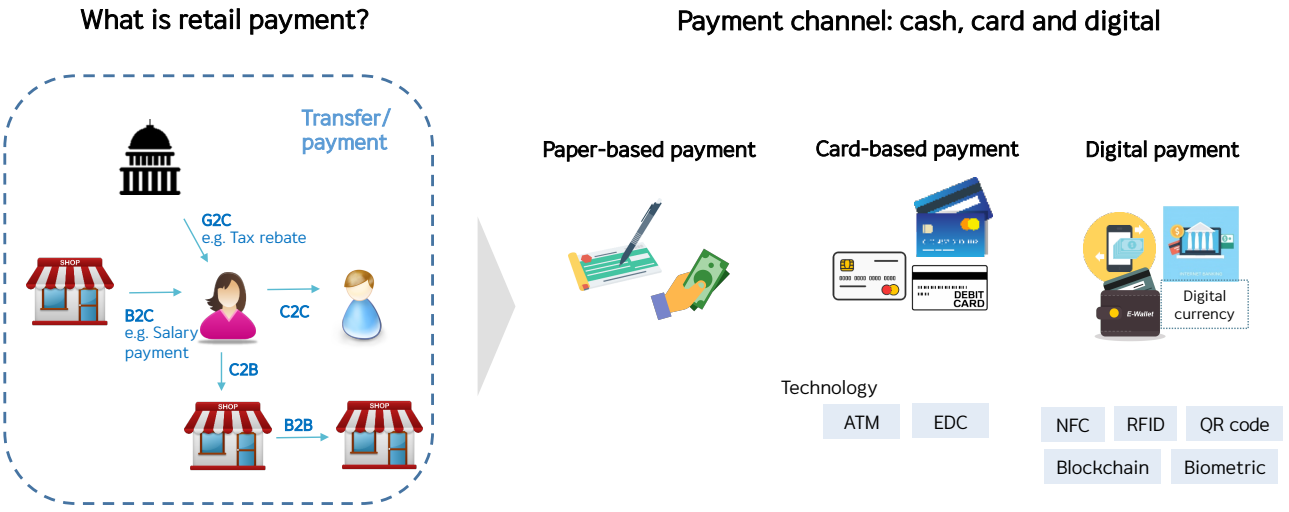
2. Retail payment in Thailand

What is retail payment?

Retail payment is everyday payment between individuals. It constitutes the bulk of payment transactions in the economy, including consumer and corporate payments, but excluding high-value payments made by banks. As such, retail payment is of relatively low value and typically not time critical. It includes payments made by consumers to retail merchants or utility payments made to service providers. Salary payments made by companies, tax refunds or social welfare benefits made by government to individuals or payments made between corporates are also categorized as retail payment.

A payment enables the transfer of funds from one party (payer) to another party (payee). Payment can be categorized broadly into 2 types. The first type is paper-based and requires physical handing such as cash and checks. The second type is electronic payment which refers to any payment methods that can be done entirely electronically. This includes card-based payment such as credit card and digital payment such as mobile/ internet banking, e-money and contactless payment device. The most commonly used payments in Thailand are cash, electronic credit transfers, card payments and direct debits.

Figure 2.1 Overview of retail payment



Recent trends in Thailand

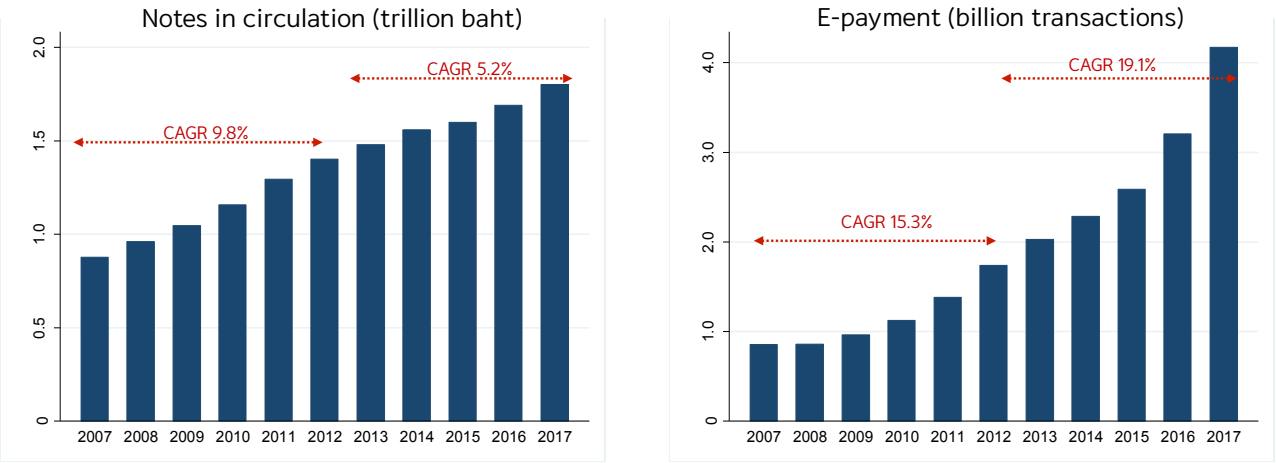
As a major payment method, cash in circulation has continuously grown over the past 10 years, totaling 1.8 trillion baht in 2017 (Figure 2.2). The average annual growth rate stalled to 5.2% during 2013-2017 from 9.8% during 2007-2012. However, cash has maintained its prevalence as the ratio of cash to GDP has stabilized around 10-12 over the past 10 years. Meanwhile, e-payment transactions grew on average at 19.1%, up from 15.3% in the preceding 5 years. Mobile/internet banking, e-money and electronics card are the top three e-payment products (Figure 2.3).

In developing countries, card payments are not as common compared to developed countries where payment card is a main non-cash payment instrument. In the U.S. and Canada, card technology and payment card infrastructures such as EDC have been present since 1950.[2] The governments also encouraged merchants to

[2] Details in Table A1 in the appendix.

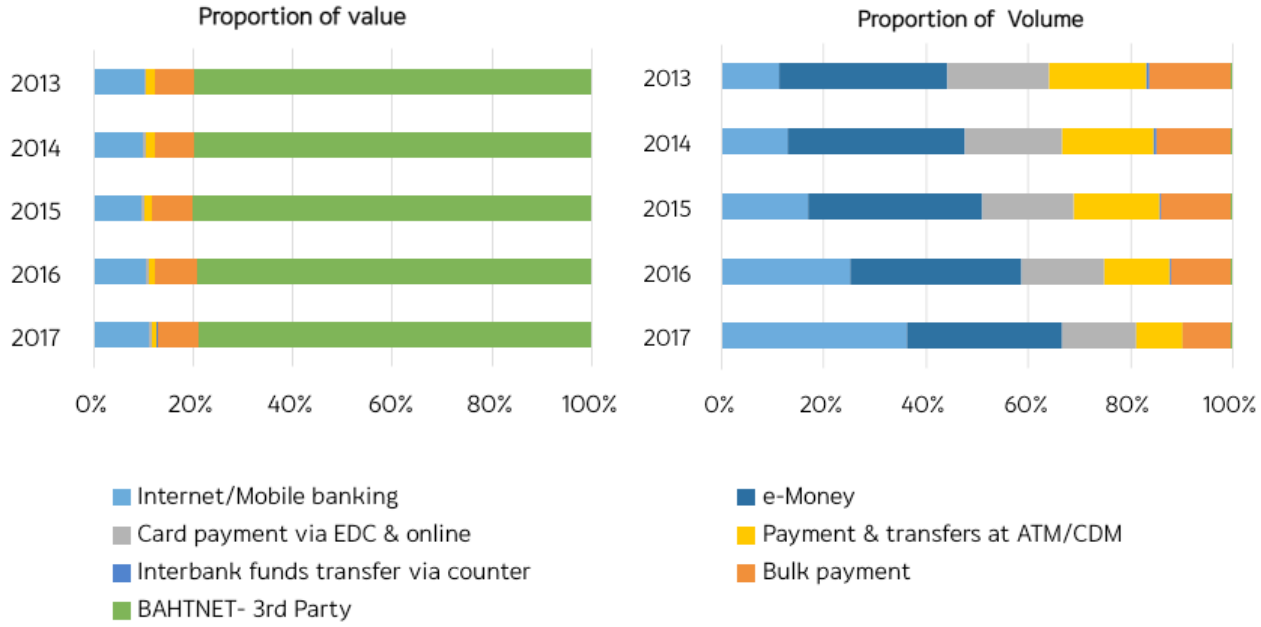
accept card payments by providing incentives such as a lower merchant discount rate.[3] In developing countries, instead, mobile phone plays an important role in payment and funds transfer transactions because the stage of development in these countries is accompanied by smartphone technology. Due to fast adoption and lower costs for both consumers and merchants, countries like Thailand, Kenya, Tanzania have shifted to digital or mobile payment, leapfrogging the use of card payments.

Figure 2.2 Recent trends in Thailand



Source: BOT

Figure 2.3 Proportions of electronic payment methods



Source: BOT

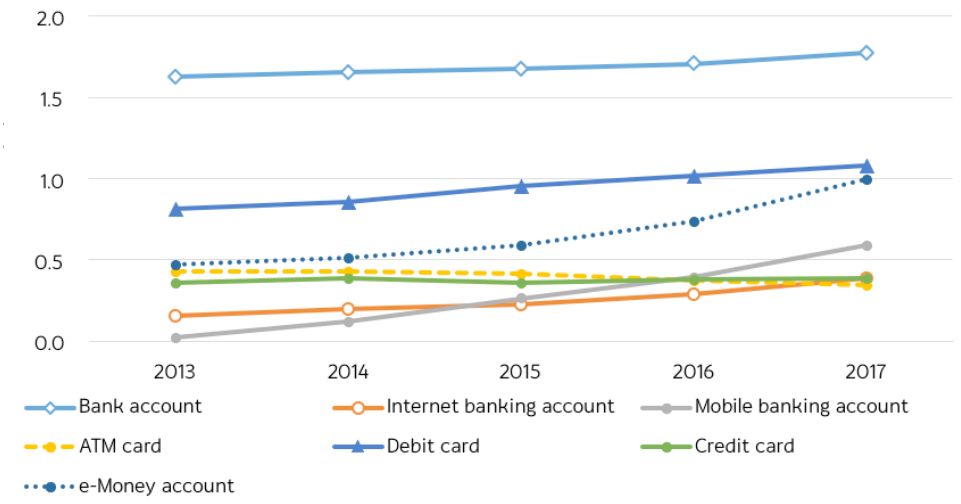
In Thailand, the volume of e-payment per person has doubled over the past 5 years, from 31 transactions/ person/year in 2013 to 63 transactions/person/year in 2017. Growth was mostly contributed by internet/mobile banking and e-money transactions while transactions via ATM/CDM and counter services trended downwards. We have observed a smaller share of fund transfers made at ATMs that fell from 19% in 2013 to 9% in 2017 (Figure 2.3). On the other hand, the share of internet/mobile fund transfers rose from 11% to 36% during the same

[3] Merchant Discount Rate (MDR) is a fee charged to merchant for accepting card payments.

period. Mobile and internet banking transactions together expanded 60.5% per year in terms of volume and 10.9% in terms of value. Mobile banking popularity notably increased, consistent with more smartphone users and advancements of mobile banking applications. As of June 2018, mobile banking accounts totaled 38 millions. The number of mobile banking accounts grew from merely 0.02 account per adult in 2013 to 0.59 account per adult in 2017 (Figure 2.4). The rising trend of mobile banking usage is driven not only by new customers (extensive margin), but also existing customers who have increased their uses in their digital lifestyle (intensive margin). Since 2015, mobile banking accounts have already surpassed the number of internet banking accounts which stood at 23 million accounts in June 2018.

In addition to mobile/internet banking, e-money is a key digital payment instrument in Thailand. In 2017, the number of e-money accounts per adult exceeded that of mobile/internet banking accounts. Mostly used for low-value daily payments, e-money volume and value rose during the past 5 years on average by 17.4% and 27.4% per year, respectively. The number of e-money service providers, the majority of which are non-banks, also continued to expand. The greater number of e-money accounts per person reflect that people are becoming more familiar with and increasingly adopting e-payment, consistent with the shifting trend in service models during the past 2-3 years from computer network-based to smart phone application-based. In fact, one person is likely to have multiple accounts depending on their lifestyle e.g. airtime top-ups, convenient store purchases, and sky train tickets. Moreover, intense competition among e-money service providers results in various discounts and reward programs.

Figure 2.4 Number of payment instruments per adult population (2013-2017)



Source: BOT

For card payments, Thais own on average 1.08 debit cards per adult in 2017. Following the government's debit card campaign, banks have started to promote debit cards for use at points of sales and online payments. However, Thai people prefer credit cards to debit cards owing to the former's offering credit terms, together with discounts from participating stores. As services mainly used by the business sector, bulk payment is a transfer with multiple recipients e.g. salary payments and constitutes. In addition, 3rd Party BAHTNET[4] credit transfer is mostly used for real time large-value fund transfers via counter and has contributed to the highest proportion of value at approximately 80 percent during the past 5 years.

[4] Third party fund transfers allow a participant to transfer funds as ordered by its client, from the client's account at the bank to a beneficiary account at the recipient bank. In accordance with each bank's Service Level Agreement, funds are available for the beneficiary on the same day basis.

3. Cost of cash

This section provides an overview of Thailand's cash distribution and management processes. Existing inefficiency is identified using various micro-level datasets including daily data on cash distribution and locations of service points such as ATMs and bank branches. We propose an estimated cost of the cash transactions and compare to that of e-payment transactions. Cost comparisons of cash and e-payment are then discussed.

3.1 How is cash distributed?

Cash distribution in the economy occurs in 3 steps through operations by Bank of Thailand (BOT) and private cash management companies such as commercial banks' subsidiaries and cash-in-transit companies. First, newly printed banknotes are transported from BOT's printing works to 10 BOT's banknote operation centers across the country, represented by the horizontal grey arrow in Figure 3.1. Second, banknotes are transported to over 100 private cash centers. Third, banknotes are subsequently distributed to over 70,000 bank branches and ATMs from where consumers can withdraw cash.

Figure 3.1 Process of cash distribution

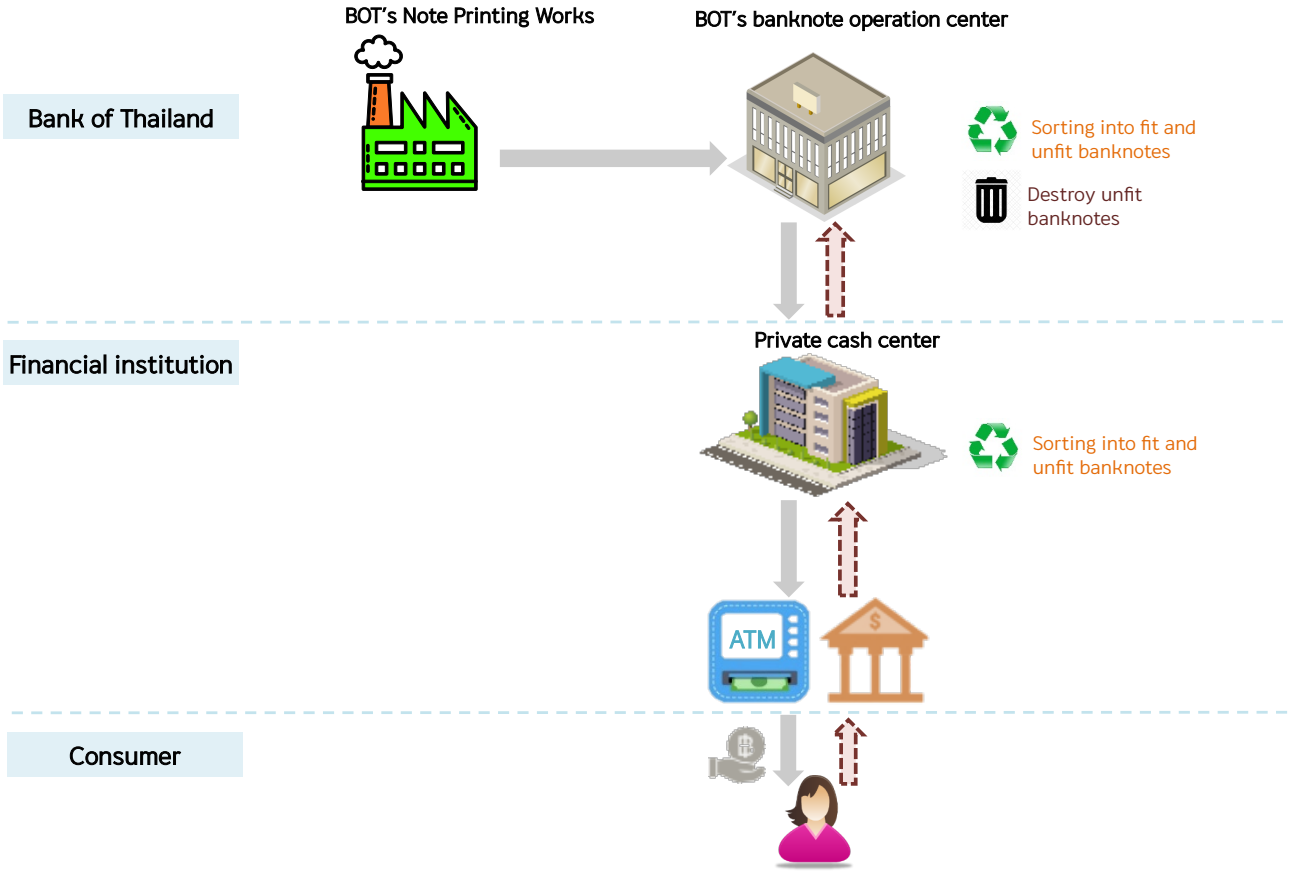
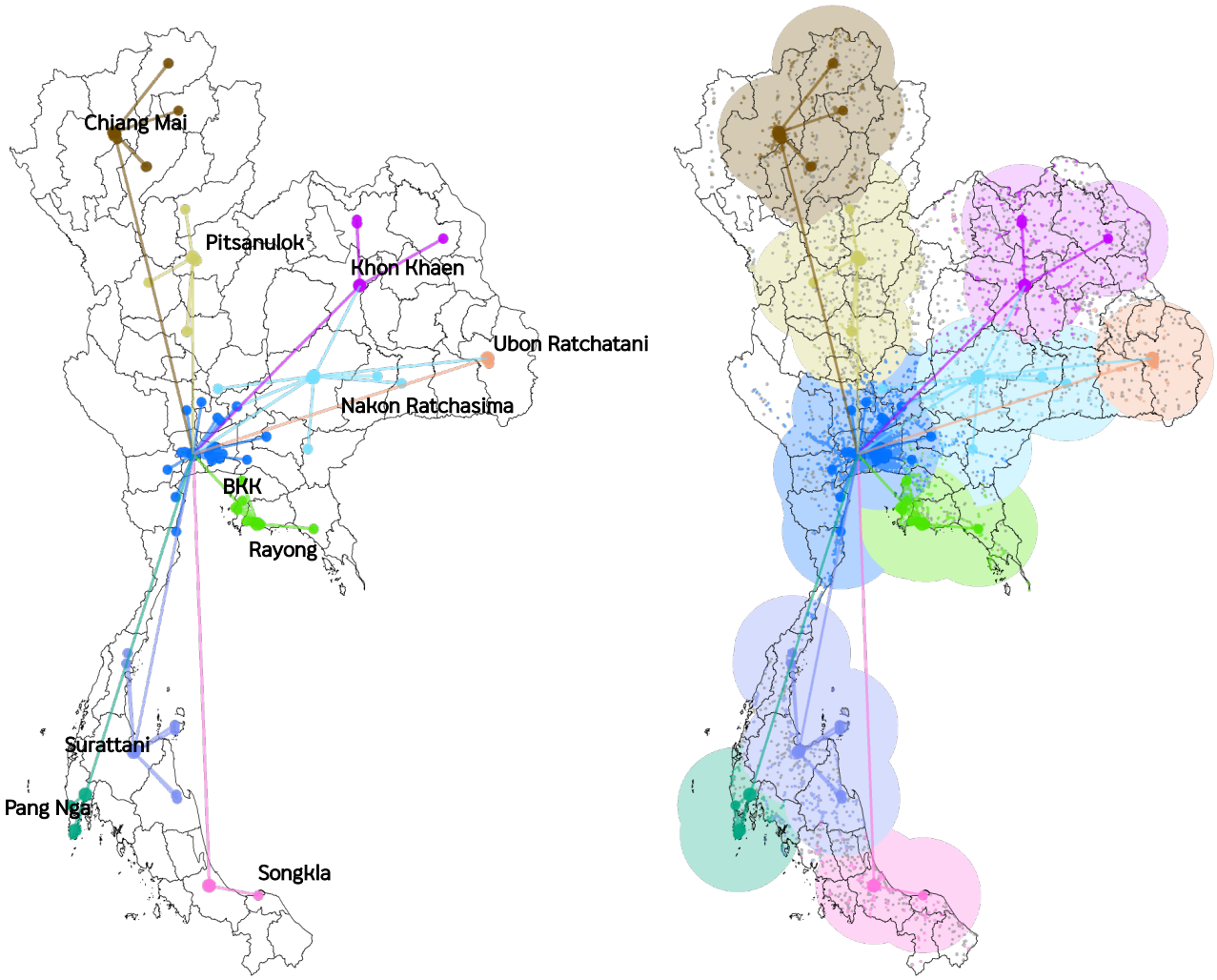


Figure 3.2 exhibits the network of banknote distribution. New banknotes are printed at the BOT's note printing works in Nakonpathom and then distributed to 10 BOT's banknote operation centers across the country: 2 in the north, 3 in the northeast, 2 in Bangkok and central region, and 3 in the south (left panel). The line represents the network of banknote distribution from the BOT's note printing works to 10 BOT's banknote operation centers, as labeled by province names. In 2017, there were a total of 33 trips from the note printing works which carried over 840 million banknotes or 261 billion baht to BOT's banknote operation centers. Among

these, there were 25 trips from Bangkok to other BOT's centers, 3 return trips to Bangkok, and 5 trips between BOT's provincial centers.

Figure 3.2 Network of cash centers and service points



From the 10 BOT's centers, private companies are in charge of distributing banknotes to over 100 private cash centers, represented by points with the same color,[5] and subsequently reaching various cash points including ATMs and bank branches (of commercial banks, specialized financial institutions and foreign branch), shown by small dots (right panel). The bubble size is a 100 kilometer radius from a private cash center to illustrate their approximated service areas.

Return of fit and unfit banknotes

The reverse process concurrently takes place as banknotes deposited at ATMs, bank branches and retail shops are transported back to over 100 private cash centers, shown by the dashed brown arrows in Figure 3.1. At

[5] Multiple private cash centers are located very close to each other. Thus, all centers are not visible on the map. For example, In Chiangmai, there are 1 BOT's banknote operation center and 5 private cash centers in total.

Source: BOT and Google Maps, calculated by authors

these centers, notes are sorted and classified into fit and unfit banknotes according to quality standards. Fit banknotes later return to cash points and are circulated in the economy. Unfit banknotes are sent back to BOT's banknote operation centers to be destroyed. Nonetheless, a considerable number of fit banknotes are transported from a private cash center back to a BOT's banknote operation center everyday. These returned fit notes are excess banknotes from daily usage. On average, around 14 million fit banknotes are returned to 10 BOT's centers everyday, or around 20% of all notes distributed to branch and ATM (Table 3.1).

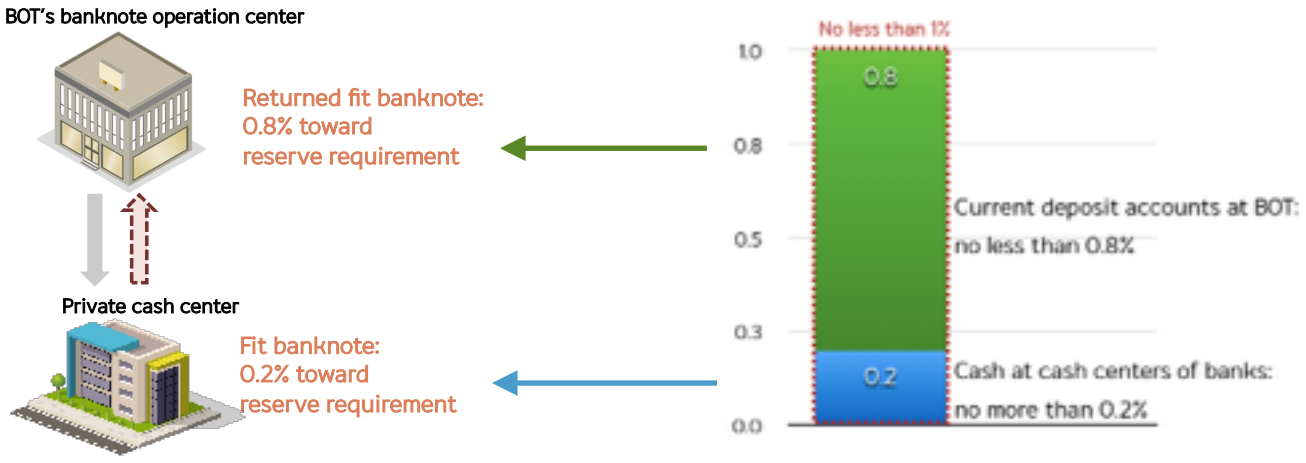
Table 3.1 Banknotes distributed from and returned to BOT's banknote operation centers

Deonomination	Distribution (million)	Distribution (share)	Returned fit (million)
1,000	36.2	52%	8.3
500	7.1	10%	1.4
100	16.0	23%	2.8
50	1.6	2%	0.3
20	8.3	12%	1.2
Total	69.3	100%	14.0

Note: Average number of banknotes per day during BOT's working days in 2017
Source: BOT, calculated by authors

Several factors can explain this. First, the composition of the 1% reserve requirements imposed by Bank of Thailand provides incentives for banks to return banknotes to BOT centers. According to Bank of Thailand's regulation (Figure 3.3), banks are required to maintain a minimum of 1% in non-remunerated current account deposits at the BOT, of which no more than 0.2% in cash at private cash centers of commercial banks can be counted towards this.[6] Therefore, it is better to move those in excess of the 0.2% from private cash centers back to BOT's centers. The balance of fit banknotes returned to BOT's centers will be credited into their current account deposits and count as the other 0.8% toward the reserve requirement.

Figure 3.3 Composition of BOT's reserve requirements



Source: BOT, illustrated by authors

[6] According to BOT Notification No. Sor.Kor.Ngor. 56/2558. Re: The Requirements for Commercial Banks on the Maintenance of Reserve Balances at BOT, commercial banks must maintain reserve balances at the BOT, on average, at 1 percent of the average sum of deposits and borrowings. Banks are required to maintain a minimum reserve requirement on average over a fortnightly period (starting on a Wednesday and ending on a second Tuesday thereafter), with carry-over provisions, equaled to a specified percentage of the previous period's average level of commercial banks' deposits/liabilities base.

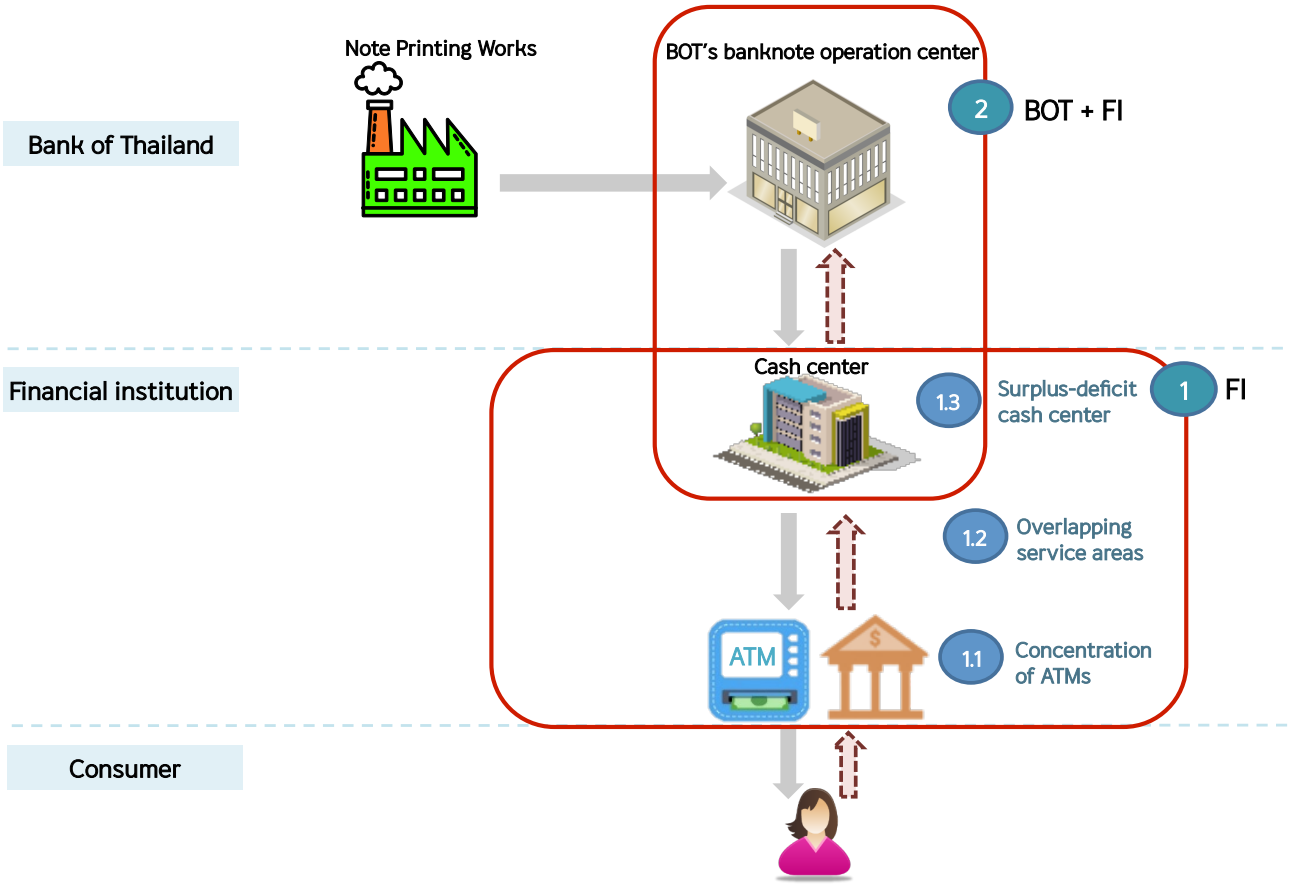
Second, there exist excess banknotes of particular denomination at a private cash center due to seasonality or spending patterns in certain areas. Third, banknote storage at private cash centers incurs considerable costs including insurance and security surveillance. It may be more economical for banks to pay logistic costs on moving fit banknotes back to BOT's centers.

In addition, fit banknotes are returned to the BOT banknote operation center in Bangkok from the other 9 centers because some centers are net receivers of certain banknote denomination. For example, the Pang-nga center receives more large denomination banknotes than what it distributes out, because tourists carry cash from other provinces and spend in tourism destinations such as Pang-nga and Phuket (details in Section 3.2: Inefficiency between BOT and financial institutions). Due to security and note quality issues, banknote surpluses cannot stay in BOT's provincial banknote operation centers over 3 months. They must be transported back to the BOT banknote operation center in Bangkok.

3.2 Inefficiency of cash management system

Two types of inefficiency emerge in the existing cash distribution system: inefficiency among financial institutions (FIs) and inefficiency between BOT and FIs (Figure 3.4). Among FIs, we identify 3 inefficiencies in existing operations based on daily data on banknote distribution by geographical area and locations of service areas such as ATMs and branches. First, ATMs of various banks are often clustered together while banknote management is carried out separately by each bank. Second, areas served by each bank highly overlap with each other. And third, individual bank's transportation arrangement does not encourage exchanges of banknotes between local cash centers of different banks. We discuss each one in turn.

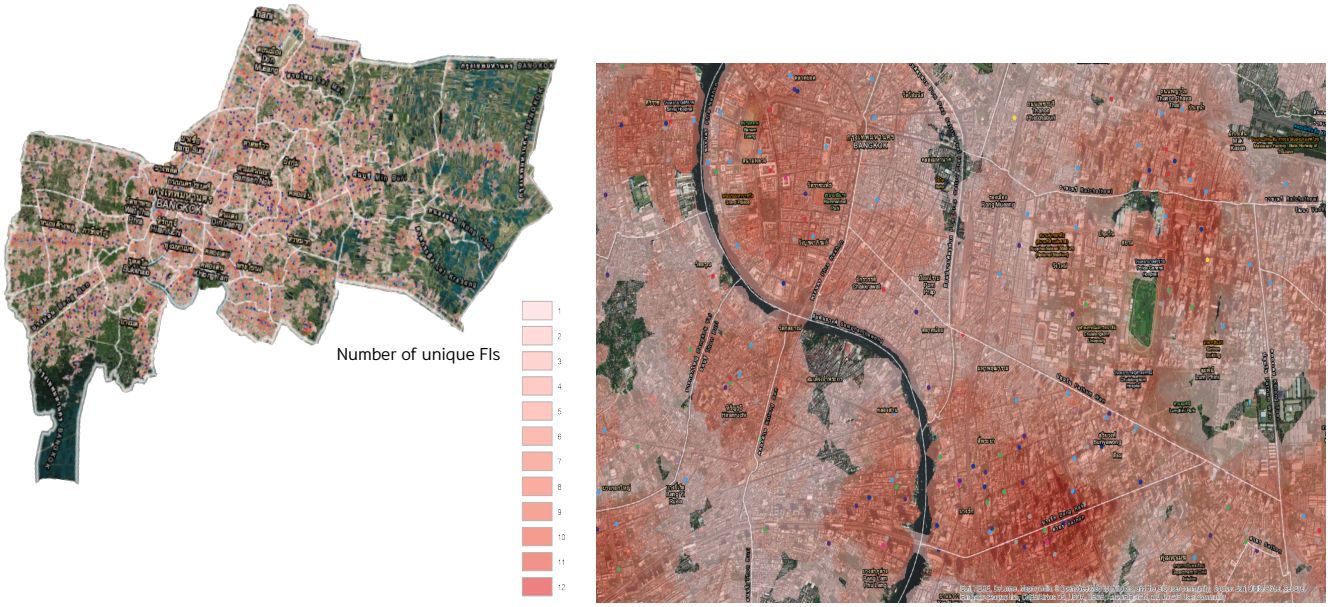
Figure 3.4 Two types of inefficiency in existing cash distribution system



Inefficiency among financial institutions

(1) Cash points are highly concentrated. Concentration of ATMs and bank branches gives rise to inefficiency because each ATM is individually managed by respective banks. We illustrate the case of inner Bangkok as an example in Figure 3.5. There are ATMs of 12 FIs within one-kilometer road distance in some areas downtown Bangkok such as Siam, Silom and the old town. One of the reasons that explain the concentration is that banks use their ATMs to promote brand awareness and distribute their marketing communications. These, in turn, cause inefficiency in the economy as banks invest in redundant operations. Moreover, for ATMs that are far away from a cash center, distance exacerbates the problem. For example, at least 5 ATMs in Mae Hong Son are clustered within a 5-kilometer radius and are almost 300 kilometers away from the nearest cash center in Chiangmai. Each one is separately served by its own bank.

Figure 3.5 Concentration of ATMs in downtown Bangkok

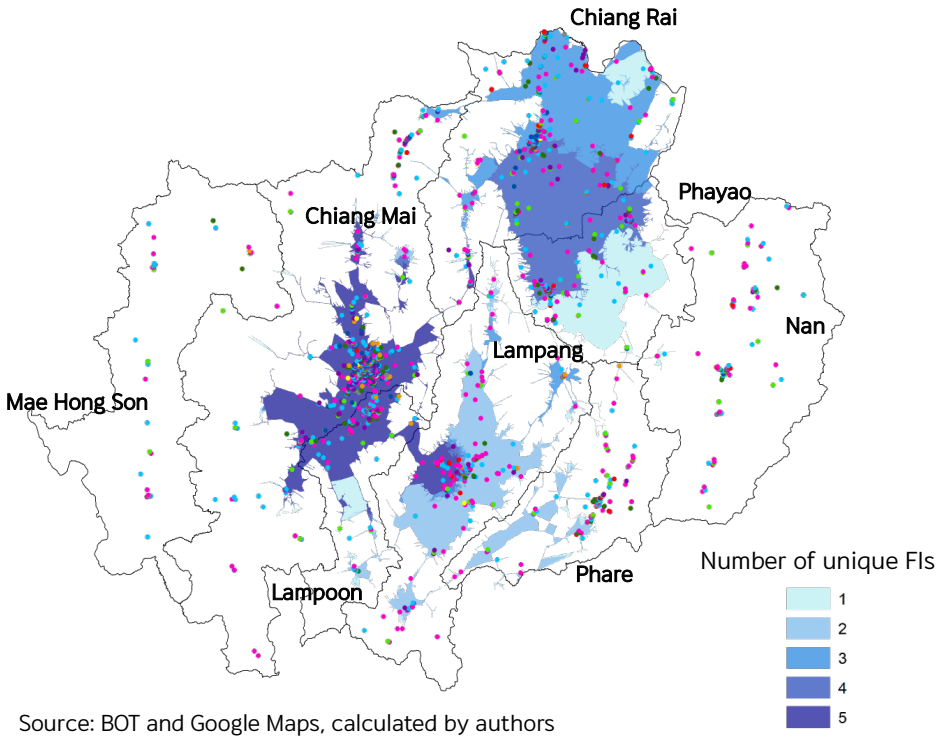


Source: Chantarat et al (2018)

(2) Areas served by each bank highly overlap with each other. Private cash centers are often concentrated in close proximity to BOT's banknote operation center. Banknotes are then transported by each bank to their respective branches and ATM points, which are sometimes also close to those of other banks. For illustrative purposes, shaded areas in Figure 3.6 display a 100-kilometer radius of road distance from each private cash center in upper-northern Thailand. A darker shade corresponds to more banks who serve the same areas. The dots represent locations of bank branches and ATMs where each color refers to a particular bank.

Despite high concentration of service points in darker shaded areas (especially in large cities), the map illustrates highly overlapping routes taken by each bank from their cash center. The darkest shade of blue shows that the same area is currently serviced by 5 financial institutions. The dots outside the shaded areas are service points which are more than 100 kilometers from a cash center. Some service points are almost 300 kilometers (or 5 hours drive) from a cash center. These faraway service points often belong to multiple financial institutions and each one is currently served by its own bank.

Figure 3.6 Overlapping areas within 100 kilometers serviced by unique financial institutions in upper-northern Thailand



Source: BOT and Google Maps, calculated by authors

(3) Banknotes are not exchanged between local private cash centers of different banks which are located in the same province. Often across provinces, armored vehicles carrying banknotes must travel far distance back and forth every day from a central cash center to sub-cash centers. Sub-cash centers distribute banknotes to local service points. At the end of the day, if disbursement exceeds the amount of banknotes returned to cash centers, we call them "deficit" cash centers. On the other hand, "surplus" cash centers are those with more returns than distribution.

Figure 3.7 Local cash centers with deficit and surplus balance

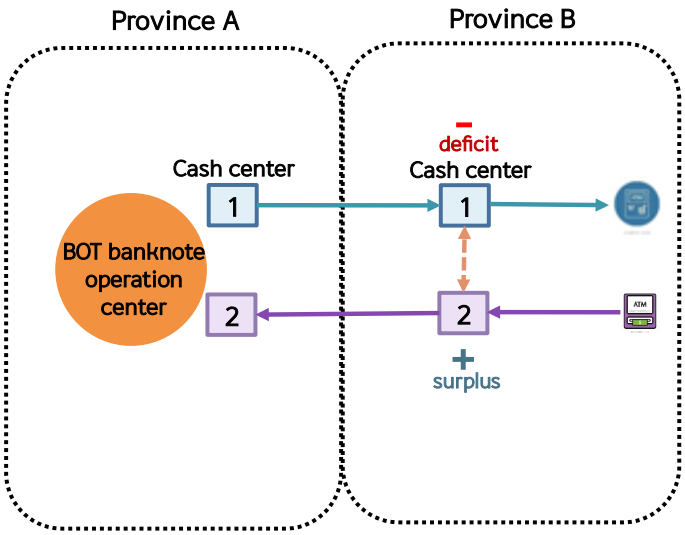
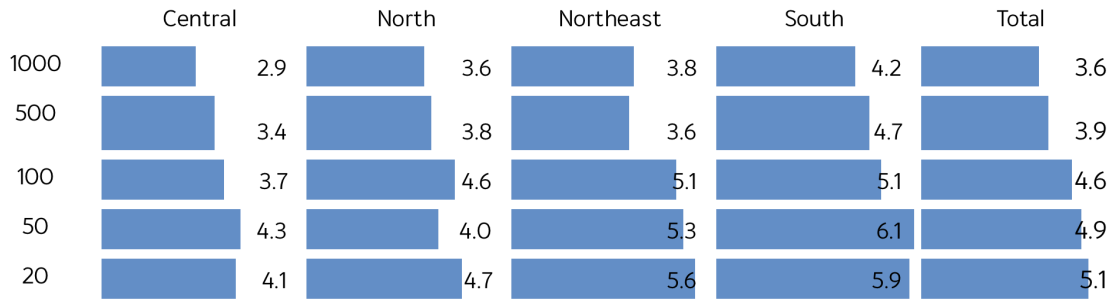


Figure 3.7 illustrates a case of two banks with their central cash centers in Province A where a BOT banknote operation center is located. For Bank 1 (blue), banknotes are disbursed from its central cash center in Province A, transported to a sub-cash center in Province B, and later distributed to Bank 1's CDMs/ATMs in Province B. Bank 1's sub-cash center in Province B is a deficit center because it records a net outflow of banknotes. On the contrary, a local cash center of Bank 2 (purple) in Province B is a surplus center because it records a net inflow of banknotes received from CDMs/ATMs and branches. Due to reasons previously described in Section 3.1, the banknote surplus are then transported back to Bank 2's central cash center in Province A and later deposited back to the BOT banknote operation center. Because each bank individually optimizes its own cash distribution, banknotes are not transferred between local sub-cash centers of different banks. The two banks do not locally exchange in Province B although one bank is a deficit and the other a surplus center.

Using daily data of cash distribution by cash center, we can match deficit and surplus centers within the same province for each banknote denomination. We then count the number of days in one year whereby matched centers can potentially exchange with sub-cash centers of different banks within the same province. This number would represent the number of inefficient days from long road trips and differ across denomination, ranging from 3.6-5.1 months (Table 3.2). Inefficiency arises in terms of number of long road trips which could have been saved between provinces should banknotes instead be exchanged between local cash centers. An average amount of banknotes available for local exchange is around 3,000-80,000 notes per day, of total daily distribution.

Table 3.2 Number of months possible for note exchange between local cash centers



Note: Only provinces without a BOT's banknote operation center are included. Those with BOT's centers can exchange with the BOT in close distance. Total refers to average across provinces.

Inefficiency between BOT and financial institutions

Ideally, once disbursed from BOT's banknote operation centers, banknotes should remain circulated in the system. Only unfit banknotes should return to BOT to be destroyed. However, certain frictions exist and cause some fit notes to be returned to BOT's centers. As illustrated in Figure 3.1, both fit and unfit banknotes are returned to BOT's banknote operation centers. For unfit banknotes, they must be returned and destroyed at one of the 10 BOT's banknote operation centers. Duplicated sorting process occurs again at BOT's centers after having been sorted at a private cash center. For fit banknotes, they are returned for various reasons as previously described in Section 3.1 (return of fit banknotes). By denomination, larger notes like 1,000 and 500 notes show the largest share of fit notes returned to BOT's centers (Table 3.3), consistent with the incentive to count these toward the reserve requirement. Moreover, it is less costly to transport larger notes relative to the banknote value. For unfit returns, once disbursed from BOT, smaller notes are circulated in the economy and

only return to BOT to be destroyed. The higher shares of unfit returns in the north and northeast may also suggest that, in these areas, there may be more low-quality banknotes circulated and brought back to BOT to be destroyed.

Table 3.3 Proportions of daily fit and unfit banknotes returned to BOT's banknote operation centers

	Fit return/Distribution	Unfit return/Distribution
Denomination		
1,000	23%	4%
500	20%	5%
100	17%	12%
50	18%	20%
20	14%	27%
Banknote operation center		
Bangkok	18%	7%
Central	17%	6%
North	22%	13%
Northeast	25%	12%
South	24%	10%
Total	20%	9%

Note:
Fit return/distribution: share of returned fit notes to those distributed to ATMs and branches
Unfit return/distribution: share of returned unfit notes to those distributed to ATMs and branches
Source: BOT, calculated by authors

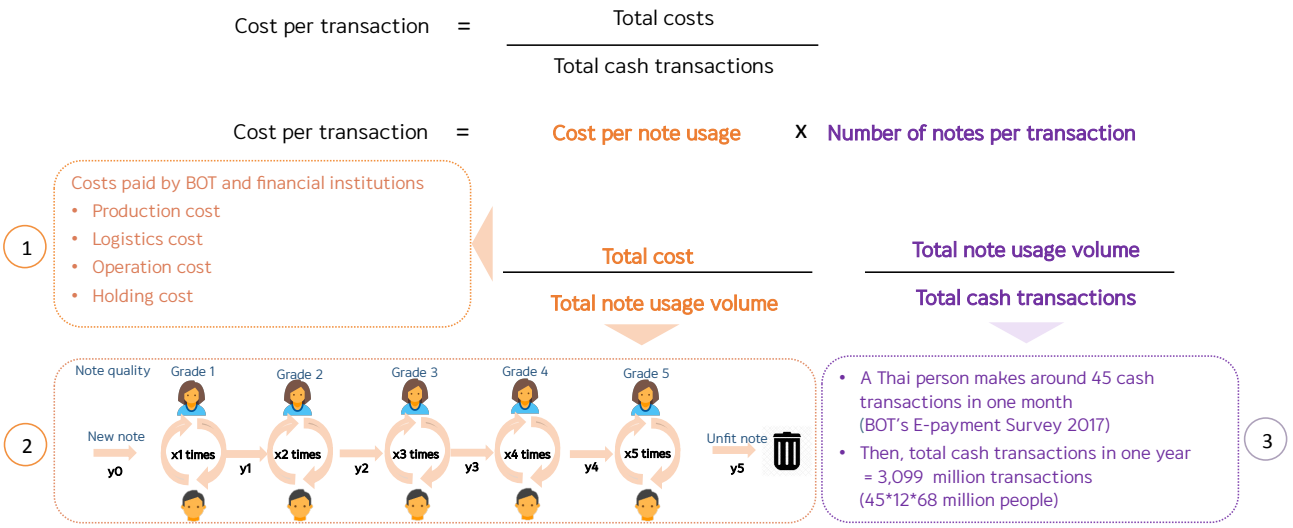
3.3 Cost of cash transactions

We propose an estimate on the cost of cash to be 1.26 baht per transaction, or 0.34 baht per note usage. We make a distinction between number of transactions and note usage as one transaction can be made with multiple note usage. Figure 3.8 displays an overview of our cost estimation. To obtain cost per transaction, we rely on 2 estimates: total costs and total number of cash transactions.

In one transaction, a different combination of banknotes can be used and result in different numbers of note usage. For example, we can make a 1,000 baht transaction with 1 note usage (1,000-baht note), 2 note usage (two 500-baht notes), or 10 note usage (ten 100-baht notes). We cannot precisely approximate the combination of banknote denominations used. Our cost estimate per transaction is essentially a product of an average cost per banknote and an average number of banknotes used per transaction.

Moreover, we are also interested in estimating cost per note usage by denomination. Costs per transaction vary according to note usage and combinations of banknote denominations e.g. one 1,000-baht note or 10 100-baht notes. Therefore, we also estimate total banknote usage volume by denomination. Methodology and details are discussed in the appendix.

Figure 3.8 Overview of cost of estimation



First, total costs[7] include (1) BOT's costs of banknote production and transportation and (2) financial institutions' costs of cash centers, branches and ATMs. For the latter, we consider logistics, operation and holding costs of cash management and distribution.

Second, total note usage volume refers to the total usage frequency of all banknotes in circulation. Unfortunately, we cannot directly measure banknote usage volume in all transactions in the whole economy.[8] Instead, we estimate total note usage indirectly from distribution of banknote quality. For each quality grade, notes are used x times before getting downgraded by the amount of y1 to y4, and eventually destroyed. All note usage volume (sum of x1 to x5) of all banknote denominations must sum up to total value of transactions in the economy i.e. value of velocity of money in circulation (notes in circulation times velocity of money). While new notes are circulated and unfit ones get destroyed every month, the BOT maintains a fixed distribution of banknote quality.

Therefore, we can solve for the frequency of note usage (x1 to x5 for all denominations) based on (1) the number of "in" and "out" banknotes, (2) fixed distribution of banknote quality, and (3) total value of transactions in the economy. The cost per note usage varies across denomination between 0.07-2.08 baht per banknote due to both production and logistics costs. For instance, larger-denomination banknotes are transported more frequently than smaller-denomination because it is "cheaper" relative to the banknote value.

Third, number of banknotes per transaction are total note usage, divided by total number of cash transactions. The nominator is estimated in the previous part, while the denominator is obtained from the BOT's E-payment survey 2017. Based on the survey, a Thai person makes 45 cash transactions per month. We aggregate this number up to be the country's total in one year.

[7] In 2017, total costs are approximately 47,000 million baht (or 0.3% of GDP), 91% of which are costs of FIs. However, this cost does not include consumer or consumer costs on waiting time, or costs related to getting and handling cash.

[8] Some studies on cost of cash resort to a survey method to gauge the volume of note usage and number of cash transactions made in the economy (e.g. Kruger and Seitz 2014).

Cost comparisons with e-payment

We compare costs of cash and e-payment transactions. On average, one cash transaction costs 1.26 baht which reflects both fixed costs of banknote production and variable costs on logistics of cash distribution, sorting and destruction processes. An electronic fund transfer costs 0.46 baht per transaction, which covers the cost of development, implementing and operating the new Faster Payment Systems, including related banks' system enhancements as well as maintenance.[9] In our cost comparisons, we would not like to focus entirely on the absolute costs in baht term because they are only guesstimates of available data. More importantly, we would like to discuss the different cost structures of the two payment methods.

First, cost of cash mainly depends on the number of banknotes used. Although an average cash transaction costs 1.26 baht according to our estimate, this number is higher for a large transaction size. Due to our estimated cost per note usage of 0.34 baht, costs of cash would amount to 0.34%-0.034% of transaction size (Table 3.4). On the other hand, e-payment transaction costs the same regardless of transaction size. As a result, cost per e-payment transaction decreases as transaction size is larger. We compare costs of cash and e-payment for transactions between 100 to 1 million baht, assuming minimum number of banknotes used and no change is required.[10]

Table 3.4 Costs of cash and e-payment (electronic credit transfer), by transaction size

Transaction	Banknotes used	Cash (baht)	%cost of transaction	E-payment (baht)	%cost of transaction
100	1x100-baht	0.34	0.34%	0.10	0.1%
1,000	1x1000-baht	0.34	0.034%	0.10	0.01%
10,000	10x1000-baht	3.40	0.034%	0.10	0.001%
1,000,000	1000x1000-baht	340	0.034%	0.10	0.00001%

E-payment cost refers to average costs during 2017-2020: the sum of costs in 5 years, divided by total transactions in 5 years. Total transactions in 2018-2020 are projected from historical growth.
Source: BOT and PricewaterhouseCoopers, calculated by authors

Second, another distinction of e-payment cost is the role of scale (Hayashi and Keeton, 2012). E-payment transactions are increasing returns to scale as cost per transaction becomes cheaper with higher volume. In other words, while 1.30 baht is currently charged per transaction, cost per transaction will fall in the future if transfer volume increases (Table 3.5). More transactions are sharing the fixed costs whereas variable costs will become marginal. On the contrary, majority of cash cost is logistics and transportation which vary according to usage. Cash cost per transaction is therefore almost constant when total transaction volume rises.

[9] Cost estimate by PricewaterhouseCoopers in a study commissioned by Thai Banks Association and NITMX. The total cost is 4.3 billion baht over 2016-2025 and split over 10 years to obtain total cost per year. Total number of electronic transfer transactions in 2018-2020 are projected from historical growth.

[10] We could in fact take into account different costs for different banknote denomination. However, for illustrative purposes, an average cost per banknote (0.34 baht) is applied here.

Table 3.5 Increasing returns to scale of e-payment cost (electronic credit transfer)

Year	Total cash transactions (millions)	Cost of cash per transaction (baht)	Total e-payment transactions (millions)	Cost of e-payment per transaction (baht)
2017	137,546	1.26	331	1.30
2018	144,423	1.26	1,093	0.39
2019	151,644	1.26	3,760	0.11
2020	159,227	1.26	12,726	0.03

*Number of total transactions in 2018-2020 projected from historical growth
Source: BOT and PricewaterhouseCoopers, calculated by authors

If cash is most costly, then why are we still using it? Part of the answers lies on more questions about who pay the cost and when. For cash transactions, most of the costs (91%) fall on the burdens of banks regarding logistics and transportation. However, banks have their own way to manage cost and pass on to customers. While consumers do not pay "a fee" when making cash transactions, cost of cash is embedded in fees charged by banks in other services. In electronic payments, part of payment cost is shared by consumers in the form of transfer fees when they make transfers with mobile/internet banking. Moreover, cost of cash on the payee's side might tell a different story. Merchants have reported that cash remains the cheapest payment method when compared to cards and other electronic devices (British Retail Consortium's Payment Survey, 2016).

3.4 Possible solutions

Given high cost and inefficiencies associated with existing cash management system, we propose 4 possible solutions as summarized in Table 3.6. The proposed solutions are ranked by the level of complexity in implementation. This ranges from a slight change in operations to a change in the business model that might also require regulatory changes. We rank the possible solutions from the least complicated to the most complex one.

(1) Exchange banknotes between local cash centers of any banks

Banks exchange banknotes at any cash centers within the same province or nearby provinces, before going further across provinces to their own bank's cash center. This, then, shall save the commute time, energy consumed and logistics costs. From our analysis, private cash centers may locally exchange up to 3.6-5.1 months per year. In fact, the centralized data system of banknote balance (Banknote Management System) currently allows banks to see the banknote position of other banks by denomination. Some banks are now locally exchanging within the province e.g. Chonburi, Udonthani and Phuket. Nonetheless, issues remain as banks cannot balance their positions in all denominations in one day with one party. Instead, banks might have to make multiple short trips to exchange all denominations while a single long trip to a BOT's cash center enable exchange of all denominations. Therefore, the BOT should work with the industry in encouraging the coordination and collaboration among banks to do bilateral matching as deemed possible and exploring the exchange point for multilateral matching.

(2) Pooled logistics management

With pooled logistics management, banks can together optimize their resources at a larger scale. In inner city where bank's branches and ATMs are largely concentrated, pooled logistics would reduce the number of cars and trips going back and forth to serve the areas. This might as well benefit the remote areas in where few branches and ATMs of some particular banks are located. To achieve this, an incentive scheme that enables all parties to collaborate is key as several parties have already invested in their own systems and operations.

Table 3.6 Possible solutions to improve efficiency of cash distribution and management

Possible solutions	Benefits	Conerns or issues to further explore
(1) Exchange banknotes between local cash centers of any banks	• Less times, trips and energy consumed • Increase number of efficient days	• Incentives for coordination and arrangement for exchange point in case of multilateral matching
(2) Pooled logistics management	• Less times, trips and energy consumed • Labor saving	• Incentive scheme for coordination and collaboration
(3) White-label cash center with NHTO	• Better cash forecast and optimize cash stocks • Reduce the number of newly printed notes or notes in circulation	• Incentive arrangement for industry to adjust business models and operations • BOT Notification on maintaining reserve balance at BOT • Operational risk
(4) White-label ATM	• Reduce operational cost i.e. logistics cost of cash distribution and holding costs given less number of ATMs • Better expansion of cash points across country • Increase financial access	• Incentive scheme that enables collaboration • Members

(3) White-label cash center with Notes-Held-to-Order (NHTO) arrangement

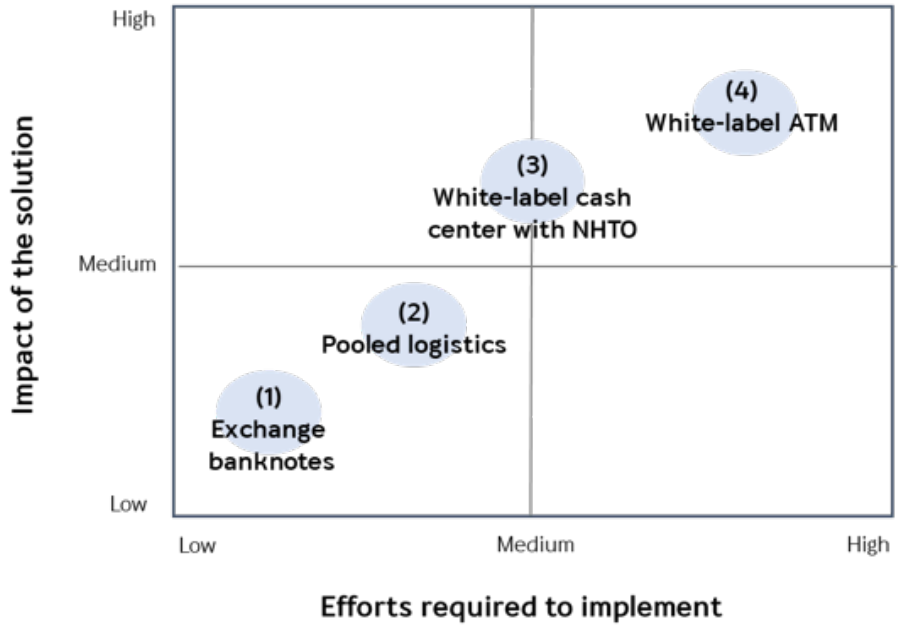
Under the Notes-Held-to-Order (NHTO) arrangement, part of private cash center's vaults can effectively be considered as central bank's vault where central bank will credit the holder's account. Therefore, banks can now count cash at their centers toward the 1% reserve requirement. This would reduce the need for transportation, logistics costs, create conditions for market to optimize its cash stocks and reduce central bank's operations. Some central banks, such as those in Australia, South Africa, the Netherlands and Spain, have already applied the Notes-Held-to-Order (NHTO) arrangement. The BOT is currently exploring this arrangement as it would have an impact on business models and operations of banks. Some concerns must be explored further, including incentive schemes to compensate banks, qualification of cash centers to become a white-label cash center, reward/penalty scheme to ensure note quality and verify vault cash holding.

(4) White-label ATM

A white-label ATM allows customers of any banks (or non-banks) to withdraw cash or do other transactions at any ATMs i.e. no banks' logo or brand put on ATM. Banks and non-banks can benefit through ATM networks that widely spread throughout the country, reducing their operational costs (e.g. logistics and cash holding costs) and labor saving. Moreover, ATMs will be more distributed across country, increasing financial access to those in remote areas. As of now, the Thai Bankers' Association has already discussed and actively explored this option amongst their members to set up white-label ATMs. With rising digital payment popularity, banks must cope with changes in consumer behavior and make adaptations regarding their ATM business model. To unlock efficiencies in our financial system and economy, a collaboration between financial institutions is needed.

Given limited budget, time and resources, it would be difficult to implement all solutions at once. Therefore, to priorities our suggested solutions, we provide an impact-effort matrix which can guide the decision process on which solution should be first carried out. The white-label ATM may have a potentially high impact when compared to other solutions. But, at the same time great, amount of efforts is also required to achieve that. Industry needs to collaborate and coordinate for this new arrangement to work given the investments on their legacy systems and ATM network. Another attractive solution is the white-label cash center with NHTO arrangement. This solution proposes considerable impact/benefits with medium effort. Moreover, we believe that if this solution has been implemented, the other two solutions i.e. pooled logistics and exchange banknotes could indirectly take off afterwards. Under white-label cash centers, industry needs to redesign their operations and logistics which can offer an opportunity to pool logistics management. Besides that, the white-label cash center can be used as the exchange point in case of multilateral banknote matching.

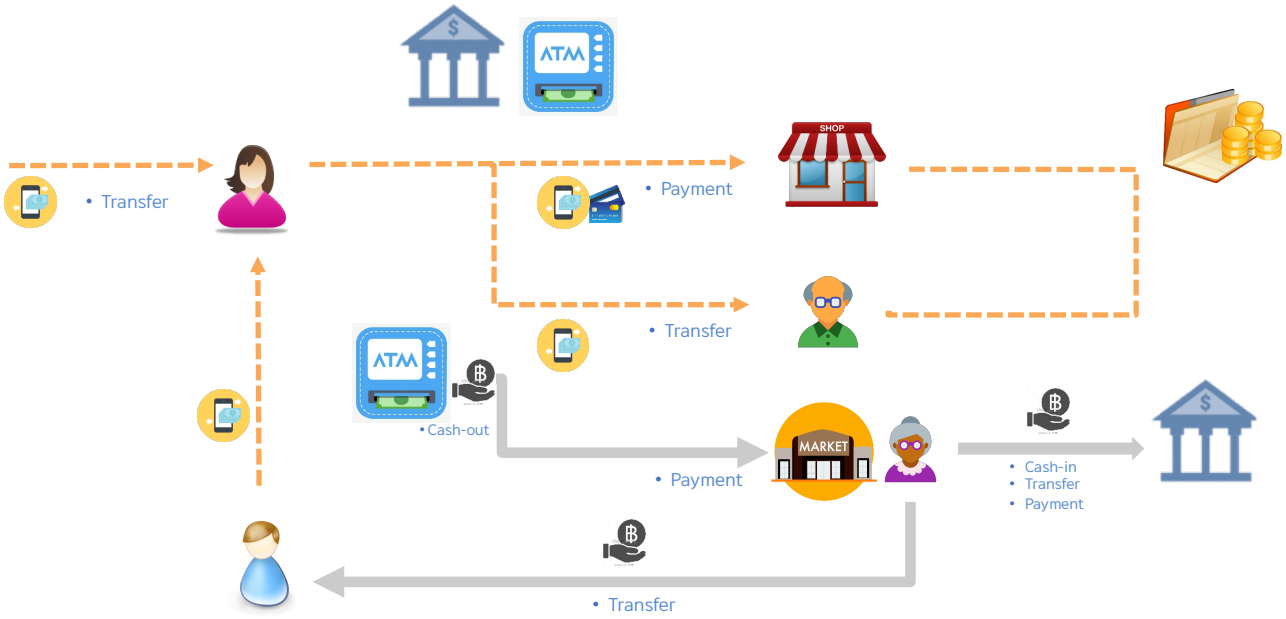
Figure 3.9 Possible solutions to increase cash distribution efficiency



4. Current challenges on going cashless

This section presents key challenges currently faced by Thailand to shift away from cash. In order to become cashless society, coordination is needed among all economic agents to use electronic payments in all transfers and payment transactions. However, in cases that one person uses cash at any point in the system, then cash must still coexist with other non-cash payments. Often, "cash leakage" in the payment system results from the last mile problem whereby some users face either physical or behavioral constraints from using other non-cash payment choices. We provide stylized facts on user's profile and usage patterns of electronic credit transfers via mobile and internet banking.

Figure 4.1 Coexistence of cash and non-cash payment



We explore two contributing factors to the adoption of electronic payments: infrastructure readiness and consumer behavior. First, we identify the extent to which financial and IT/ICT infrastructure are available to accommodate electronic payments by geographical areas. Second, we review cases of consumer behavior that makes e-payment remain an imperfect substitute for cash.

4.1 Infrastructure

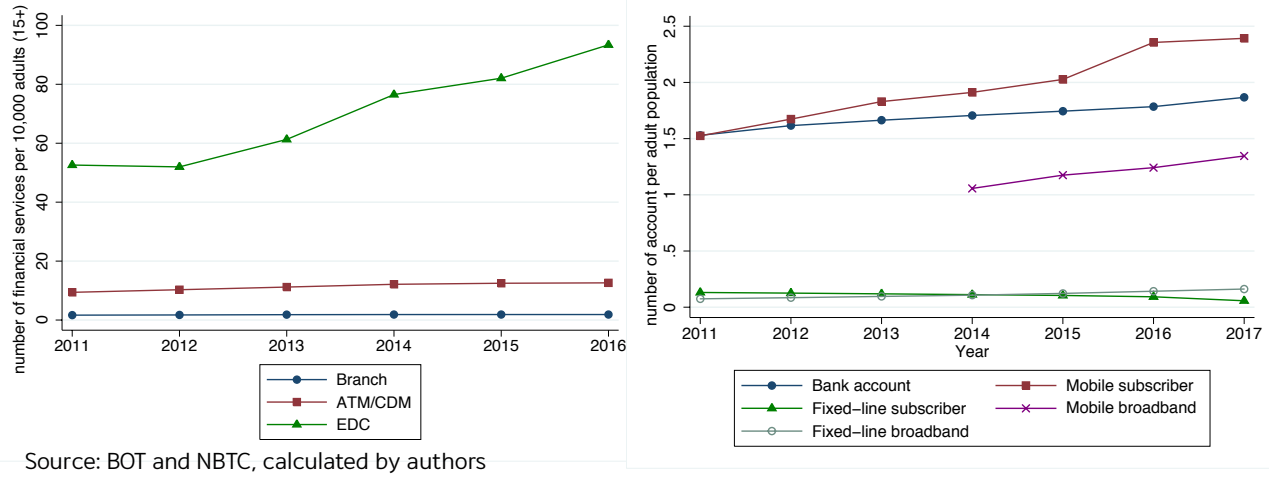
Both physical and IT/ICT infrastructure have improved overtime which would accommodate e-payment adoption and usage (Figure 4.2). Not only does Physical infrastructure in financial services such as ATMs and bank branches enable consumers to withdraw and deposit cash, it also facilities non-cash transactions including credit transfers and bill payments. Such infrastructure reflects options for consumers to make transactions by other means other than solely relying on cash. In Thailand, coverage of physical infrastructure in financial services has continued to improve over time. In 2017, the number of EDC, ATM and branches reached 101.5, 12.3 and 1.8 points per 10,000 adults,[11] respectively.

IT and ICT infrastructure provides the basis for adoption of wide range of electronic payments. Similarly to physical infrastructure, mobile and internet usage has become more prominent overtime. In 2017, there were 2.4

[11] Adult population is over 18 years old, unless otherwise specified.

mobile subscriptions per adult. The number exceeded the number of bank accounts per adult which stood at 1.8. Penetration of mobile broadband also continued to rise in recent years and reached 1.4 mobile broadband accounts per adult in 2017.

Figure 4.2 Infrastructure on financial services



Source: BOT and NBTC, calculated by authors

However, the aggregate number might not completely reflect infrastructure readiness to move toward e-payment. In fact, there is a large variation in coverage of financial services infrastructure across regions and provinces (Chantarat et al, 2018). In particular, the numbers of EDC, ATM and bank branches per adult in the northeast are below the country's averages. Within the region, the south exhibits a large variance ranging from Phuket with the best coverage (e.g. over 60 ATMs per 10,000 adults) to the lowest coverage of physical infrastructure in three southern-most provinces (e.g. less than 10 ATMs per 10,000 adults).

Figure 4.3 Number of EDC, ATM and bank branch per 10,000 adults, by provinces

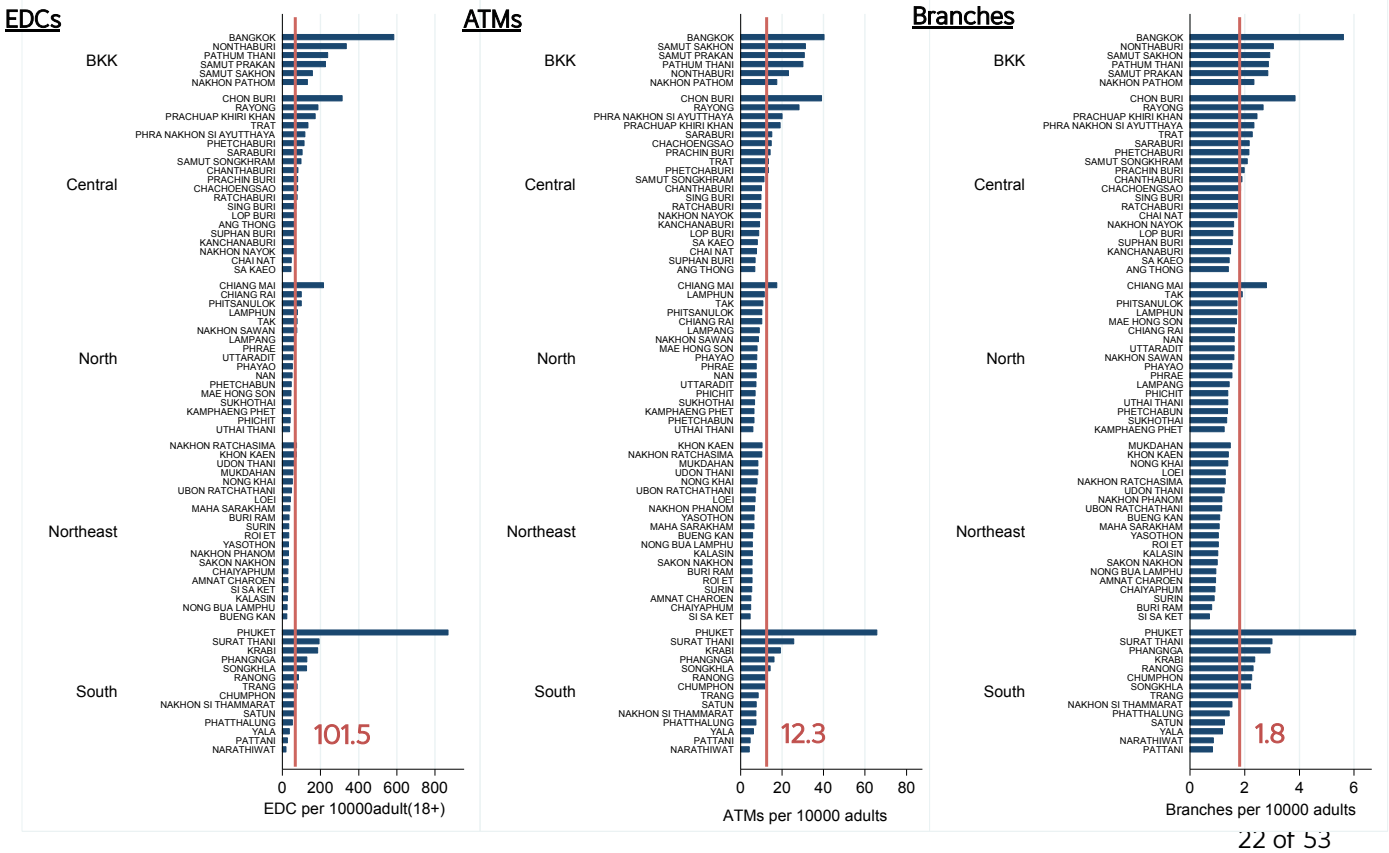
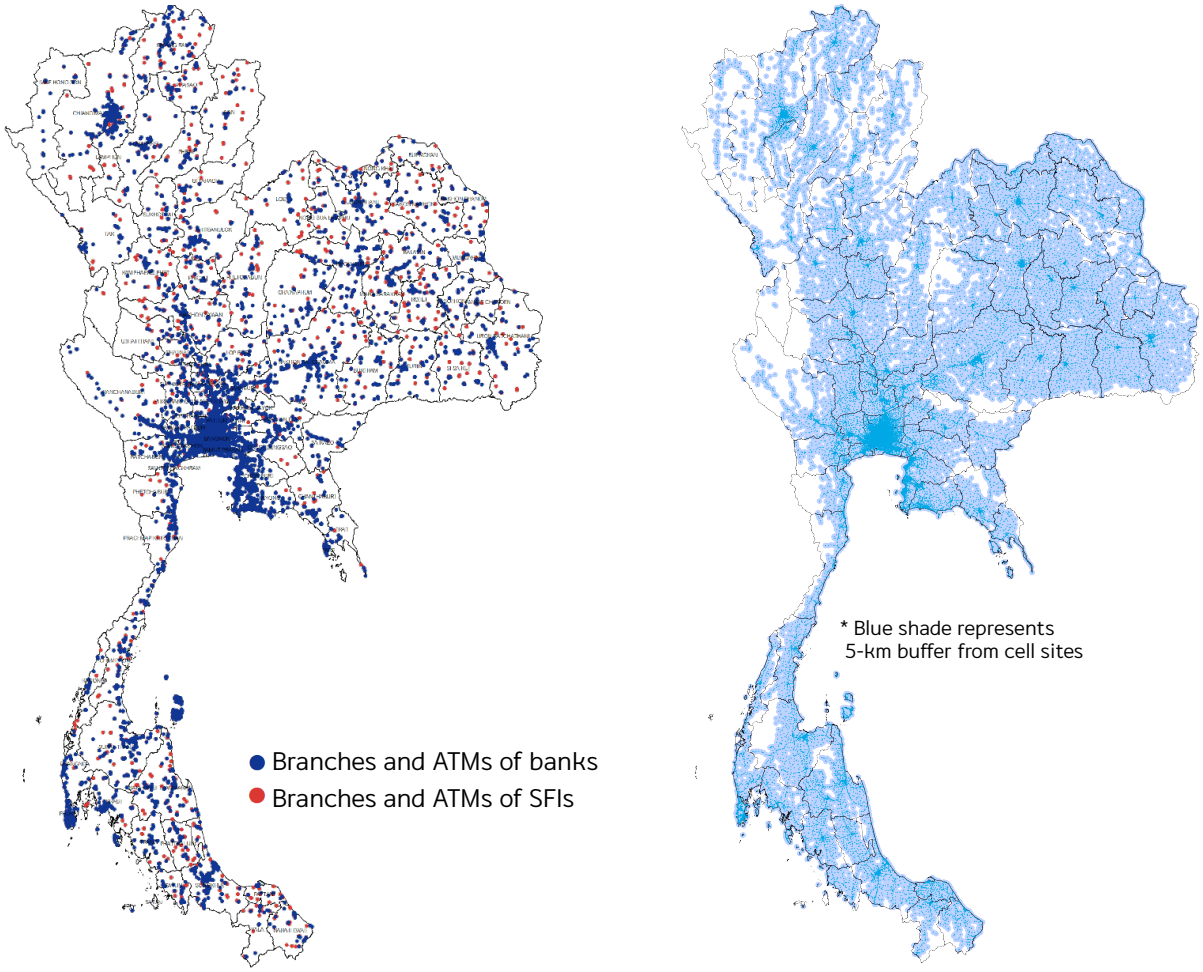


Fig 4.4 Locations of branches and ATMs (left) and areas covered by mobile broadband (right)

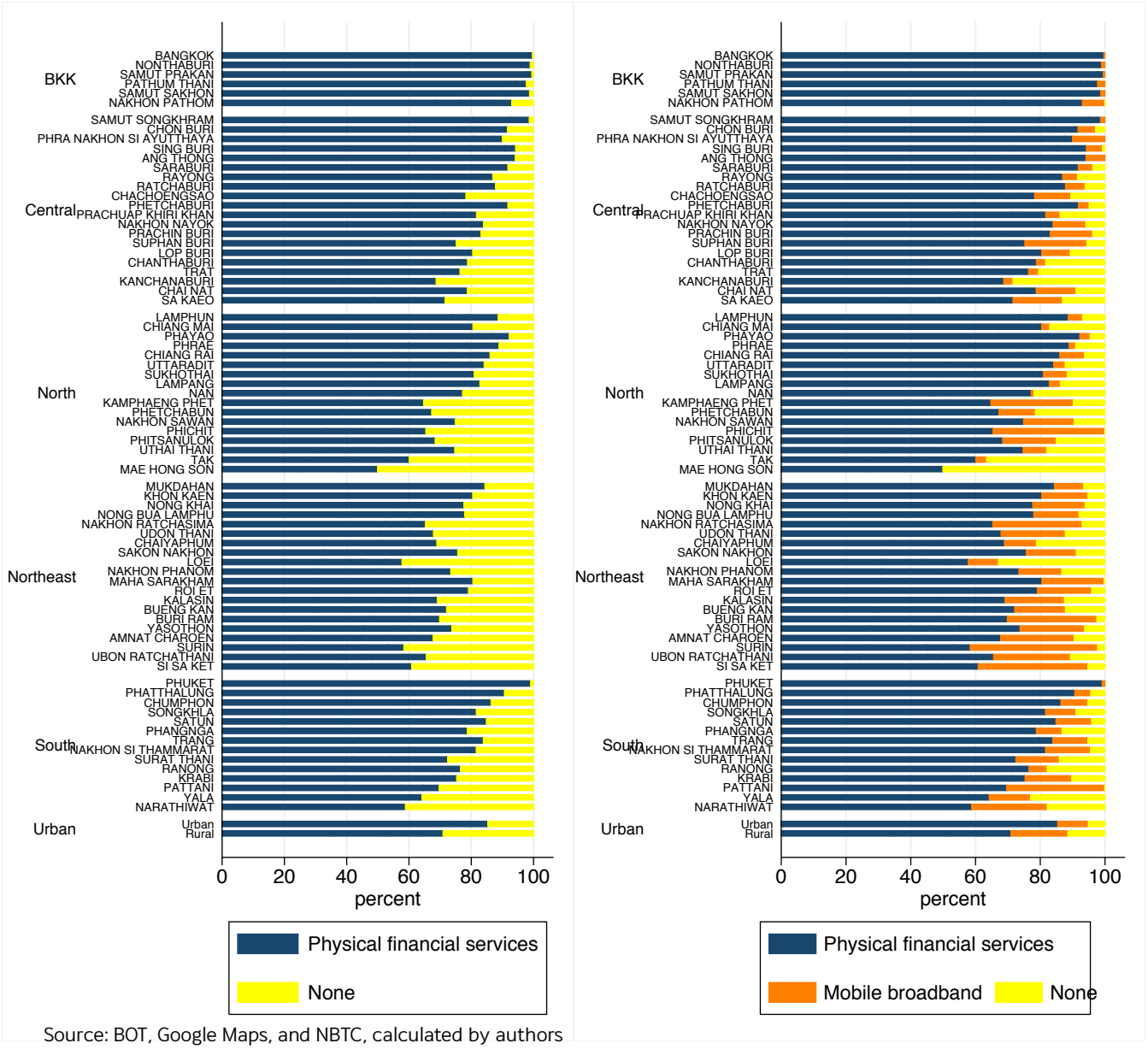


Source: BOT, Google Maps and NBTC, calculated by authors

Limited access to financial services is also highlighted by that fact that 23.2% of villages Thailand are without any financial service point within 5 kilometers (Chantarat et al, 2018). A financial service point includes ATMs and branches of formal financial institutions (commercial banks, SFIs and non-banks), semi-formal financial institutions (village funds and savings cooperatives), and potential banking agents (gas stations, post offices, convenient stores and shops with EDCs). In this regard, adoption of mobile banking or other mobile-based payments could mitigate this limitation, especially in the northeast where the internet coverage is relatively good (Figure 4.4). Areas with stable internet connections are identified at tambol level where mobile broadband coverage per population exceeds 75%.

The left panel of Figure 4.5 illustrates the share of villages with physical financial services. The yellow bar reflects the share of villages currently without physical service points within 5 kilometers. The orange bar in the right panel of Figure 4.5 represents the extent to which mobile banking has the potential to fill in the gap. Among the 23.2% of villages without physical financial services within 5 kilometers, some villages are in fact in areas with stable mobile broadband connections. Should adoption of e-payment occur in such areas, access to financial services can be improved for half of the villages currently being left behind.

Figure 4.5 Share of villages with access to physical financial services and internet coverage



Source: BOT, Google Maps, and NBTC, calculated by authors

Despite improvements overtime in both physical and IT infrastructure, there exist 23.2% of villages with limited access to physical financial services. Nonetheless, only two thirds of these villages are in areas with good mobile broadband coverage. The remaining 8.9% of villages are with convenient access to neither physical financial services nor good internet coverage. In these villages, cash is therefore an inevitable option for consumers to make payment transactions. This partly reflects the last mile problem whereby cash is still needed in the system given the existing infrastructure availability.

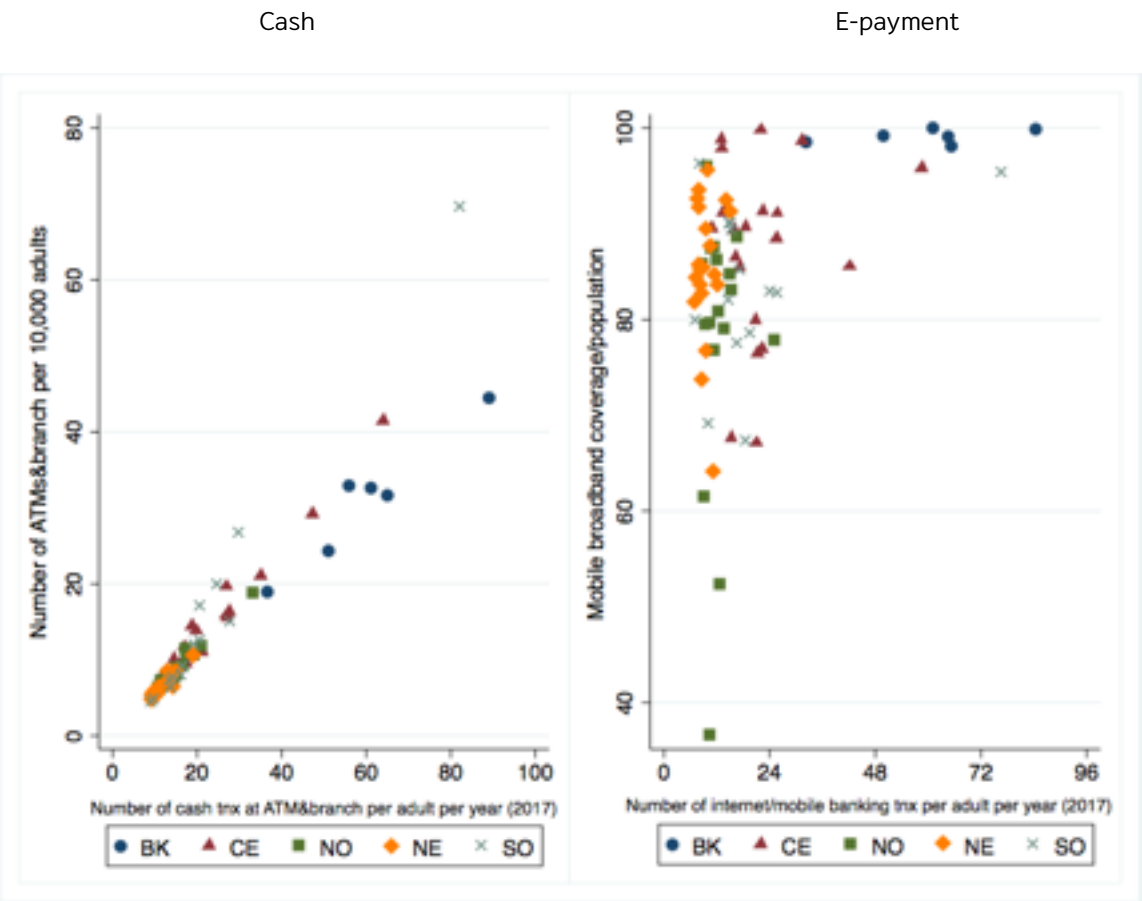
4.2 Consumer behavior

Do we usually see more transactions in areas with good infrastructure? Infrastructure alone does not guarantee adoption of electronic payments. We will illustrate the correlation between infrastructure and usage through cases of (1) cash transactions at ATM and branch and (2) electronic credit transfers via mobile and internet banking.

We first discuss the case of cash. Greater presence of physical financial services such as ATMs and branches makes it convenient for consumers to withdraw cash whenever they want. Cash is then a preferred payment choice. In this case, physical infrastructure is positively correlated with cash usage.

Unfortunately, the relationship between infrastructure and cash usage is not straightforward. (BIS 2018) It can be argued that consumers with convenient access to financial service points can afford to hold fewer physical cash as they can easily withdraw from a nearby ATM. Such consumers also have more options and flexibility in managing their transactions. Instead, consumers who must travel afar to reach a financial service point would instead solely rely on cash transactions. These people are likely to spare a substantial amount of cash in their wallet for daily transactions as well as emergency usage. They may also choose to use other non-cash payment options. Under this scenario, physical infrastructure is negatively related to cash usage.

Figure 4.6 Infrastructure and usage



Source: BOT, administrative data from 5 banks and NBTC, calculated by authors

We explore the relationship between cash usage and infrastructure at province level. An average number of cash transactions at ATM and branches per adult in 2017 (usage intensity) is plotted against the number of ATM and branches per 10,000 adults (infrastructure coverage) in the same year. The left panel of Figure 4.6

illustrates a positive correlation between usage intensity and infrastructure coverage. Usage intensity is higher in provinces with better infrastructure coverage such as Bangkok and its vicinities, while the northeastern provinces see fewer usage and infrastructure.

The right panel of Figure 4.6 plots usage intensity against infrastructure coverage for internet and mobile banking transactions for each province. Usage intensity is a total number of credit transfers via mobile and internet banking in one year. Here, infrastructure is proxied by mobile broadband coverage that is calculated at tambol level and averaged to provincial level. Unlike cash transactions, a number of provinces with good mobile internet coverage observe low usage of electronic credit transfers, particularly provinces in the northeast.

Good infrastructure may not positively correlate with usage due to a number of reasons. First, it might take time for consumers to learn about and adopt electronic payments after infrastructure has been installed. In the case of cash, ATMs have been around since 1983 and consumers are accustomed to cash transactions. Second, mobile broadband infrastructure serves various purposes and multiple applications other than banking, while cash infrastructure such as ATM and branch are specific infrastructure for making financial transactions. Third, consumers will also need data subscription and smartphones/computers to engage in electronic credit transfers. In addition, user characteristics may offer some insights on both adoption and usage intensity of e-payment.

Who are e-payment users?

We offer stylized facts on e-payment users based on two types of data. First, we utilize the BOT's E-payment Survey in 2017 to illustrate e-payment participation by different groups such as age and education. The survey sample is 10,805 persons with age between 18-89 years old from all provinces, both rural and urban areas.[12] Second, we focus on e-payment users and their usage characteristics with actual administrative data on internet and moiling transactions from 5 banks.

As with findings in other countries, Thai e-payment users are also younger, richer and higher-educated groups of consumers according to BOT's payment survey in 2017,[13] Table 4.1 displays the shares of people with access to 3 types of payment methods: cash, semi-electronic and electronic payments. Access is defined as availability and readiness to use such payment channels i.e. registration for internet banking account with an installed mobile application. Cash payments include purchase of goods and services, deposit and withdrawal at branch and ATM. Semi-electronic channel includes fund transfer and bill payments at branch and ATM because consumers can make both cash-based and electronic transactions at ATMs. To pay bills, consumers may choose to deposit cash at CDM/ATM or electronically deduct money from their bank account. E-payment refers to card payments and internet/mobile banking.

Virtually everyone has access to cash payments, while 58% and only 17% of Thai population have adopted semi-electronic and electronic payments, respectively.[14] Most profile attributes show similar patterns for semi-electronic and e-payment. In terms of regions, the northeast shows the lowest share of e-payment adoption of 9% despite its good mobile internet coverage, while the highest adoption rate is in Bangkok and vicinities at 29%. Almost one-third of younger cohorts (18-39) has access to e-payment. Those who earn above 10,000 baht

[12] Weights are applied to correct for population share at province level by urban/rural, sex and age cohorts.

[13] Similar to findings in Bagnall et al (2016)

[14] Around 67% of Thai population has access to computers or smartphones. E-payment and ownership of computer/ smartphone are highly correlated, but e-payment adoption is still lacking.

per month show the largest share of e-payment adoption at 28%. Income likely correlates with education where 44% of college graduates have adopted e-payment. Private and government employees, likely to be in the formal sector, have the highest adoption rates of e-payment at 48% and 34%, respectively.

Table 4.1 Share of people with access to cash, semi-electronic and e-payment

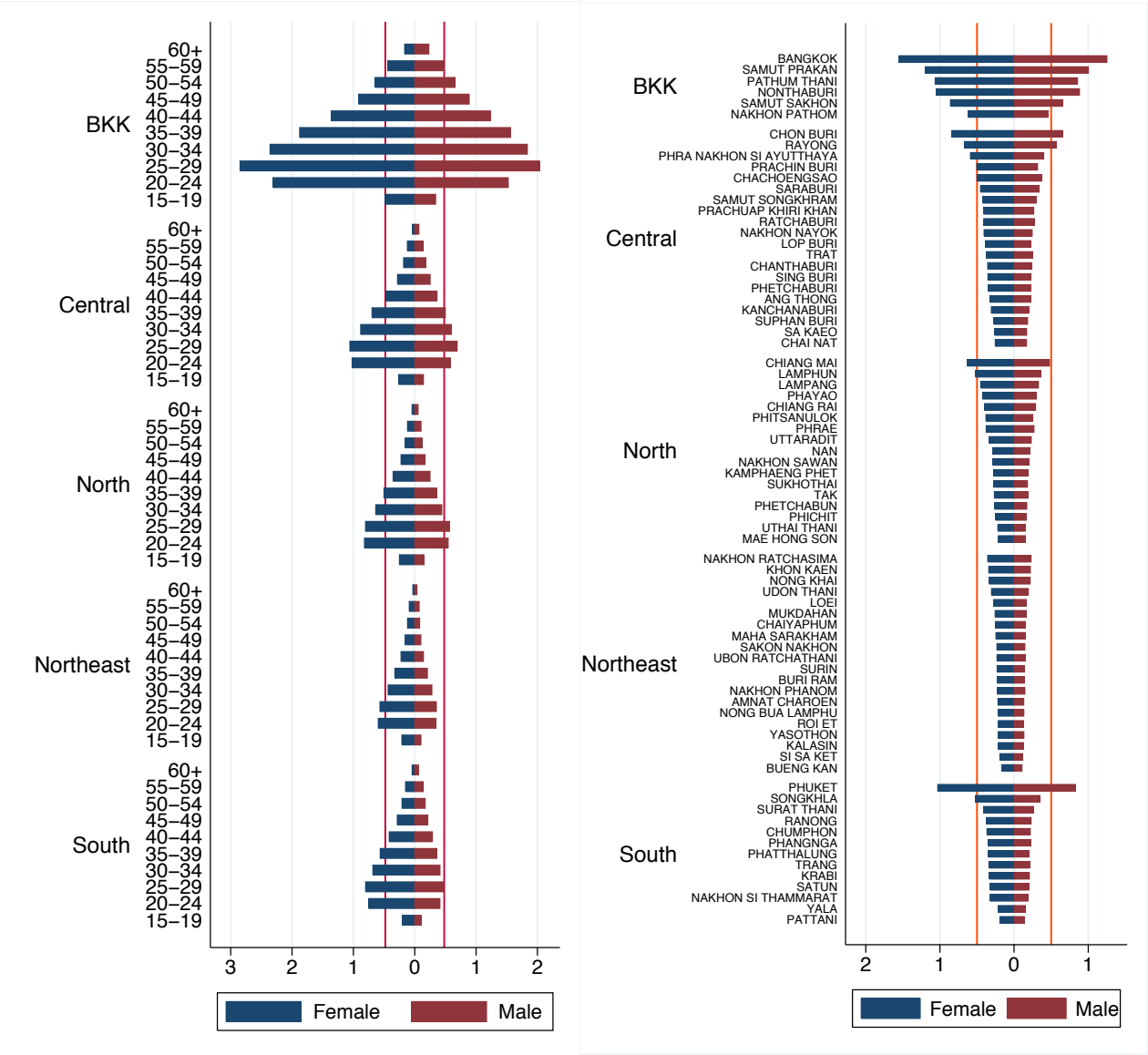
	Cash	Semi	E-payment	Comp/smartphone
Region				
North	97%	54%	14%	65%
Northeast	98%	54%	9%	58%
Central	99%	65%	24%	71%
South	96%	58%	17%	73%
East	98%	62%	22%	71%
West	96%	54%	18%	65%
Bangkok	100%	68%	29%	79%
Age				
18-29	99%	75%	29%	94%
30-39	99%	76%	28%	86%
40-49	99%	64%	15%	69%
50-59	97%	46%	7%	53%
60+	93%	23%	2%	27%
Income				
<3,500	96%	38%	6%	47%
3,501-10,000	98%	57%	14%	67%
>10,000	99%	74%	28%	82%
Education				
Primary	95%	34%	2%	41%
Secondary	99%	70%	19%	83%
Tertiary	99%	88%	44%	93%
Occupation				
No job	95%	38%	10%	48%
Student	99%	70%	27%	97%
Agriculture	97%	47%	6%	52%
Business/trade	98%	65%	26%	80%
Government	99%	89%	34%	94%
Private employee	99%	91%	48%	91%
General worker	98%	57%	9%	65%

Source: BOT's E-Payment Survey 2017, calculated by authors

Now, we zoom in consumers who use electronic fund transfers based on data collected from 5 banks during March-May 2018. Our data comprise total number of internet/mobile banking accounts and usage of individuals (not corporates) by groups of customers based on sex, age group and province.[15] The data were reported by 4 large commercial banks and 1 specialized financial institution (SFI) which represent 53% of total internet and mobile banking accounts, 83% of total transaction volume, but only 33% of total transaction value in March 2018. What our data do not cover are accounts owned by corporates who usually make larger transactions. Therefore, total value of transactions reported in our data are much lower than the overall aggregate.

[15] Unfortunately, we do not have data on individual accounts. The stylized facts presented are group aggregates reported by each bank. For example, a group refers to 25-29 year-old female living in Bangkok and vicinities.

Figure 4.7 Number of internet/mobile banking accounts per person (May 2018)



Source: Administrative data from 5 banks, calculated by authors

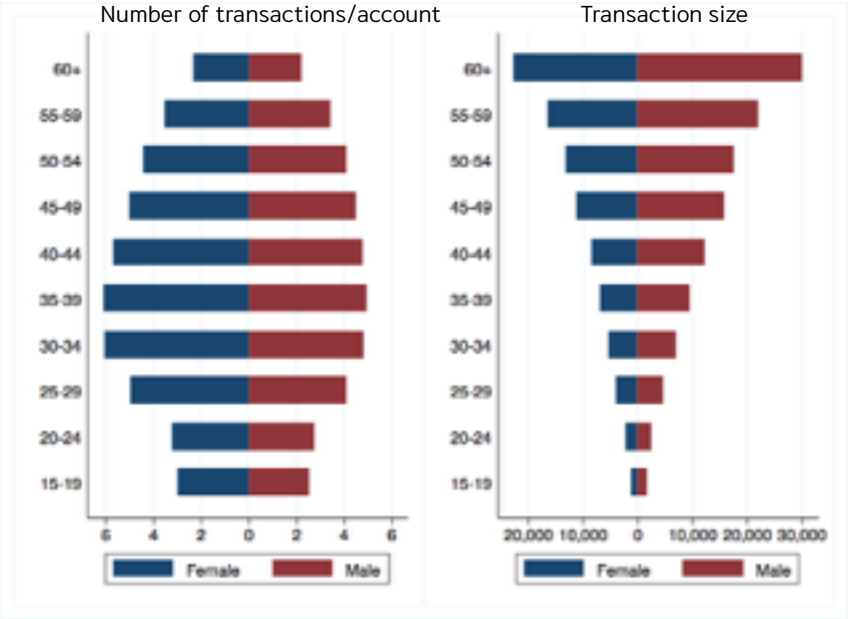
Adoption of electronic transfers is more prevalent among women, 25-34 year olds and those living in Bangkok and vicinities (Figure 4.7). Women have more accounts and make electronic transfers more frequently than men. The number of electronic banking accounts is 0.5 accounts per person on average. Women in almost all age groups have more accounts than the average. In particular, prime working-age (20-34) women in all regions have more accounts than the country's average, with 25-29 year-old women in Bangkok and vicinities having the highest number of 3 accounts per person.

Variation is also observed within region. The right panel of Figure 4.7 pinpoints that consumers in very few provinces have at least 0.5 account per person (the country's average). These provinces are Bangkok and its vicinities, Chonburi, Rayong, Ayutthaya, Chiangmai and Phuket. We also observe a higher number of accounts per person in larger cities in the northeast e.g. 0.3 accounts per person in Nakhon Ratchasima. Women in all provinces also have more accounts than men.

In terms of usage intensity, women also make more frequent transactions when compared to men in all age groups (Figure 4.8). On average, Thai electronic payment users make around 5.5 transactions per month. Women

across all age groups (and in all regions) also make more frequent transactions than men although men make larger transactions than women regardless of age. An average transaction size is 7,562 baht, ranging from a few hundred baht among users age below 20 to around 20,000 baht among 60+ women and 30,000 baht among 60+ men.[16]

Figure 4.8 Usage of internet/mobile banking by age (May 2018)



Source: Administrative data from 5 banks, calculated by authors

What attributes are relatively more important? We employ simple regressions to gauge the extent to which infrastructure and observable customer profile can explain variation in e-payment usage. Regression results are reported in Table A1 in the Appendix whereby two dependent variables on e-payment usage, (1) number of accounts per person and (2) number of transactions per person, are regressed on user profiles—namely sex, age group, and region— and provincial-level infrastructure. The results offer some insights as user profile can well explain who register for electronic banking accounts, while good infrastructure correlates with higher usage volume.

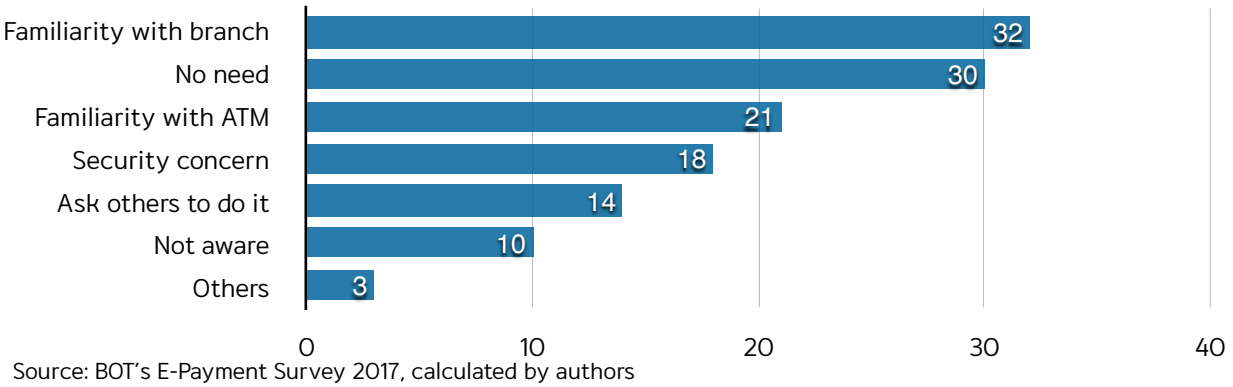
With regard to the number of electronic banking accounts per person, user profiles and internet coverage can explain around 70% of variation across groups. Compared to internet coverage (our proxy for infrastructure), user profile shows statistically significant and larger correlations with number of accounts. In particular, age generally exhibits a downward sloping relationship with number of accounts, except for the 15-19 age group which has fewer number of accounts than working-age population. The largest number of accounts are among the 25-29 year olds who on average have 0.7 accounts more than the 60+ year olds (reference group). People in Bangkok and vicinities are likely to have 0.4 accounts more while those in other regions have slightly more accounts than those residing in the northeast. After controlling for age, region and infrastructure, the difference between women and men (women have 0.1 account more than men) is smaller than the crude descriptive statistics reported earlier.

[16] In aggregate data, an average transaction size is 19,336 baht and one account makes 3.5 transactions per month. The number of accounts per person is 1.05.

Regarding transactions, we also observe similar patterns of user profile. Women, young working-age and Bangkok users make electronic transactions more frequently. In a month, the 25-34 year olds make around 3 transactions more than the 60+ reference group. Areas with internet coverage show a larger correlation with transactions than user profile does. In particular, areas with more than 75% internet coverage display an increase of 0.6 transactions/month compared to usage in areas with scarce internet coverage. Improving internet coverage in areas where people already have electronic banking accounts might see some increase in usage volume. However, observable user characteristics can better explain adoption of electronic banking accounts in the first place.

Nonetheless, there could be other unobservable characteristics such as financial literary and attitudes which would likely play a critical role in adoption.[17] Despite limited data on such characteristics. Survey responses indicate that habits play a critical role on explaining why people do not use digital banking. Around half of respondents reported that they are familiar with making money transfers at bank branches or ATMs, while 14% of respondents ask others to make electronic transfers for them.[18] Nonetheless, there remain 18% and 10% of respondents with security concerns and limited knowledge about digital banking, respectively. The role of financial literary could indeed promote e-payment adoption of at least the latter 3 groups: those who ask others to make electronic transfers for them (14%), those with security concerns (18%), and those who are now aware of digital banking (10%).

Figure 4.9 Reasons for not using e-payment



Source: BOT's E-Payment Survey 2017, calculated by authors

Other roles of cash

Apart from adoption problems, e-payment may not perfectly substitute cash. The literature on cash usage has identified other roles of cash in addition to being medium of exchange. Cash is more than just means of payment, but also used due to precautionary motive and speculative motive. During a financial crisis or when trust in banks is lacking, cash is fall-back payment choice. Following the collapse of Lehman Brothers, Australia saw a 12% rise in values of banknotes in circulation (Cusbert and Rohling, 2013), while notes in circulation in the Eurozone also surged in the first half of October 2008 (ECB, 2008). Stix (2013) finds that people who have experienced a financial crisis are subject to a scarring effect and resort to cash payments due to little trust in banks. In rural Thailand, cash is often stored and used as a financial device in periods when income falls short of

[17] E.g Eelu and Nakakawa, 2018 and Van der Cruijsen and Van der Horst, 2016

[18] We do not know the reasons for 30% of respondents who report no need to make fund transfers. For example, they do not need to make electronic fund transfers because they might not use banking services or might have zero balance in their account.

expenses. Moreover, technology failure still poses concerns if we were to move toward a completely cashless society.

In addition, in periods of low interest rates, the price of cash holding is low (BIS, 2018). At the extreme, negative interest rates mean that consumers pay a fee for banks keep their deposits. In this context, it is better to withdraw money from banks and hoard cash at home. Japan is a case in point where people rushed to buy home safes in order to store banknotes after the Bank of Japan lowered rates to -0.1% for some deposits in January 2016 (Lewis and Harding, 2016). There also exist other behavioral motives to use cash. Von Kalckreuth et al (2011) reports consumer preferences to use cash as an expense monitoring tool during economic slowdown. Moreover, due to its anonymity, cash is also preferred in shadow economy (Schneider and Buehn, 2012).

5. Journey to less-cash society

Despite overwhelming digital technology, challenges on going cashless still remain and cash will likely stay as the most basic form of financial inclusion. Nonetheless, given the high cost of cash transactions, electronic payments can be offered as alternatives in some cases. This section draws lessons learned from Thailand's embarkment on a journey toward less-cash society through cases of PromptPay and transfer fee reduction. With Thailand's payment system at a crossroads, costs and benefits are discussed with regard to each stakeholder including consumers, businesses, regulators and policy makers.

In many countries, initiatives have been taken to cause friction on cash transactions. As the world's leader toward cashless society, Sweden made a major progress and witnessed a dramatic drop in cash usage due to a number of factors. Cash transactions were more costly as the government required merchants to possess certified cash registers in its attempt to tackle value-added tax avoidance. The largest note in circulation was slowly taken out and became invalid in 2013. In Europe and Nigeria, charges were introduced on cash withdrawals from ATM and large cash handling at branches. Some cash machines were also removed to make it inconvenient for consumers to get a hold of cash in the first place. Moreover, cash usage has fallen due to a spillover from other policies such as demonetization of large banknotes to curb corruption in India. After the policy came into effect, digital transactions surged as consumers made adjustments (Rai and Antony, 2017).

On the other hand, e-payment promotion has taken place in a number of countries. It is important to note that countries which are regarded as successful e-payment adopters have undergone unique experiences. This highlights that there is no one-size-fits-all solution to encourage adoption of e-payment. One route is to ensure well-established ICT and financial infrastructure as with the case of faster payment systems in the UK, Singapore and Hong Kong. E-payment has been made a national agenda by coordinating readiness and promoting usage in all aspects of consumer life including public transportation, welfare benefits, and electronic government services. Behavioral incentives are employed to nudge consumers to adopt e-payment. In Taiwan, tax reductions are offered to businesses who use electronic payments. Moreover, digital financial literacy is key to make consumers comfortable and able to make electronic payments in daily life.

However, e-payment initiatives cannot solely be driven by the government. Greater e-payment usage results from collaboration, innovation and competition of service providers. In cases of China and Taiwan, third-party payment providers, particularly non-banks, have played critical roles in inducing consumers to adopt e-payment. Amid tense competition, these service providers offer discounts and compete to attract consumers to use their platform. In these cases, the government or regulator does not directly influence consumer adoption of e-payment, but fosters the market environment that is conducive to competition and innovation. For Thailand, we explore the introduction of PromptPay and the transfer fee reduction in March 2018 as case studies of a common infrastructure in the payment system and market competition.

5.1 Case of PromptPay

In December 2015, the government together with the Bank of Thailand launched the National e-Payment Master Plan to create an efficient and integrated digital payment infrastructure that can support financial transactions made by all sectors. This project led to the introduction of "PromptPay", a fast payment service with similar features to those in other countries such as Paym in the UK, NPP in Australia and Paynow in Singapore (Table 5.1). PromptPay was introduced to address pain points in Thailand's cross-bank fund transfers with three key attributes.

(1) Lower transaction fees

PromptPay's fee structure allows everyone, particularly consumers and small merchants, to access e-payment services at lower costs of 0-10 baht per transaction. Prior to PromptPay, cross-bank electronic fund transfers via mobile/internet would normally cost at least 25-35 baht per transaction.

(2) Single integrated infrastructure

PromptPay is a centralized system that can support online retail payments made from all channels including ATMs, bank counters, as well as mobile/internet banking transactions. The new infrastructure system has consolidated two switching provides in the legacy online retail fund transfer system (ORFT) where one provides services for transactions made via ATM and bank counter, the other provides services for internet/mobile transactions. In the old system, it would be costly and inefficient to develop add-on services or improvements to both systems.

(3) Convenience

PromptPay transfer is more convenient because a payer does not need to input a bank account number to make fund transfers. Instead, a payer enters a proxy ID of the payee's receiving account. Linked with a payee's bank account or e-wallet, a proxy ID can be mobile phone number, national, business tax, biller or e-Wallet ID as well as QR code. Proxy IDs can make it easier for consumers, businesses as well as the government to make payments.

Table 5.1 Credit transfer services

	Thailand	UK	Singapore	Australia
Service name	PromptPay	Paym	PayNow	NPP
Proxy ID	Mobile number National ID Business tax ID Biller ID E-wallet	Mobile number	Mobile number National ID	Mobile number Business tax ID E-mail address
Member banks	23	15	9	53
Channel	Internet/Mobile ATM Counter (some banks)	Internet/Mobile Counter (some banks)	Internet/Mobile Others (by bank services)	According to bank services
Fee	Free	Free	Free	Free
Limit/transaction	Varies by bank e.g. 2 million baht	GBP 250 (11,150 baht)	SGD 200,000 (4.8 million baht)	AUD 2,000 (50,000 baht)

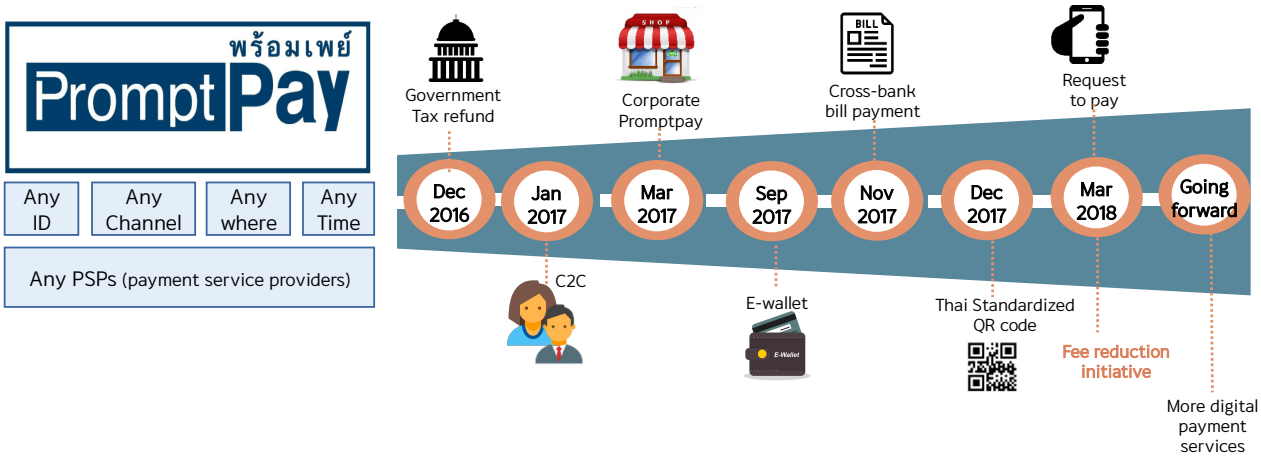
Note: In Thailand, PromptPay is free as banks announced the reduction of electronic money transfer fees, including internet/mobile banking. Prior to that, the fee was between 2-10 baht for transactions above 5,000 baht.

PromptPay infrastructure offers cost saving to all parties. Consumers can conveniently transfer funds to recipients at any banks, and the payments can also be made anywhere anytime with modern devices such as smartphones. For businesses, businesses can benefit from significant cost-savings due to reduced paperwork and cash processing as well as opportunities to sell their product online and instantly receive payments. PromptPay will also improve government disbursement processes, such as social welfare and tax returns. Such

processes should be more transparent and accurate because benefits are electronically transferred with recipients' national ID numbers. Costs can be substantively saved compared to the old disbursement system based on cash and checks.

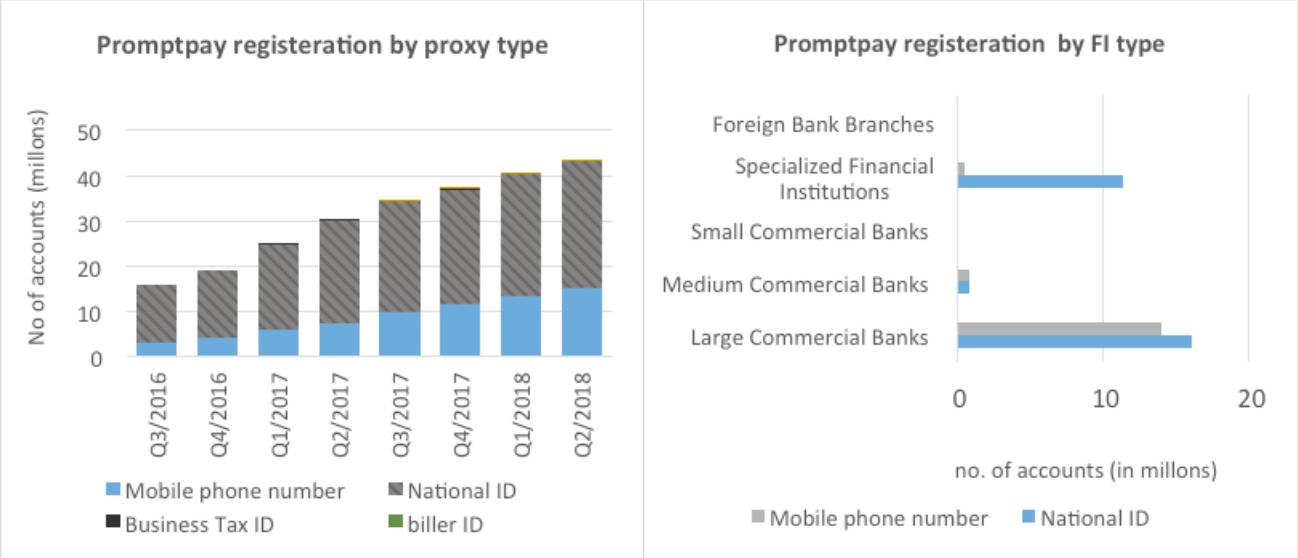
Since the introduction of PromptPay in December 2016, a number of add-on services were introduced on the PromptPay platform. To highlight a few, cross-bank bill payments allow customers to pay bills at any banks regardless of the receiving company's service banks. PayAlert (request to pay) allows sellers to send a payment request to buyers. This helps facilitate e-commerce businesses and provide a channel for billings and payments. The Electronic Donation System (e-Donation) allows customers to donate to charitable organizations such as temples and foundations by scanning QR codes where information will be directly sent to Revenue Department for tax rebate. Customers will also receive an electronic tax invoice that can be used for tax rebate filing.

Figure 5.1 Timeline of PromptPay



Using hourly data on PromptPay transactions, we provide stylized facts on PromptPay usage in 3 dimensions: registration, intra-bank and cross-bank usage, and transaction frequency. As of June 2018, one year and a half after the service launch, over 44 million IDs have been registered for the service and around 2.7 million transactions are made every day. The 44 million IDs registered include 28.4 million national IDs (or around 43% of Thai population), 15.4 million mobile phone numbers and the other 150 thousand proxy IDs such as biller ID, business tax ID, and e-wallet ID.

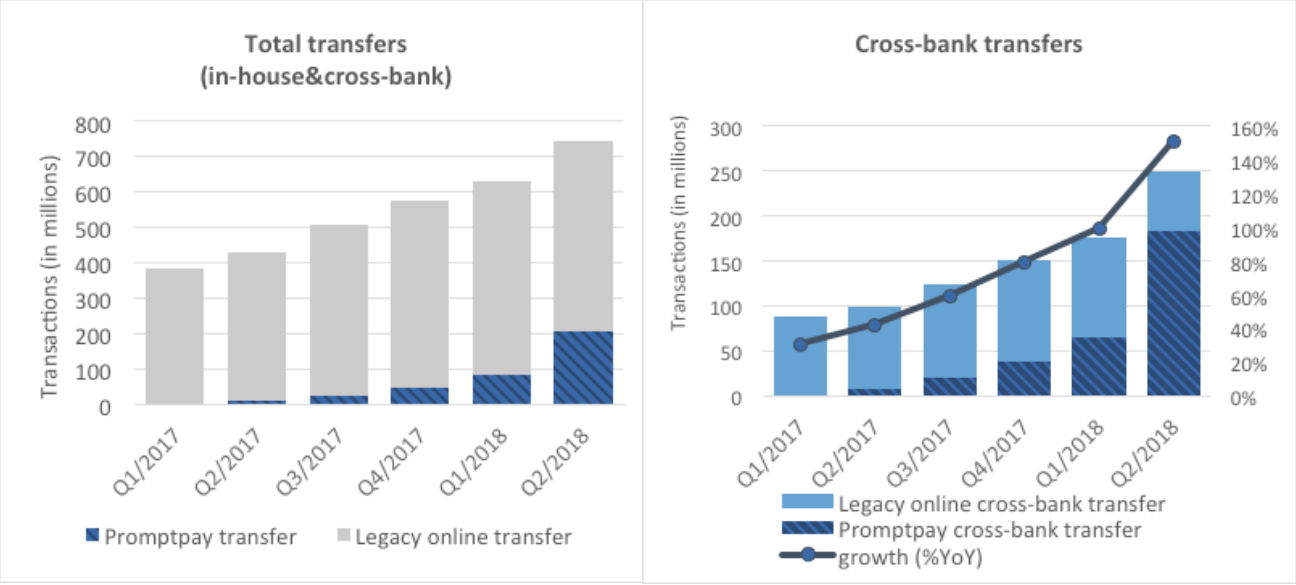
Figure 5.2 PromptPay registration



Source: BOT, calculated by authors

Most people register for PromptPay by linking their national IDs. This is particularly the case for SFIs from where welfare money will be distributed. Biller and business tax IDs are mostly used by real estate companies, educational institutions, department stores, whose customers make monthly bill payments. However, the most active users are those who link their mobile numbers which are easier and more convenient to use in daily life. Around 80% of PromptPay transactions is through a mobile number proxy.

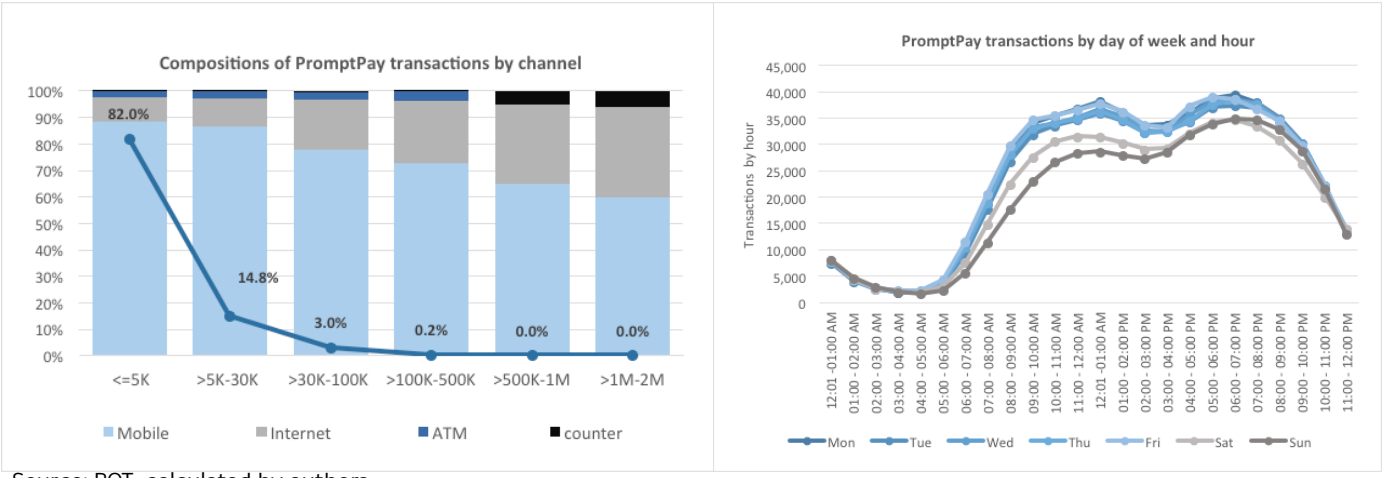
Figure 5.3 PromptPay and legacy online transfers



Source: BOT, calculated by authors

In the past, the majority of online payment transactions were intra-bank (in-house) transfers because fees were normally charged for cross-bank transactions. Total PromptPay transactions accounted for only 1% of total electronic transfers in Q1 2017, while the figure increased to 28% in Q2 2018 (Figure 5.3 left panel). Nonetheless, PromptPay transfers play a greater role on cross-bank transfers and gradually gained a larger share of total cross-bank transactions (Figure 5.3 right panel). In Q2 2018, PromptPay cross-bank transactions rose 6 times compared to the previous quarter, or 152%YOY, mainly due to 2 reasons. First, banks migrated their mobile/ internet banking transactions from the old ORFT system to the PromptPay system. Now, electronic transfers made by bank account numbers are also executed on the PromptPay platform. And second, a number of banks made an announcement to waive fees on electronic transfers via mobile and internet banking.

Figure 5.4 PromptPay transaction size and frequency

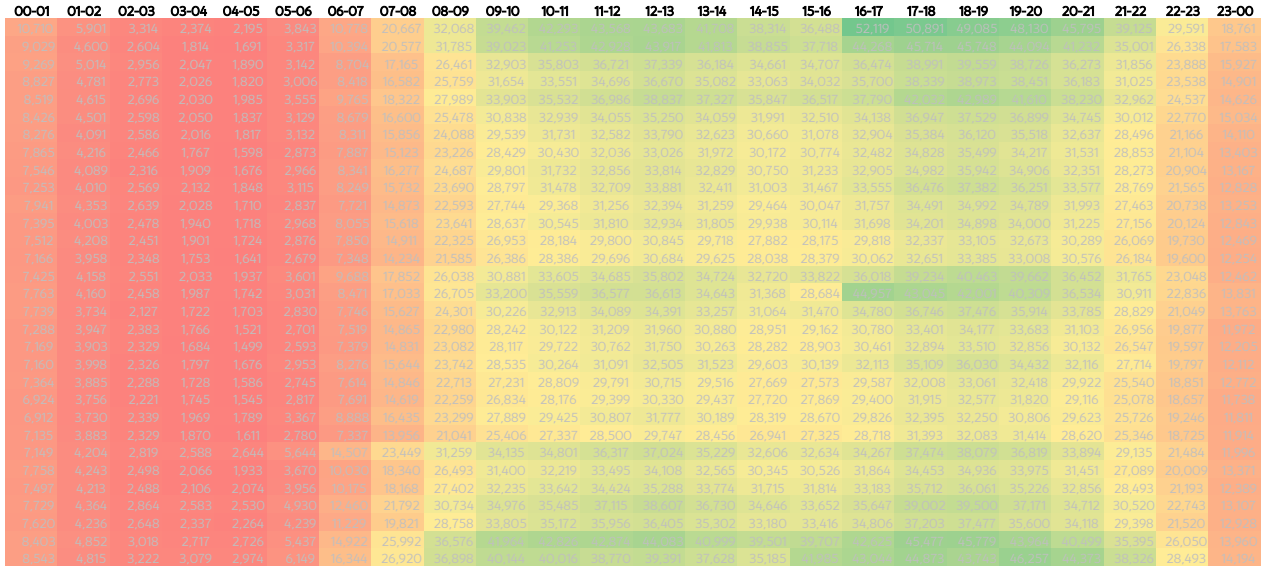


Source: BOT, calculated by authors

Most of money transfers with PromptPay is low-value and likely used by individual consumers for day-to-day transactions. The left panel of Figure 5.4 shows that 82% of total transactions is below 5,000 baht. In terms of payment channels, most of transactions are made via mobile device, while people resort to internet banking and bank branches for higher-value transactions. Transactions below 5,000 baht were initially fueled by the zero transfer fee at the beginning of PromptPay. Nonetheless, after banks waived the fees on online transfers, low-value transactions still dominate total transfer volume. Indeed, the average transaction size has been steadily decreasing from 7,000 baht/transaction in early 2017 to about 4,600 baht/transaction in 2018.

PromptPay transactions show higher volume during weekdays compared to weekends (Figure 5.4 right panel). Yet, the intra-day patterns are similar across days of a week. The number of transactions peaks during lunch (12.00-13.00) and after work (18.00-19.00). The heat map in Figure 5.4 illustrates that there are more transactions around the beginning and end of month, similarly to patterns of cash in circulation. Moreover, we also observe higher volume of PromptPay transactions during the middle of a month. In particular, transactions jump over 50% during 2 hours between 15:00-17:00 on the 1st and the 16th.

Figure 5.4 PromptPay transactions by date of month and hour



Source: BOT, calculated by authors

The introduction of PromptPay has provided a centralized infrastructure for digital payment services. Among others, online money transfers can utilize the PromptPay platform and have shown impressive growth of 34.9%MOM on average. However, questions remain whether cash usage has decreased following more intensive digital transactions. Based on an econometric estimation with monthly data during 2010-2017, preliminary findings on the relationship between PromptPay usage and currency in circulation suggest that higher PromptPay usage, especially through internet/mobile banking, has contributed to a slower growth of cash (Thonghui et al, 2018). Their contribution is also larger than that from other forms of electronic payments such as card payments.

The case of PromptPay has underlined the importance of available infrastructure that enables adoption of digital transactions. High growth of PromptPay transactions and the declining transaction size suggest that consumers use PromptPay services to make day-to-day transactions, those which may have been transacted by cash. With PromptPay infrastructure in place, other add-on digital services can also utilize the system and allow innovations on digital transactions. Less costly online money transfers certainly put pressures on transfer

fees previously charged by banks. In fact, banks later made a major adjustment by waiving transfer fees for transactions made by mobile/internet banking.

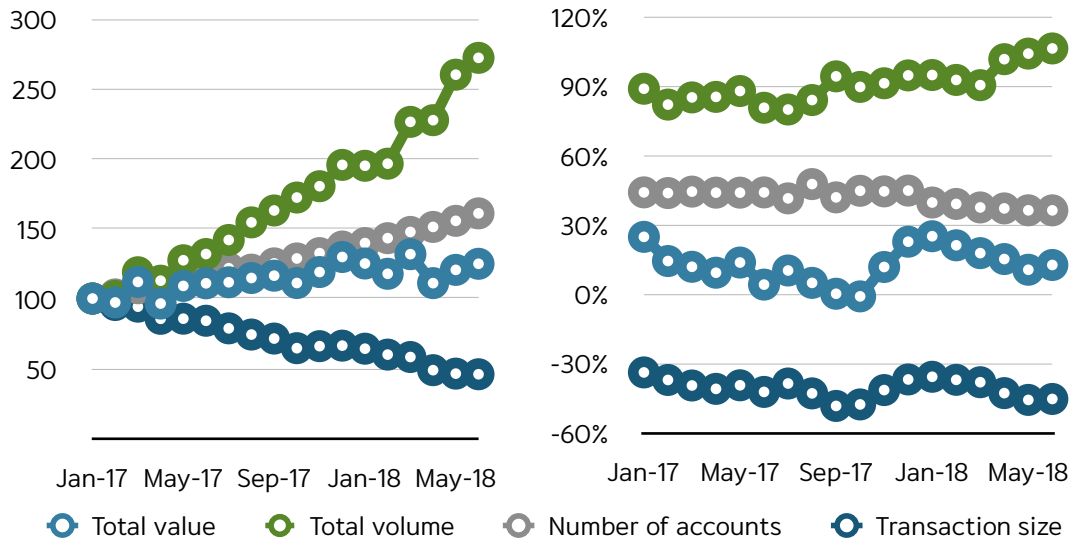
5.2 Case of fee reduction

Prior to March 2018, electronic fund transfers were subject to a minimum fee of 25 baht per transaction for most banks. Fee income of all 30 banks totaled 196 billion baht in 2017 and enjoyed significant growth over years. On March 26, the Siam Commercial Bank was the first to waive transfer fees for all electronic fund transfer services on their mobile application including credit transfers and bill payments. Other banks, such as Kasikorn Bank, Krungthai Bank and Bangkok Bank, followed the lead in just a couple of days later and announced to have their fees reduced.

The fee reduction highlights 4 features of Thailand's retail payment dynamics. First, competition among banks was a key driver of fee reduction. It was a competition to attract customers to make transactions in their system. The larger the customer base, the better network effects banks can enjoy and exploit in the future. The move was industry-driven although it was also made possible by the available infrastructure and value of data which showcase the second and third features.

Second, available common infrastructure has been put in place thanks to the introduction of PromptPay. PromptPay is not a banking product, but rather a platform on which existing and future banking products can utilize. In fact, the legacy system of fund transfers by bank account numbers gradually moved to the PromptPay platform in March 2018. Third, transactional data on electronic transfers can provide banks additional information about their customers. Banks can later offer or tailor products that suit spending and financial behavior of each customer. And fourth, costs of cash handling for transactions at branch and ATM are expected to fall. The latter two features should promise a good business outlook going forward.

Figure 5.5 Index (left) and %YOY (right) of internet and mobile banking fund transfers



Source: BOT, calculated by authors

The recent monthly data, as of June 2018, on electronic fund transfer via mobile and the internet reveals heavier usage among Thai consumers (Figure 5.5). The transfer volume saw an impressive growth of over 90%YOY in the past year. The number of electronic banking accounts and their transfer value also significantly

grew despite at lower growth rates (40%YOY and 20%YOY respectively). As a result, transaction size has become smaller. This reflects that users who have already started engaging with electronic transfers are now making transactions more frequently.

Now we zoom in during the fee reduction period between March and May 2018 (Table 5.2). The number of accounts increased 5.4%, slightly lower than an average 2-month change of 6.0% during the past two years. During the two months, around 3 million accounts were registered, or 1 new account per 18 persons (0.06 account per person). The number of transactions surged 14.9% compared to a historical average 2-month change of 11.4%. An average number of transaction volume per account per month increased from 3.6 in March to 3.9 in May. The figures could suggest that the fee reduction prompted existing users to make more transactions, more than inducing users to register for new accounts.

Table 5.2 Change in internet and mobile banking during March-May 2018

	%Change MAR-MAY (5 banks)	%Change MAR-MAY (total)	Historical average of 2-month growth (2016-2017)
Value	3.7	-8.5	4.4
Volume	7.0	14.9	11.4
Number of accounts	4.7	5.4	6.0
Transaction size	-3.1	-20.4	-6.8

We consider a subset of data from 5 banks with some user profile (data as described in Section 4.2: who are e-payment users?) to further understand changes during the fee reduction. Table A3.2 in the Appendix reports regression estimates whereby the March-May difference in number of accounts and transactions is regressed on group characteristics: sex, age and region. Bangkok and vicinities enjoyed the largest increase in e-payment usage during the fee reduction after controlling for existing usage in March 2018 and internet coverage. The southern region indeed saw the lowest increase.

Younger cohorts experienced the largest increase of e-payment usage, both in terms of number of accounts and transactions. Those with age between 20-29 years old saw the largest increase. Women also showed a larger increase of usage when compared to men although women also have more accounts and make more transactions in the first place. This could suggest that, in comparison to men, women are more likely to adopt new technology like e-payment. In summary, increased usage during fee reduction was most evident among women, younger cohorts and those living in Bangkok and vicinities. Future campaigns on e-payment promotion might target these groups as they are likely to use more frequently. For other groups, additional insights on reasons for not adopting e-payment could be useful to design ways to attract them.

5.3 Future of Thailand's retail payment

Before delving further into the future of retail payments, we might like to revisit what we mean by money and why it exists. Since Adam Smith's The Wealth of Nations in 1776, economics textbook definition of money has referred to its roles as a store of value, medium of exchange and unit of account.

"These functions of money operate in a hierarchy. There are many assets that people view as stores of value — houses, for instance — that are not used as media of exchange. By comparison, an asset can only act as a medium of exchange if at least two people are prepared to treat it as a store of value, at least temporarily. And for an asset to be considered a unit of account, it must be able to be used as a medium of exchange across a variety of transactions over time between several people." (Carney, 2018)

With these functions, existence of money has solved the problem of double coincidence of wants whereby trade between agents A and B can only take place when A wants what B produces and B also wants what A produces. Without money, only quid-pro-quo trade can occur. Money has made exchanges more likely to occur by changing the "double" coincidence of wants into "single" coincidence of wants— either A likes what B produces or B likes what A produces.

This paper considers fiat money in two forms: cash and e-payment. These days, we hold both paper money (or cash) and, among others, bank accounts (electronic money). Different payment forms define the experience, cost, efficiency, or even usability of the asset that we call money (Fatas and Weder di Mauro, 2018). The three functions that may not be equivalent as payment forms are also defining the value of money. Paying by cash, credit card or electronic fund transfers may cost differently in a purchase of the same product. Nonetheless, money does not need to be equivalent among the three functions it serves, but its existence can solve the problem of double coincidence of wants.

E-payment methods such as electronic fund transfers, though still based on central bank's money, do not offer the anonymity property that cash enjoys. For any form of fiat money— paper or electronic, usage crucially relies on the network effects. The more people who accept the payment method, the better this payment method can serve as medium of exchange. And, in order to popularize non-cash transactions, the payment process must occur readily and easily through a payment device, authentication process and infrastructure.[19]

Toward less-cash society

At the foundation of less-cash society, financial inclusion must be ensured.[20] Infrastructure needs to be available and distributed across geographical areas which include access to financial services such as bank account,[21] and physical financial services such as bank branches, ATMs and top-up machines. Affordable payment device such as smartphones and reliable internet coverage[22] are also key basic infrastructure. In addition to infrastructure, adoption remains an issue where initiatives are needed to nudge consumers,

[19] To use electronic money as medium of exchange, a general process of payment requires 3 elements: a device that makes payment (e.g. credit card, internet banking account, smartphone application), a way to authenticate both the buyer and the seller (e.g. signature, fingerprints, PIN code), and an infrastructure that connects the buyer's account to the seller's account.

[20] Rogoff (2016) proposes 3 guiding principles to phase out paper currency after having laid out drawbacks of cash. First, anonymous untraceable transactions must be more difficult to make. Second, the transition out of cash needs to be slow and will take at least 10-15 years. And third, access to free basic banking accounts and smartphones must be ensured for the poor and unbanked individuals.

[21] On 23 July 2018, the BOT and 16 FIs (14 Thai banks and 2 SFIs) announced the basic banking account initiatives which aims to widen opportunities for the unbanked to access financial services and digital payments. This basic bank account would be fee-free deposits and have no minimum balance requirement.

[22] One of the government's initiatives is the nationwide broadband internet project. Last year, 25,000 villages were enable to access to free-WiFi hotspots via fiber optics network. Moreover, home broadband also increases access at affordable prices.

especially those with readily infrastructure and payment device, to change their behavior. While digital adoption rate takes time and varies across technology, smartphone technology has become a game changer in digital retail payment with impressive penetration and features of real-time, convenient, and 24/7 connectivity.

Developments of a new faster payment system, a shared payment infrastructure, requires collaboration from the government, Bank of Thailand and the industry, especially financial institutions and non-bank service providers. Once dominated by banks, the retail payments industry will benefit more from new players e.g. non-bank service providers who offer diverse products that meet needs of consumers in different segments. A new platform can enable payment service providers to compete and innovate simpler, cheaper, and user-friendly payment products. Most importantly, network effects can take place when more services are utilizing the platform with more consumer and business users. To coordinate relevant parties to engage on the platform, we can unlock the potential gain from the system with incentive schemes and alignments among the government, regulator, service providers as well as users. On the government side, both infrastructure and adoption initiatives must be provided to both consumer and business users. A centralized infrastructure that is interoperable will enable payment service providers, banks and non-banks, to be on the same platform and provide seamless customer experiences. At the same time, initiatives to encourage adoption must simultaneously take place such as tax benefits for merchants/retailers and government welfare card for consumers. Such measures should aim to induce consumers to be familiar with using e-payment.

On the regulator side, regulatory framework must support innovations and foster competition while ensuring cyber security and financial stability. Regulations must not hinder product innovations that often result from market competition. For instance, to encourage a level-playing field among incumbent providers and new entrants, an open API platform of open consumers' data will facilitate market entry of third-party payment providers (TPPS) to compete and offer competitive products to consumers. A new digital banking license will help encourage new players, e.g. platform, and enable regulators to oversee them regarding their digital services which may differ from traditional banking. On payment service provider side, new products and services may consider offering discounts, loyalty programs or incentives for consumers to try out. Service providers should also promote digital literacy and cyber security so that their customers are safeguarded against cybercrimes and will continue using their digital payment services.

In fact, all parties can benefit from a shift toward less-cash society. For consumers, more choices of simpler, cheaper and user-friendly payment services will save time and travel costs e.g. wait time at check-out retail counters. For merchants and retailers, significant cost savings are possible from fewer workers needed to handle cash and consolidate cash balances. For the government, increased economic activities due to new businesses will raise tax collections. The overall welfare of the country will further benefit from improved quality of life, lower cash-related crime and shrinking informal economy. Data recorded from e-payment transactions can also be utilized for other purposes such as loan applications. Digital payments may possibly uplift the country's economic potential and promote inclusive growth.

However, we must also bear in mind potential drawbacks of less-cash society. Some consumers may be marginalized due to limited access to infrastructure or digital illiteracy. Cyber risks and technology failure remain obstacles for users to completely rely on digital transactions. Business and government must bear substantive fixed costs to install electronic payment devices as well as upgrading the accounting system in spite of increasing returns to scale of e-payment infrastructure. With fewer paper cash, central banks are indeed faced with tremendous challenges from falling seigniorage and constrained monetary policy transmission channels. Furthermore, advance technology also gives rise to other digital monies which might one day be alternatives to central bank money.

Central bank's role

The central bank's role in the payments system has adapted and expanded overtime through different stages of payments landscape and technological innovation. At an initial stage of a new technology wave, its major role is to establish a common infrastructure and make technology available to service providers. This is when BAHTNET, the high-value fund transfers real time gross settlement, has been developed and operated by the BOT. In some cases, initial operations are also carried out by the central bank itself, but later operated by private sector. During the early days of ATMs in Thailand, the BOT facilitated the industry in building shared ATM infrastructure that pooled the ATM operations across banks, while continuing to operate the legacy retail payment system. After service providers have adopted the common infrastructure and began running payment services, the central bank spins the retail payment system operation to industry. Moreover, the central bank expands its role toward oversight and supervision while maintaining its role as an operator of the wholesale payment system. For example, fee ceilings are imposed to ensure affordable payment services to consumers. Security standards are put in place to safeguard consumers as well as preventing system failure. This is to ensure the safety and efficiency of payment system, safeguard financial stability and promote market competition and fairness to consumers.

Now, with digital payment technology, a new retail payment infrastructure of PromptPay, has been set up with collaboration of the industry, government and the BOT. Apart from being a catalyst for digital infrastructure development, one of the BOT's mandates is to ensure the safety, efficiency and resilience of payment system as well as promoting market competition and fairness through the new Payment Systems Act and the Payment Systems Roadmap. Through the National E-payment Master Plan, the BOT aims to facilitate and promote collaboration among players and stakeholders in sharing infrastructure and promoting innovation. Moreover, the central bank must promote market mechanisms in allowing new payment services and new players to compete. However, regulations imposed on existing providers must constantly be reviewed and made flexible to accommodate changes in technology and business model. Under this role, the central bank is therefore a facilitator of innovation because new products and services can emerge.

Amid fast-changing technology, the central bank must also work closely with the industry as uncertainties remain at this critical juncture where one does not know the best practice or solutions. Looking beyond electronic payments, a new wave of payment technology, i.e. distributed ledger technology (DLT), promises to streamline, payment, clearing and settlement processes by reducing the number of intermediaries and eliminating the need for reconciliation among those that remain (CPMI, 2015 and 2017). This would then disrupt the payment landscape. The industry already began exploring and started using the DLT technology to improve their operational efficiency e.g. blockchain-based letter of guarantee and FX cross-border transactions. In such cases, the BOT has enabled experiments of financial innovations through a regulatory sandbox with more flexibility and engagement with the industry's evolving technology developments. Moreover, in a larger extent, the BOT has also started to look at the possibility of using DLT technology in wholesale payment system. Under the Project Inthanon[23], the BOT has worked closely with 8 financial institutions in co-developing a new way of conducting interbank settlement through wholesale Central Bank Digital Currency (CBDC). While the wholesale side has already begun, the CBDC may take some time to gain presence in retail payments.

[23] The first phase will begin in Q1 2019 whereas third-party fund transfers and cross-border fund transfers will follow.

6. Conclusion

This paper outlines the existing payments landscape in Thailand in several dimensions including cash, physical and IT/ICT infrastructure in financial services, and consumer behavior on e-payment adoption. While certain segments of population have already engaged with electronic transactions, cash remains the main payment method for the majority of Thais. With technology advancements, payment methods will inevitably continue to evolve just as financial innovation saw multiple breakthroughs throughout history.

What will the future of Thailand's retail payment look like? While overwhelming technology points to a shift away from cash payments, cash will likely persist due to a number reasons. Despite infrastructure readiness in most areas, the last mile problem still exists and cash is needed to ensure financial inclusion. Moreover, cash is not solely a transactional device, but it also serves other roles such as a fall-back option during times of economic uncertainty or technology failure. In addition, our paper underscores different cost structures of cash and electronic payments. Cash payments are subject to huge variable costs of logistics and transportation, while electronic payments yield increasing returns to scale. Adoption of electronic payments is an attractive alternative to improve overall welfare of society. Therefore, further coordination between the regulator and industry is critical in improving efficiency in the cash system, given that cash will probably stay for some time.

Nonetheless, digital payments are undeniably becoming more popular as they have proven to be less-costly and convenient real-time payment options. With Thailand's retail payments at a crossroads, the central bank can work to induce desirable changes due to its roles as a banknote printer and payments policy regulator. In addition to providing a common infrastructure platform, the central bank should embrace market mechanisms and must work to remove any regulatory barriers that currently hinder competition and innovation. The central bank should together move with the industry to foster an ecosystem that enables both existing and new players to compete in a level-playing field.

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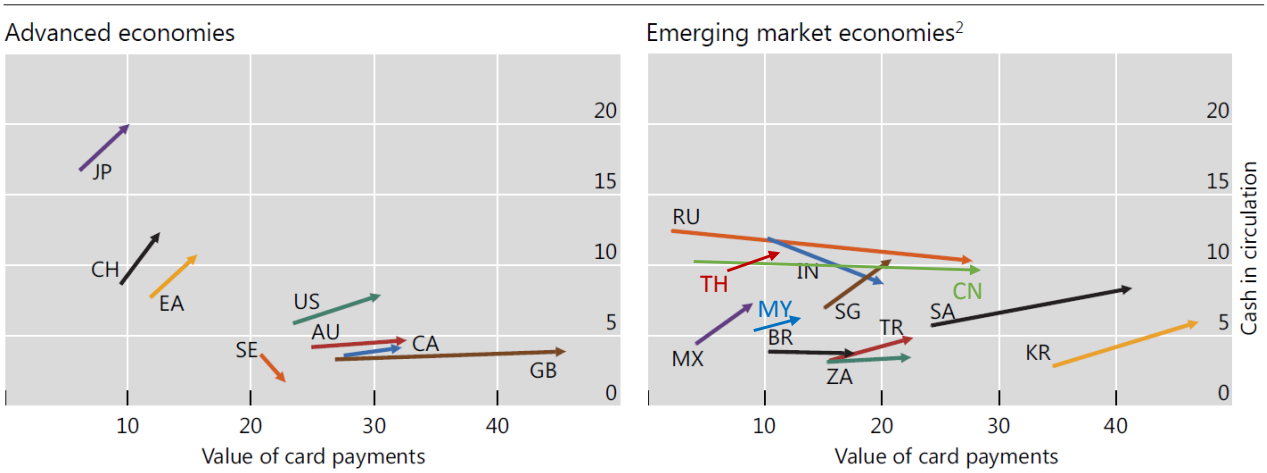
Appendix

A1

Figure A1 Change in cash and card usage during 2007-2016



Source: BIS, BOT, BNM and PBOC, calculated by authors

Table A1 Share of transactions made by cash and cards

Share of transaction	US	NL	CA	FR	AU	AT	DE	TH
Cash	46%	52%	53%	56%	65%	82%	82%	86%
Debit card	26%	41%	25%	31%	22%	14%	13%	0.2%
Credit card	19%	1%	19%	1%	9%	2%	2%	0.2%
Transactions/month	56	50	48	36	63	40	40	53

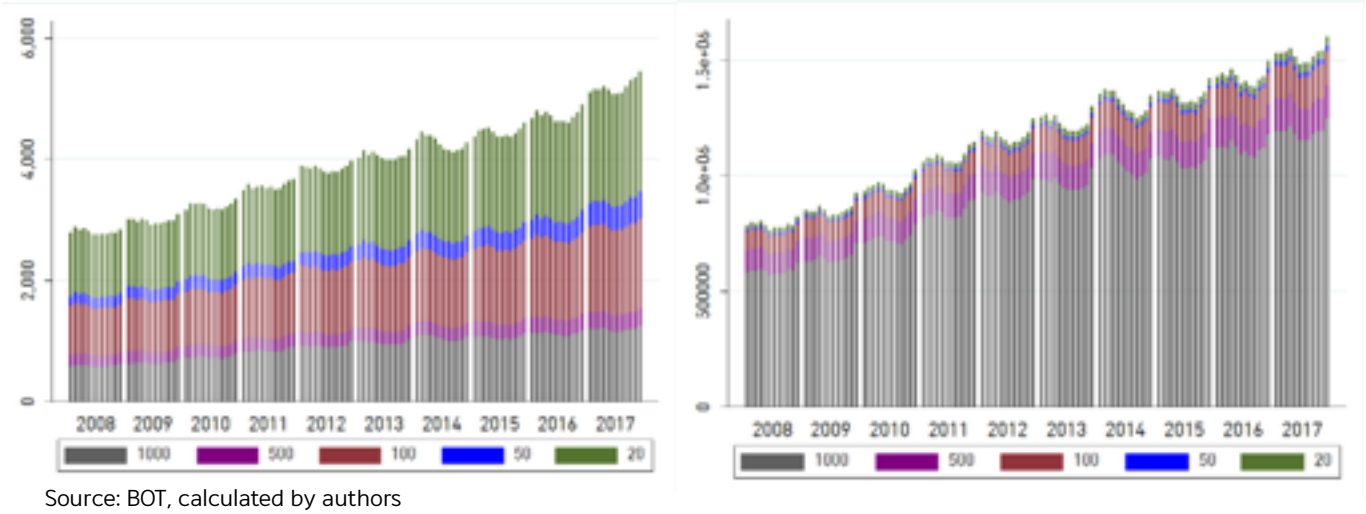
Source: Bagnall et al. 2016 and BOT's Payment Survey 2016, calculated by authors

A2 Cash

A2.1 Stylized facts

At the end of 2017, notes in circulation totaled 1.8 trillion baht, up 6.6% from the previous year. Average growth rates of notes in circulation during the most recent 5 years (2013-2017) dropped to 5.2% from 9.8% in 2007-2012. According to Figure A2.1, the composition of banknote denomination has been fairly consistent over the past 10 years. The 20-baht banknotes (37%) are the most popular in terms of volume, followed by the 100-baht (27%), 1000-baht (22%), 500-baht (9%) and 50-baht (5%) notes. Within a year, banknotes display a strong seasonality as volume peaks during holiday seasons in December-April.

Figure A2.1 Monthly average of banknotes in circulation
by volume (million notes: left) and value (million baht: right)



Source: BOT, calculated by authors

Within a month, however, seasonality differs by denomination. Based on daily data of banknote distribution, we illustrate cases of 1000-baht and 100-baht notes in Figure A2.2. End-of-year period exhibits the largest number of banknotes in circulation for both denomination. The volume of 1,000-baht notes is generally higher at the beginning and the end of month and during Songkran in April. For the 100-baht denomination, the beginning/ end of month pattern is less obvious. In addition to Songkran, 100-baht notes are also popular during Chinese New Year in early February.

Moreover, we also observe distinct patterns of each denomination on different days of a week. During weekdays, commercial banks can withdraw and return banknotes from BOT's banknote operation centers. Solid-colored bars represent withdrawals of banknotes from BOT's centers which will later be circulated in the economy. Larger banknotes show greater volume on Friday and Thursday, while volume of smaller ones is fairly similar across days. Because BOT's centers are closed on weekends, the patterns could reflect stocking up of 1000, 500 and 100 banknotes at ATMs before a weekend arrives. The 50 and 20 baht banknotes do not go to ATMs and we therefore do not observe such pattern. On the reverse process, larger notes are returned to BOT's centers on Monday and Tuesday more than they are withdrawn out (grey bars). Our hypothesis is that larger notes are quickly deposited back at ATM or bank branch on Monday after having been spent by consumers during weekends. Merchants deposit large notes while they are more likely to keep smaller denomination to provide change to customers.

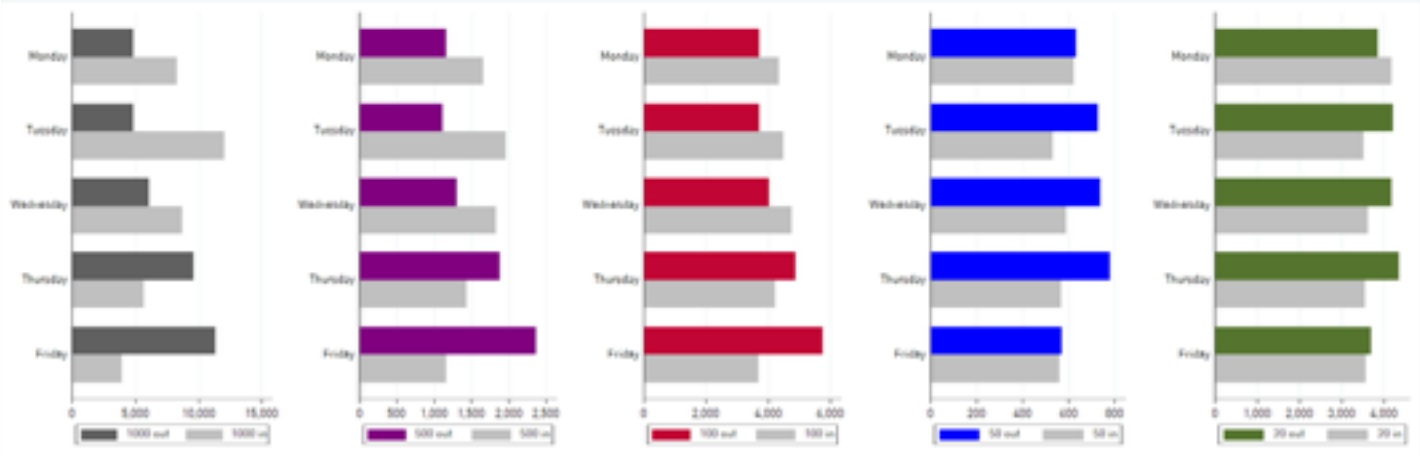
Figure A2.2 Daily average of 1,000-baht (left) and 100-baht (right) notes in circulation (millions)

1000	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	988	933	939	933	943	925	918	910	907	914	936	952
2	986	932	942	936	945	926	918	911	908	918	937	957
3	981	930	943	938	949	923	920	911	908	921	937	961
4	970	929	942	942	951	919	919	907	906	920	935	967
5	953	928	940	944	952	916	915	904	905	917	931	973
6	938	926	937	946	951	912	911	898	902	914	928	972
7	926	923	934	946	946	908	906	894	899	909	925	970
8	919	919	929	946	938	903	901	892	894	904	922	967
9	913	915	924	943	927	898	894	891	889	900	919	964
10	908	913	919	944	920	892	888	889	883	897	915	961
11	902	909	915	949	916	887	886	890	880	894	911	960
12	897	907	910	955	909	883	882	891	878	892	907	955
13	893	907	907	959	903	880	879	891	875	892	905	950
14	889	904	904	959	900	877	877	887	873	890	904	946
15	888	900	902	959	896	875	876	881	871	888	904	941
16	888	897	900	959	893	873	873	877	871	887	903	937
17	887	897	898	949	891	871	872	874	869	888	903	934
18	887	899	896	932	893	869	874	870	869	889	903	934
19	886	903	894	921	893	869	875	868	871	889	902	937
20	887	905	894	914	890	870	874	866	871	888	902	938
21	888	905	895	906	887	870	870	865	872	891	905	942
22	890	908	895	902	886	871	870	866	871	895	906	946
23	892	910	896	898	888	872	869	867	875	902	907	952
24	895	914	897	897	890	874	871	868	874	902	909	959
25	898	919	901	900	891	876	875	871	878	905	913	969
26	902	927	905	903	894	881	878	875	886	909	918	985
27	907	934	910	908	900	889	884	880	891	912	924	999
28	914	937	917	914	906	895	891	884	896	916	934	1,013
29	921		922	924	910	902	895	892	902	920	941	1,027
30	927		926	934	918	911	901	899	909	926	947	1,048
31	929		930		923		904	904		933		1,060

100	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	1,084	1,112	1,109	1,089	1,095	1,080	1,074	1,074	1,072	1,078	1,094	1,094
2	1,085	1,114	1,109	1,091	1,096	1,080	1,074	1,075	1,073	1,080	1,095	1,097
3	1,085	1,116	1,109	1,093	1,097	1,080	1,076	1,075	1,075	1,083	1,095	1,099
4	1,084	1,120	1,110	1,096	1,099	1,081	1,079	1,076	1,076	1,084	1,096	1,103
5	1,085	1,123	1,111	1,099	1,100	1,081	1,080	1,076	1,078	1,085	1,097	1,106
6	1,084	1,124	1,112	1,101	1,101	1,081	1,080	1,077	1,078	1,087	1,098	1,107
7	1,082	1,124	1,112	1,101	1,101	1,081	1,081	1,078	1,079	1,088	1,099	1,108
8	1,081	1,124	1,111	1,103	1,101	1,080	1,081	1,079	1,078	1,088	1,099	1,109
9	1,080	1,126	1,110	1,104	1,100	1,079	1,080	1,079	1,078	1,088	1,098	1,110
10	1,079	1,126	1,109	1,106	1,099	1,078	1,080	1,079	1,076	1,088	1,097	1,112
11	1,078	1,126	1,107	1,109	1,098	1,076	1,079	1,079	1,075	1,088	1,096	1,111
12	1,077	1,125	1,105	1,113	1,096	1,075	1,077	1,080	1,075	1,088	1,095	1,110
13	1,076	1,125	1,103	1,115	1,094	1,073	1,076	1,080	1,074	1,087	1,094	1,109
14	1,073	1,122	1,101	1,115	1,093	1,071	1,075	1,079	1,074	1,086	1,092	1,108
15	1,072	1,120	1,099	1,115	1,091	1,070	1,073	1,078	1,073	1,085	1,091	1,107
16	1,073	1,119	1,097	1,115	1,088	1,068	1,071	1,076	1,072	1,084	1,090	1,106
17	1,075	1,117	1,095	1,113	1,087	1,067	1,070	1,075	1,071	1,084	1,089	1,104
18	1,077	1,115	1,093	1,110	1,086	1,066	1,070	1,073	1,070	1,084	1,088	1,104
19	1,078	1,113	1,091	1,107	1,085	1,065	1,069	1,071	1,070	1,084	1,087	1,104
20	1,081	1,112	1,090	1,104	1,083	1,064	1,069	1,070	1,071	1,084	1,087	1,105
21	1,083	1,111	1,088	1,100	1,083	1,063	1,068	1,069	1,071	1,085	1,086	1,106
22	1,085	1,110	1,088	1,098	1,082	1,063	1,067	1,068	1,070	1,086	1,086	1,107
23	1,086	1,109	1,087	1,095	1,081	1,062	1,066	1,068	1,074	1,088	1,086	1,108
24	1,089	1,108	1,085	1,093	1,080	1,063	1,067	1,068	1,070	1,089	1,086	1,111
25	1,093	1,108	1,085	1,092	1,079	1,063	1,067	1,068	1,071	1,089	1,086	1,114
26	1,095	1,109	1,085	1,091	1,079	1,063	1,067	1,068	1,072	1,090	1,086	1,121
27	1,097	1,109	1,085	1,091	1,079	1,065	1,068	1,068	1,073	1,091	1,087	1,125
28	1,101	1,109	1,086	1,091	1,079	1,066	1,070	1,068	1,074	1,092	1,089	1,130
29	1,104		1,086	1,091	1,079	1,068	1,070	1,070	1,078	1,092	1,091	1,137
30	1,107		1,087	1,093	1,079	1,071	1,071	1,071	1,080	1,093	1,093	1,148
31	1,108		1,088		1,080		1,072	1,072		1,093		1,154

Source: BOT, calculated by authors

Figure A2.3 Banknotes withdrawn from and returned to cash centers by day of week



Source: BOT, calculated by authors

Now, we turn to distribution of banknotes by geographical areas (Table A2.1). In 2017, over 69 million banknotes per day were distributed to branches and ATMs all over the country. With concentration of financial services in Bangkok, the BOT's banknote center in Bangkok takes up more than a half of the whole country's distribution, followed by Rayong and Khonkaen at 9% and 8% of total distribution, respectively.

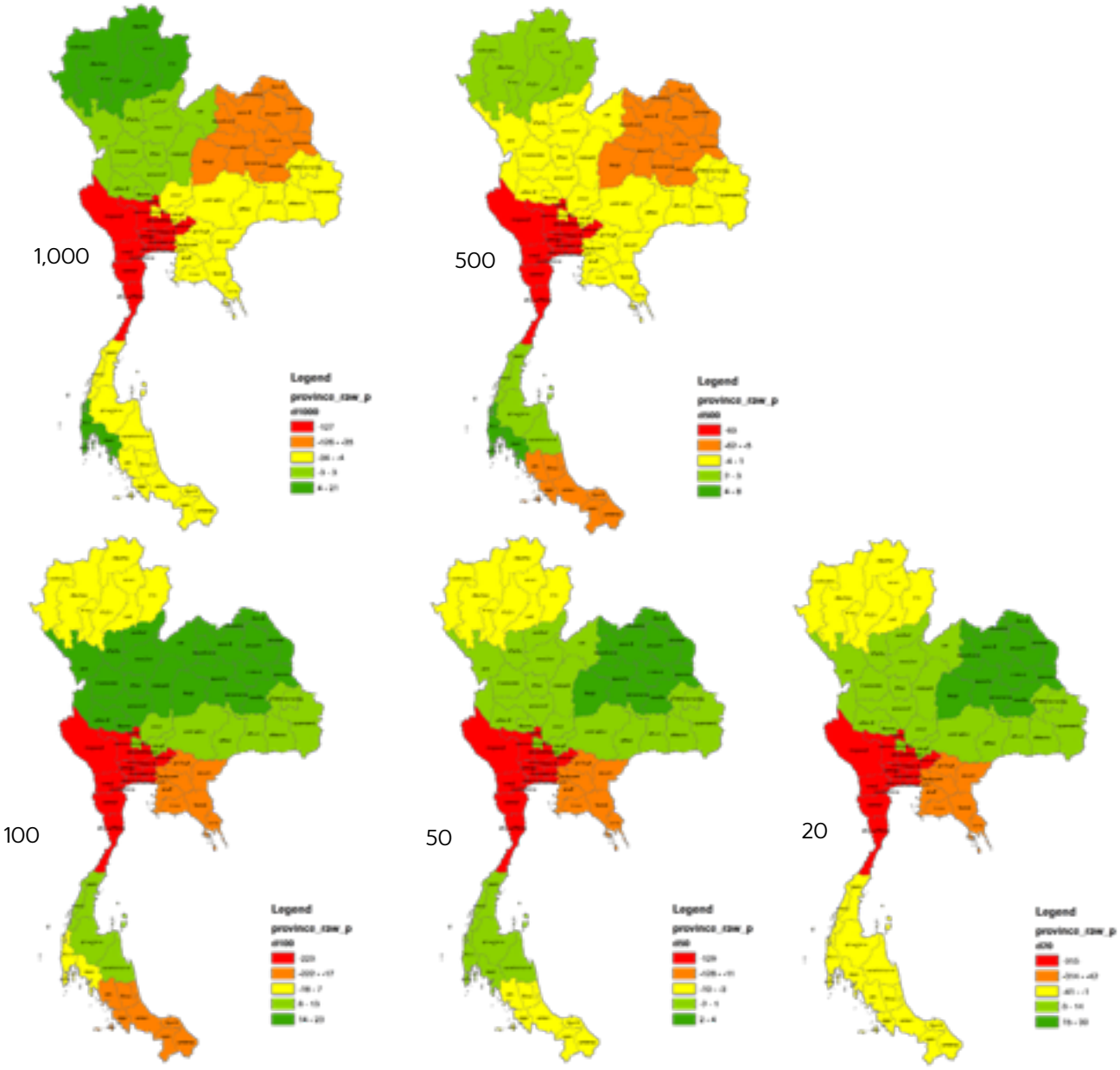
Geographical differences are also seen by the difference between distribution (outflow) and receipt (inflow) of banknotes by denomination. The heat map in Table A2.1 displays the net deficit (-) and surplus (+) of total banknote distribution in 2017 by BOT's center. Bangkok, Rayong and Songkla are net deficit centers for all denomination, i.e. they distribute more notes than what they receive. Deficit centers could reflect cash is withdrawn out in these areas but probably spent somewhere else. On the contrary, net surplus centers indicate that cash is brought in from other areas. Chiangmai, Pitsanulok and Pang-nga are net surplus centers of large-

denomination notes. Khonkaen, Nakornratchasima and Ubonratchathani in the northeast are surplus centers of small-denomination notes.

Table A2.1 Net surplus and deficit by BOT's banknote operation center and by denomination

Region	Banknote operation center	Distribution (million)	Share	1,000	500	100	50	20
Bangkok	Bangkok	36.2	52%	-	-	-	-	-
Central	Rayong	6.2	9%	-	-	-	-	-
North	Chiangmai	4.4	6%	+	+	+	-	-
	Pitsanulok	3.7	5%	+	+	+	-	-
Northeast	Khonkaen	5.6	8%	-	-	+	+	+
	Nakornratchasima	3.4	5%	-	+	+	-	+
	Ubonratchathani	2.3	3%	-	-	+	+	+
South	Songkla	3.1	4%	-	-	-	-	-
	Suratthani	3.0	4%	-	+	+	-	-
	Pang-nga	1.5	2%	+	+	+	-	-
	Total	69.3						

Source: BOT, calculated by authors



A2.2 Cost estimation

Cost of cash transactions

cost per transaction	=	(total cost/total note usage volume)	x number of notes per transaction
	=	cost per note usage	x number of notes per transaction
	=	0.34	x 3.7
	=	1.26 baht per transaction	

(1) TOTAL COST

First, we estimate total costs of banknotes incurred to the Bank of Thailand and financial institutions.[24] In 2017, cost of cash management totaled 47,000 million baht, or around 0.3% of GDP. Financial institutions, particularly banks, bear the largest share of costs (or 91%) on cash distribution and management at branch and ATM.[25] The cost estimate takes into account both variable costs—such as holding, logistic and operation costs—and fixed costs through depreciation. Table A2.2 summarizes costs associated with each stakeholder and the components considered in our calculation.

Table A2.2 Summary of cash management cost in 2017

Stakeholder		Types of cost	Cost (million baht)	Share of cost
Bank of Thailand	1 note printing works 10 banknote operation centers	Production Distribution Sorting Destroy	4,100	9%
Cash center	69 cash centers 48 sub-centers	Holding Logistics Operation	7,000	15%
Branch	9,255 branches	Holding Operation	16,600	35%
ATM	66,90 ATM and CDM	Holding Rent	19,300	41%
Total			47,000	

Source: BOT, calculated by authors

(2) TOTAL NOTE USAGE VOLUME

Second, we estimate the total volume of note usage of all banknotes in circulation. Total note usage counts the number of exchange that occurs for each banknote. For instance, if A pays 250 baht to B with two 100-baht notes and one 50-baht note, the total volume of note usage is 3. Ideally, we would like to directly measure the frequency by which each banknote is used. However, we cannot observe all transactions that occur and must

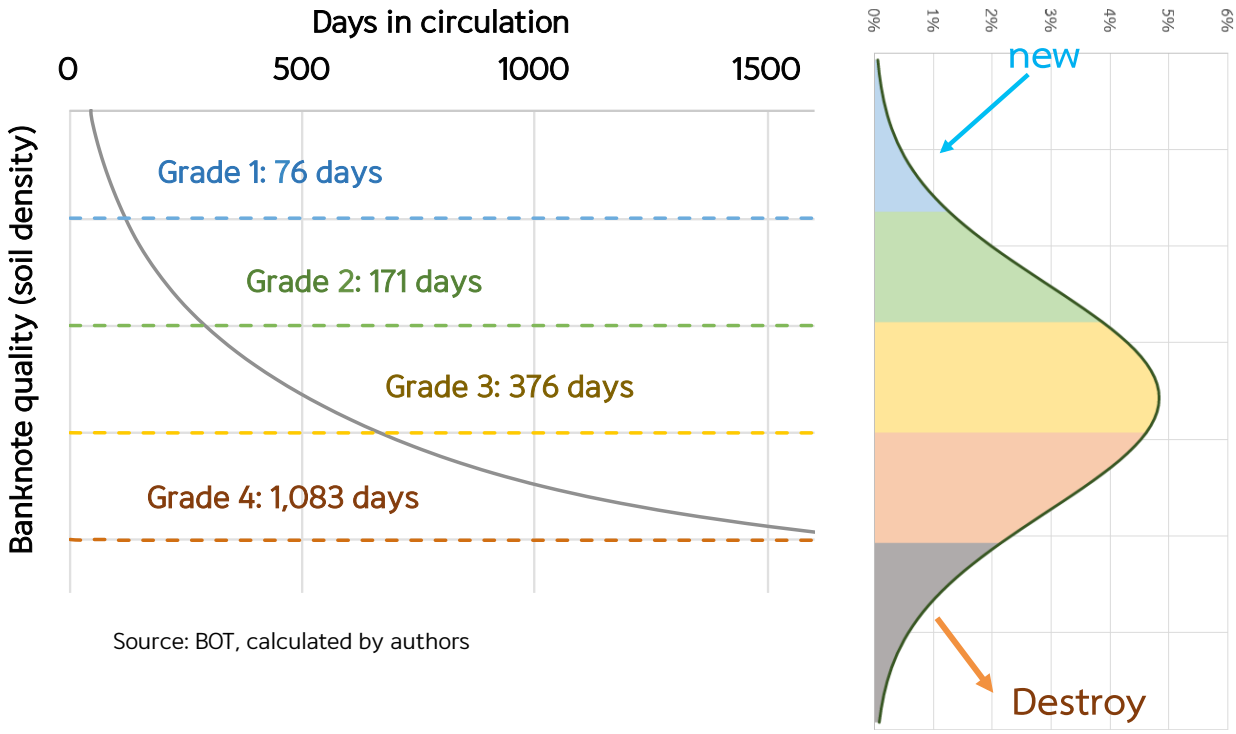
[24] It is important to note that our cost estimate does not include consumer costs such as transportation costs to reach an ATM to withdraw cash and time cost.

[25] Costs at branch take into account the share of cash-related transactions to total branch operations.

resort to an indirect measure. Instead, we estimate the volume of note usage from two components: velocity of money[26] and depreciation of banknote quality. The velocity of money tells us that each baht "changes hand" 12 times in one year to produce the country's GDP. We later translate the velocity per baht to that per banknote. For each denomination, we obtain the total value of transactions by multiplying 12 to the number of notes in circulation by denomination.[27] The next step is to backtrack the volume of note usage that results in such value for each denomination.

We obtain the volume of note usage from information on usage frequency that results in changes in banknote quality. To maintain banknote quality in the system, the Bank of Thailand circulates new notes and destroys unfit or low-quality ones. In other words, the distribution of banknote quality is fixed. Quality is measured by soil density as recorded by optical character recognition technology (OCR) during the sorting process at BOT's banknote operation centers. Greater soil density indicates worse note quality. Depreciation of banknotes is shown in the left panel of Figure A2.4 where quality is a parabolic projection of the number of days in circulation. The right panel then illustrates the distribution of banknote quality from newly printed grade-1 notes to grade-5 notes which are ready to be destroyed.

Figure A2.4 Depreciation and distribution of banknote quality for 100-baht notes



Source: BOT, calculated by authors

Banknote quality deteriorates overtime and each note moves to the right of the distribution. Here, we allow banknotes to depreciate by different rates according to their existing grade. For example, fewer usage is required for 2nd-grade notes to become 3rd-grade notes relative to that required for 1st-grade notes to become 2nd-grade notes. However, we assume that all denominations depreciate at the same rate, that is, 1st-grade 1,000 and 20 banknotes depreciate by the rate to become 2nd-grade notes.

[26] The velocity of money is calculated by dividing nominal GDP by money supply, V=GDP/(NIC-deposits), where money supply, for our purpose, is currency in circulation less currency held by central government and depository corporations such as commercial banks.

[27] Assuming that velocity is constant across denomination.

To keep distribution of banknote quality fixed, we can estimate the frequency that a banknote is used before getting downgraded for each grade and denomination. The sum of frequency must match the total value of transactions that happen. We finally arrive at the total number of note usage by aggregating note usage by denomination and grade. The estimated number provides some facts on our cash usage, as summarized in Table A2.3.

Table A2.3 Estimation of banknote usage by denomination

Denomination	Total usage in 2017 (million)	Cost per banknote use (baht)
1,000	11,720	2.1
500	4,979	1.0
100	39,229	0.3
50	9,763	0.1
20	71,855	0.1
Total	137,546	0.34

(3) NUMBER OF BANKNOTES PER TRANSACTION

Third, we estimate the number of banknotes involved in one transaction. We divide the total volume of note usage (137,546 millions) by the total number of cash transactions made by 68 million Thai people. According to the BOT's payment survey in 2016, Thais make on average 53 transactions per month, 86% of which is with cash. Therefore, each person makes around 45 cash transactions per month. As a result, on average, around 3.7 banknotes are used in one transaction.

Banknotes per transaction = total volume of note usage/number of cash transactions
= 137,546 million/(0.86*53*12*68 million)
= 3.7

A.3

Table A3.1 Regression results on usage

	(1)		(2)	
	Accounts/person		Transactions/person	
Female	0.123***	(0.00602)	0.754***	(0.0349)
15-19	0.122***	(0.0120)	0.349***	(0.0689)
20-24	0.626***	(0.0142)	1.922***	(0.0636)
25-29	0.667***	(0.0182)	3.196***	(0.104)
30-34	0.534***	(0.0155)	3.114***	(0.0999)
35-39	0.413***	(0.0129)	2.455***	(0.0802)
40-44	0.283***	(0.0111)	1.654***	(0.0655)
45-49	0.173***	(0.0106)	0.979***	(0.0606)
50-54	0.112***	(0.0111)	0.601***	(0.0636)
55-59	0.0718***	(0.0119)	0.326***	(0.0679)
BKK	0.435***	(0.0320)	2.187***	(0.186)
Central	0.0182**	(0.00646)	0.281***	(0.0404)
North	0.0822***	(0.00513)	0.263***	(0.0290)
South	0.0185*	(0.00726)	0.293***	(0.0441)
internet=2	0.0446***	(0.00539)	0.211***	(0.0299)
internet=3	0.0379***	(0.00491)	0.122***	(0.0278)
internet=4	0.113***	(0.00929)	0.649***	(0.0640)
cash volume=2	0.0678***	(0.00497)	0.291***	(0.0285)
cash volume=3	0.128***	(0.00536)	0.633***	(0.0306)
cash volume=4	0.307***	(0.0103)	1.681***	(0.0676)
Constant	-0.253***	(0.0129)	-1.510***	(0.0755)
Observations	4560		4620	
R-squared	0.711		0.662	

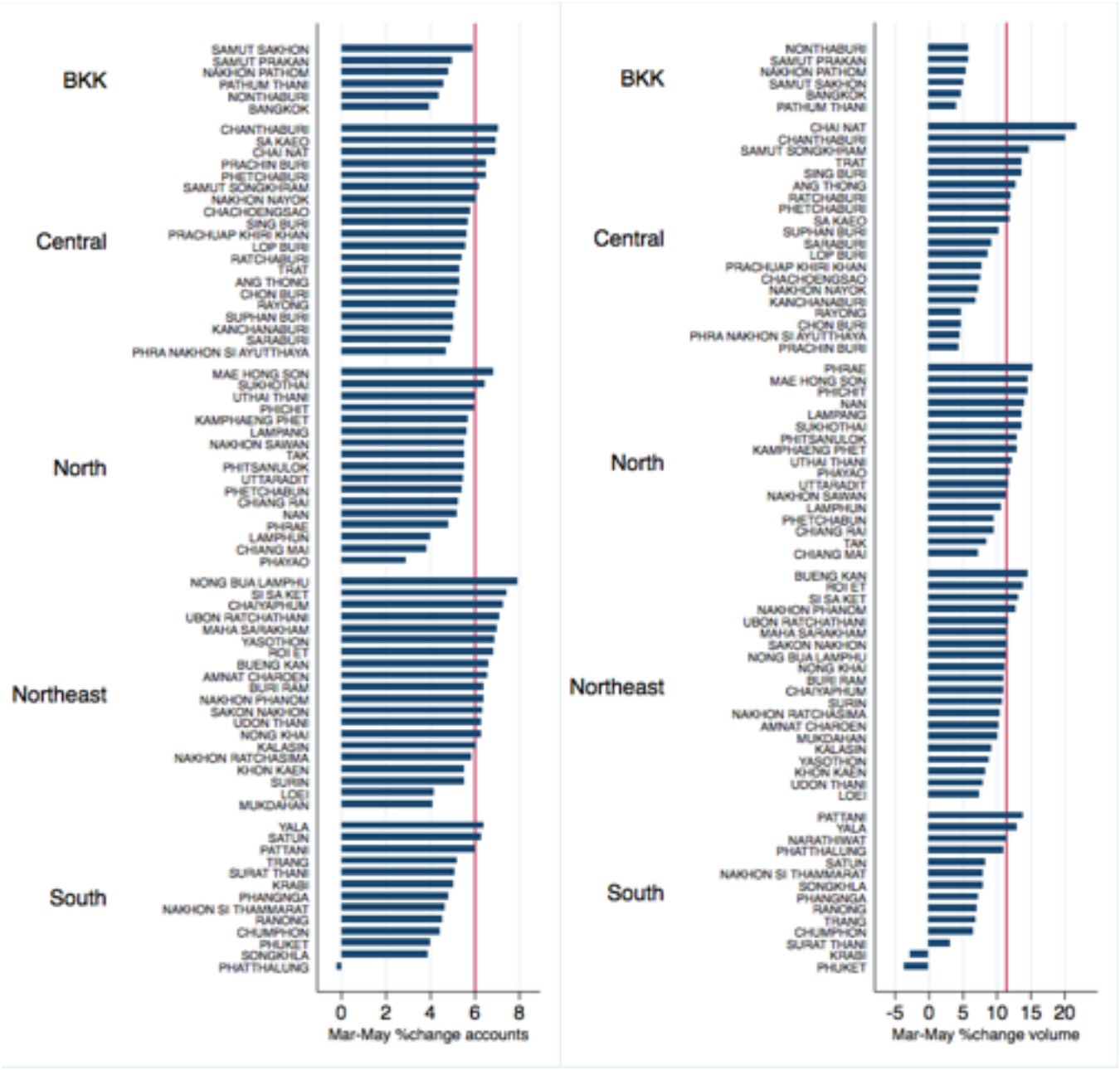
b coefficients; se in parentheses; * p<0.05, ** p<0.01, *** p<0.001; Data collected from 5 banks during March-May 2018; Month fixed effects included; Narathiwat is excluded in the first model due to data issues. All variables entered as dummy variables. Internet coverage and cash volume at ATM and branch are dummy variables for each quartile. Cash volume controls for volume of transactions which normally occur in a province.

Table A3.2: Regression results on change in usage during fee reduction period

	(1)		(2)	
	Change in Accounts/person		Change in Transactions/person	
Female	0.00381***	(0.000442)	0.0835***	(-0.0072)
15-19	0.0310***	(0.00135)	0.152***	(-0.00828)
20-24	0.0253***	(0.00126)	0.222***	(-0.0154)
25-29	0.00781***	(0.00143)	0.222***	(-0.0244)
30-34	0.00408***	(0.00116)	0.171***	(-0.017)
35-39	0.00410***	(0.000964)	0.149***	(-0.0155)
40-44	0.00389***	(0.000749)	0.0859***	(-0.012)
45-49	0.00360***	(0.000591)	0.0444***	(-0.00961)
50-54	0.00344***	(0.000525)	0.0403***	(-0.00805)
55-59	0.00303***	(0.000479)	0.0263***	(-0.00781)
BKK	0.00877***	(0.00199)	0.196***	(-0.0298)
Central	0.00193***	(0.000476)	0.0857***	(-0.0112)
North	0.000236	(0.000417)	0.0364***	(-0.0055)
South	-0.00287***	(0.000612)	-0.0232**	(-0.0075)
internet=2	0.00150***	(0.000414)	0.00388	(-0.00714)
internet=3	0.0000391	(0.000450)	-0.00292	(-0.0071)
internet=4	0.00213***	(0.000601)	-0.015	(-0.0126)
cash volume=2	-0.000201	(0.000402)	0.00709	(-0.00542)
cash volume=3	0.00236***	(0.000496)	0.0272**	(-0.00843)
cash volume=4	0.00569***	(0.000896)	-0.0101	(-0.0114)
Accounts (March)	0.0232***	(0.00216)		
Transactions (March)			0.00163	(-0.00562)
Constant	-0.00378***	(0.000755)	-0.0749***	(-0.0107)
Observations	1520		1540	
R-squared	0.829		0.447	

b coefficients; se in parentheses; * p<0.05, ** p<0.01, *** p<0.001; Data collected from 5 banks during March-May 2018; Change in dependent variables are May-March difference.; Narathiwat is excluded in the first model due to data issues. All variables entered as dummy variables. Internet coverage and cash volume at ATM and branch are dummy variables for each quartile. Cash volume controls for volume of transactions which normally occur in a province. Number of accounts and transactions in March control for existing usage level.

Figure A3.1: Percentage change in number of electronic banking accounts (left) and transaction volume (right) during March-May 2018, by province



Source: Administrative data from 5 banks, calculated by authors