Mobile Wallet and Entrepreneurial Growth

Sumit Agarwal[*], Wenlan Qian[†], Bernard Yeung[‡], and Xin Zou[§]

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Abstract

Using mobile wallet and card transaction data from a leading Singapore bank, this paper studies the effect of a mobile wallet payment technology introduction in 2017 on business growth. We find the mobile wallet usage doubled after the new technology introduction, and the improved payment convenience generated a significant spillover effect. Small merchants experienced a monthly increase in debit and credit card sales amount (count) of 3.5 percent (3.4 percent) compared to large merchants. The payment technology promoted sales growth primarily for new businesses by facilitating customer acquisition.

Keywords: mobile wallet, cashless payment, entrepreneurship, small business, sales growth, credit card, debit card, banking, fintech, digital economy

JEL Classifications: D12, D14, E21, G21

[*] Sumit Agarwal, NUS Business School Department of Finance, National University of Singapore, Email: ushakri@yahoo.com.

[†] Wenlan Qian, NUS Business School, Department of Finance, Email: wenlan.qian@nus.edu.sg.

[‡] Bernard Yeung, NUS Business School, Department of Finance, Email: bizdean@nus.edu.sg .

[§] Xin Zou, Hong Kong Baptist University, Department of Finance and Decision Science, Email: zouxin@hkbu.edu.hk.

1. Introduction

With the rapid development of smartphone and financial technology, mobile payment has been growing fast in recent years. By 2017, the total transaction value worldwide through mobile wallet payments is over 350 billion of US dollars, and expects to grow at an annual rate of 39 percent and reach 1.6 trillion by 2022 (Statista, 2018).

Compared with other payment methods, mobile wallet can settle consumers' everyday payments, both to other consumers and to merchants, with lower cost and greater convenience. The high smart mobile phone penetration (e.g., 72% in the US) provides the infrastructure that allows consumers to make cashless payments almost anywhere (so long as they carry their mobile phones). While it is easy to see its critical role in facilitating transactions in developing countries where cashless payment arrangements, e.g., credit and debit cards, are not prevalent, it is interesting that even in developed countries, where credit and debit cards are prevalent, consumers appear to welcome the added convenience, as witnessed by the rapid growth in the mobile wallet transaction volume (Capgemini, 2017). A natural question arises, then, on the incremental benefit of mobile wallet as a new payment technology. How does the introduction of mobile payment technology affect the economy?

One the one hand, mobile wallet improves shopping convenience and efficiency, which in turn can increase consumption. On the other hand, it is not obvious whether the economic gains to the added convenience are sufficiently large relative to other cashless payment technologies (e.g., bankcards). Moreover, a large fraction of mobile wallet transactions to date serves to facilitate consumer-to-consumer funds transfer, also weakening the effect on consumption.

This paper approaches these questions by investigating business sales after the introduction of a new mobile payment technology with a proprietary dataset on mobile wallet and bankcard transactions from a representative sample of 250,000 customers of a leading bank in Singapore. Surprisingly, we find that the introduction of a mobile payment technology promotes debit and credit card sales growth, especially for small and entrepreneurial firms through its role in driving consumer traffic.

On 13th April 2017, Singapore has first introduced the use of the Quick Response (QR) code payment function in the mobile wallet. This new technology enables all users to receive and make immediate payments by generating their own QR code on the mobile phone APP. Buyers and sellers of goods and services can complete the transaction by displaying or scanning QR codes. The technology not only brings added convenience to consumers given the large smart phone ownership, but it also reduces the transaction costs especially for small and new businesses.[5]

First, the introduction of the new QR code payment technology indeed boosted the mobile wallet usage. Both the transaction amount and transaction count of the mobile wallet doubled after the first QR code payment introduction on 13th April 2017. Consumers used the mobile wallet mostly for small-amount transactions. The weekly count of small-amount transactions (i.e., less than S$100 per transaction) increased by 114 percent, and the large-size transactions (i.e., greater than S$100 per transaction) increased by 88 percent.

We then investigate whether the enhanced convenience with mobile wallet payment brings positive externality to card payment transactions, which is also by far the dominant cashless payment instrument in Singapore. Our empirical identification strategy relies on the differential benefits of the mobile wallet convenience across merchants. The QR arrangement facilitates transactions, e.g., reduces the trouble of handling cash and the waiting time. This will move customer traffic more efficiently and raise customers' effective demand, mostly in shops involving small transactions.

Utilizing all credit and debit card payments for 16,479 Singapore offline merchants from the same set of customers during a two-year period of 2016:01 to 2017:12, we document a significant spillover effect in merchant's sales through card payment. Compared with the large merchants, small merchants which have median monthly sales amount in 2016 lower than the cross-sectional median, experienced on average 3.5 percent (3.4 percent) more monthly card sales amount (count) during the 9-month period upon the first QR code payment introduction. Moreover, the adjustment comes fast, the effect is already very pronounced in the immediate quarter after the QR code payment technology shock.

The spillover effect on card sales is also stronger among the merchants selling goods of smaller values. Dividing the small merchants into two groups based on their median transaction size in

[5] Micro businesses such as vendors or hawker stands have zero fixed or variable cost for accepting QR code payment. Larger merchants will be charged fees capped at 0.8 percent per transaction, which is still much lower than the fees imposed on card payments which vary between 2.5 to 4 percent (NETS, 2018; DBS, 2017).

2016, we find the sales growth only manifests in the small merchants generally receiving small-size payments – after the adoption of the QR technology; these stores experienced a significant increase in the monthly card sales amount (count) by 7.4 percent (6.7 percent).

New merchants run business at a smaller scale with a less stable customer base, so they may have greater gains than others from the introduction of the lower-cost, higher-convenience payment technology. Indeed, we find that new merchants (those with first sales occur in the later half year of 2016) are driving the card sales growth after the QR code introduction. Relative to the change in large merchants, newly established small stores increased monthly card sales amount (count) by 11.0 (10.2) percent, compared with 2.1 percent (2 percent) growth among the more established small merchants.

One plausible economic channel driving the sales growth lies in the role of the improved payment convenience in promoting retail traffic. As stated earlier, the QR technology moves customer traffic more efficiently, especially for shops that concentrated in small transactions. This rise in efficiency then facilitates consumers' exploration of new shopping locations. Using the same difference-in-differences specification, we find consistent results that the fraction of new customers, defined as consumers residing in the postal sectors that never spent at the merchant in 2016, increased by 1.8 percent per month more for small merchants, and the effect is statistically significant. This result also suggests that the positive effect reflects genuine business growth instead of the substitution effect whereby consumers simply switch from cash to cards. Finally, the sales growth is more pronounced among merchants of dining restaurants.

This paper contributes to the emerging literature on fintech and digitization with the focus on cashless payment. Cashless payment improves efficiency by reducing transaction costs and mitigating frictions (Chakravorti and Mazzotta, 2013; Bachas, et al., 2018). [6] Our paper provides novel insight on its real effects. In particular, the results highlight the positive impact of mobile payment technology, relative to other cashless payment means, on promoting business growth, especially the small, entrepreneurial firms. While some earlier studies state that households tend

[6] Another strand of the literature discusses consumers choice between cash and cashless payments (Rysman, 2007; Klee, 2008; Ching and Hayashi, 2010; Cohen and Rysman, 2013; Koulayev et al., 2016; Wang and Wolman, 2016; Wakamori and Welte, 2017), or the adoption of cashless payments (Crowe, Rysman, and Stavins, 2010; Yang and Ching, 2013; Shy, 2014). Specifically, Agarwal et al. (2018) uses the exogenous demonetization shock in India to study consumers' adoption of several cashless instruments, including mobile wallet and cards.

to concentrate their consumption in one type of instrument (Cohen and Rysman, 2013) or even in one type of card (Shy, 2014), our findings suggest complementarity among different (cashless) payment means, and introducing a new technology (e.g., mobile wallet) can drive retail traffic and attract new customers.

We also contribute to the literatures on technology innovations. Empirical studies have documented the diffusion of new technologies (Caselli and Coleman II, 2001; Comin and Hobijn, 2004), and its impact on various economic areas such as economic growth (Greenwood, Hercowitz, and Krusell, 1997; Galor and Tsiddon, 1997), labor market (Doms, Dunne, and Troske, 1997), stock market (Laitner and Stolyarov, 2003), shadow bank (Buchak et al., 2018), and business organizations (Cohen, DeLong, and Zysman, 2000). Just as written by Cohen, DeLong, and Zysman (2000), the "E-conomy" is not just amplify productivity in one leading sector, but give all economic sectors powerful new tools. Specific to the payment system, Marquis and Reffett (1994) modeled the situation that the efficiency of cashless payment system can be enhanced by improvements in the payment technology itself, or the spillover from other technologies applicable to cashless payment such as computer and information system technology. Rysman and Schuh (2017) provides a nice review on the studies of new payment innovations in three areas: mobile payments, faster payments, and digital currencies. We add to the literature by showing that a new mobile wallet payment technology can foster the growth of small business and entrepreneurs.

The rest of the paper proceeds as follows: Section 2 introduces the institutional background of cashless payment in Singapore. Section 3 describes the data and methodology. Results are presented in section 4, and Section 5 concludes.

2. Mobile payment in Singapore

Singapore possesses a strong banking and payment system. It is among the world's first to launch the FAST (Fast and Secure Transfers) payment system, which supports 24/7 fund transfers in real time. On the other hand, most consumer payments are still completed via cash. Among the 2.2 billion non-SVF (Stored Value Facilities) consumer transactions in 2015, 60 percent are still paid in cash, followed by 27 percent of card payment (including credit and debit card), 12 percent funds transfer, and 1 percent cheque payment.[7] The preference towards cash, however, is not unique for Singapore. By 2010s, the value of currency in circulation for developed regions is around 10 percent of the GDP (Rogoff, 2015); around 60 percent of North America consumers pick cash as (one of) the most frequently used payment instrument in 2016 and expect to be frequent cash users in the future (Accenture, 2016). The paper-based payments (including cash and cheques) cost around 0.52 percent of Singapore GDP per year. (KPMG, 2016)

According to a survey by KPMG in 2015, e-payments in Singapore are primarily accepted for online shopping or paying bills, while paper-based payments prevail for offline consumption, especially for small merchants like hawker center/food court, small shops, and convenient stores. Among the surveyed businesses, the acceptance of cash is nearly universal (84 percent), while less than half of them accept card payments; and cash is the preferred payment instrument for 54 percent of the businesses, especially the retailers. The slow settlement of payment, high transaction and management cost, and concerns for fraud and security are the top challenges prevent merchants from accepting cashless payments.

Starting from 2017, Singapore has been working hard to move towards a cashless society, and the fast development in mobile payments plays a critical role. 13th April 2017 marks the first date of the introduction of QR (Quick Response) code payment in the city state, which allows users to make transactions by generating their own QR code. Buyers and sellers of goods and services can complete transactions by displaying or scanning QR codes on their mobile phones, which reduces the transaction costs especially for small and new businesses. Based on the machine-readable image of QR code, which can hold 300 times more information than a standard barcode, the QR code payment technology provides a reliable method of payment by allowing for immediate settlement, lower transaction costs, and enhanced security. On 10th July 2017, the Association of Banks in Singapore announced a unified peer-to-peer (P2P) fund transfer service called PayNow, allowing customers of the seven participating banks to make real-time FAST transfers for free.

The transaction value of mobile POS payments in Singapore has more than doubled from 218 million US dollars in 2016 to 470 million by the end of 2017 (Statista, 2018). According to a survey conducted by VISA in July 2017, 67 percent of Singapore respondents have made device-

[7] The SVFs (Stored Value Facilities) need top-ups before using, and are used mostly for public transportation (eg., the EZ-link card in Singapore).

initiated payments (including both mobile payments and card payments such as Visa contactless payments); additionally, 68 percent of them are confident to go cashless for a whole day, and 42 percent are comfortable without cash for 3 days (Visa, 2018).

3. Data

3.1 Raw Data

We base our study on a large panel of dataset containing a variety of bank activities for 250,000 Singapore consumers from a leading local bank during 2016:01 to 2017:12. This bank covers over 80 percent of the entire Singapore population; our sample comprises randomly drawn individuals from the bank's customer base. In this dataset, we can observe the transactions for the mobile wallet developed by the bank which allows for QR code payment. Additionally, we have all the debit card, credit card, and ATM transactions information in this bank for the same set of individuals (see detailed description on the bank data in Agarwal and Qian, 2014, 2017).

The bank's mobile wallet was first launched in May 2014. Before the availability of QR code payment, this mobile wallet is mainly used for person-to-person (P2P) fund transfers within the bank's customers; whereas after 13th April 2017 all the mobile wallet users, including customers without this bank's account, can receive and make payments by generating QR codes. In 2017, this mobile wallet is Singapore's fastest growing personal mobile wallet, with more than 785,000 users, and processes over 15,000 P2P transactions a day. In our sample, we have every transaction from the randomly chosen customers. For each transaction, we are able to observe the transaction amount and transaction time. We aggregate all the mobile wallet transaction amount and count of transactions in 2017 at weekly and monthly frequency, to directly check the effect of QR code payment technology. The ATM withdrawals, on the other hand, are also aggregated into monthly frequency and used as a benchmark.

The information we mainly rely on in investigating the spillover effect of QR code payment technology on business growth is the debit and credit card transactions from the same group of bank customers. For each card transaction, besides the information on transaction amount, transaction time, we can also observe the merchant name where the transaction is completed, plus the Merchant Category Code (MCC) for each merchant. Moreover, the data provides (masked) card holder information so that we are able to identify for each merchant, who are making the purchases, and which region do the customers come from (i.e., the 2-digit postal sector).[8] Debit and credit cards together are the dominant cashless payment instruments for disposable consumption of Singapore households, accounting for nearly 30 percent of aggregate consumption in the country (Agarwal and Qian, 2014).[9] Therefore the card transaction information particularly fits our study which aims to investigate the spillover effect of a new mobile wallet payment technology on consumption. We aggregate all the card sales for each merchant at monthly frequency.

The proprietary dataset offers several key advantages for our study. First, digital payment, which contributed 80 percent of the global FinTech transaction in 2017 (Statista, 2018), is reshaping the world's payment system and households' consumption behaviors. The real-time mobile wallet transactions give us the opportunity to directly check the effect of a payment technology shock. Second, our high-frequency administrative dataset records (card) consumption with little measurement error, compared with the traditional survey-based datasets in the United States such as the Survey of Consumer Finance (SCF), Consumer Expenditure Survey (CEX), or Consumer Payment Choice (CPC) survey. Moreover, we can track the sales to each merchant through the transaction record, which is crucial for our study. Relative to earlier studies utilizing consumer shopping diary or scanner data (Klee, 2008; Cohen and Rysman, 2013; Wang and Wolman, 2016; Wakamori and Welte, 2016; Agarwal et al., 2018), we are able to study a long time series (two-year) of sales from large scale of offline merchants (over 16,000 merchants in final sample) in different categories. This enables us to make more generalizable inferences on the entrepreneur growth. Finally, compared to existing studies that use micro-level credit card data (e.g. Gross and Souleles 2002, Agarwal, Liu, and Souleles, 2007, Aaronson, Agarwal, and French, 2012; Agarwal, Qian, and Zou, 2018), our card transaction dataset provides more comprehensive consumption information. For example, rather than observing a single credit card account, we have information

[8] A 6-digit postal code in Singapore represents a very small neighborhood of one building. The first two digit from the 6-digit postal code represents the postal sector of a building, and there are 81 postal sectors in total. One to six postal sectors constitute one postal district, and there are 28 postal districts in total.

[9] The remaining 70 percent of consumption is transacted via checks, direct transfers, and cash. Consumers with recurring payments like mortgages payment, rent payments, and auto loans payments use instruments such as checks and direct deposit. We confirm this using our credit and debit transaction-level data; looking through the transaction category codes, merchant names, transaction types, we do not find a *single* transaction for mortgage, rent, and auto loan payments in over 35 million debit card and credit card transactions. Hence, we conclude that these reoccurring payments are through checks and direct deposits.

on every credit card and debit card that each customer has with the bank. In addition, we also observe individuals' other bank activities such as the ATM withdrawals, and rich demographic information such as the 2-digit postal sector of their residence.

One limitation of our data is that we do not have information for the card consumption from other banks, therefore we cannot fully capture all the card sales for each merchant. Nevertheless, similar to Agarwal, Qian, and Zou (2018a), our identification strategy does not require a complete account of all card spending by customers. To the extent that the choice of card is plausibly exogenous to the merchant's size (i.e., customers do not use cards from the financial institution in our sample to only purchase goods from small merchants), spending aggregated from our dataset is an unbiased indicator of the card sales of the merchants. Additionally, given the market share of the bank (also as a card issuer), it is likely that we are picking up a majority proportion of the (card) sale for merchants in sample.

3.2 Sample and Methodology

As our study heavily relies on clean identification of local offline merchants, our first step is to manually correct the merchant names. Since the decision of accepting a payment instrument is at the merchant level instead of store level, we classify stores in different locations, or with different names but belonging to the same merchant as one merchant (e.g., All Uniqlo stores in Singapore are classified under the same merchant – "Uniqlo"). Additionally, we only include the card sales within Singapore, as the payment technology shock only applies to local merchants.[10] We also exclude the transactions that are obviously not real consumption, such as cash backs, rebates, or fees. Our dataset covers 45,469 unique merchants in total during the two-year period.

As our identification requires a benchmark period to assign merchants as small or large, we conduct the classification base on their median monthly sales in 2016. In this sense, we require all the merchants in our final sample to have sales in both 2016 (i.e., the benchmark period) and 2017 (i.e., the estimation period). To further ensure that the merchants in our sample are actively running business, we require them to have positive card sales for at least six months in 2016. After this

[10] Note that we do include brands from other countries such as "Uniqlo", as long as the sales happened within Singapore. What we exclude here is the sales incurred in other places outside Singapore, such as a bar in China.

step, we are left with 17,095 merchants. Finally, we exclude all online stores from our sample because the QR code payment should only affect offline consumption. 16,479 offline local merchants are included in our final sample; this number is comparable to the total number of retailers in Singapore by 2016, and the number of QR code-enabled merchants.[11]

Among the offline local merchants in final sample, if a merchant has median monthly card sales lower than the within-merchant-category median in 2016, then it is assigned as a small merchant; otherwise it is a large merchant[12].

We compare the response of small merchants' card sales (both the sales amount and count of transactions) to the first introduction of QR code payment technology with that of large merchants in a difference-in-difference setting. Event month 0 is April 2017, when the first QR code payment mobile wallet is released. We use the following regression model to estimate the average sales response:

$$\ln Y_{m,t} = \beta_1 Small\ Merchant_m \times Pre_1 + \beta_2 Small\ Merchant_m \times Post + \delta_t + \alpha_m + \varepsilon_{m,t} \qquad (1)$$

Where $\ln Y_{m,t}$ is the log of card sales amount or count for merchant *m* in month *t*. All sales amounts or counts are winsorized at 1% and 99% level to eliminate the possible influence of outliers. $Small\ Merchant_m$ is the dummy variable indicating the small merchant status as described above. Pre_1 is an indicator variable for the one month *before* the technology shock (i.e., month -1), and $Post$ is an indicator variable for the 9 months *on and after* the technology shock (i.e., month 0 to month 8). The estimation period for this regression is the twelve months in 2017. δ_t represents a vector of year-month fixed effects, and α_m represents a vector of merchant fixed effects. Standard errors are clustered at merchant level.

This is a standard event study model where the estimated coefficients β_1 and β_2 approximate, relative to the baseline period and control group, the average monthly (log) change in the card sales in the month before, and during the 9-month period upon the QR code payment introduction respectively. We expect to see the card sales increase more for small merchants relative to large

[11] Total establishments in Singapore retail trade industry by end of 2016 is 24,598. (Singapore Department of Statistics, 2017, https://www.singstat.gov.sg/modules/infographics/-/media/01e961624f3c4eafaacb9b1ff48739ea.ashx). Current number of QR code-enabled merchants is over 30,000 (https://www.dbs.com.sg/personal/deposits/pay-with-ease/scan-and-pay).

[12] It is possible that one merchant is selling multiple types of goods hence is assigned with multiple Merchant Category Code (MCC). For this case, we assign it to the MCC with highest number of transactions during the two-year period.

merchants only *upon* the new payment technology, implying a significantly positive β_2, and a β_1 estimated indifferent from zero.

To estimate the dynamics in sales change, we split the 9 months on and after technology shock into three quarters, and estimated the following distributed lag model:

$$\ln Y_{m,t} = \theta_1 Small\ Merchant_m \times Pre_1 + \sum_{s=0}^{2} \theta_s Small\ Merchant_m \times Quarter_s + \delta_t + \alpha_m + \varepsilon_{m,t} \quad (2)$$

Where the $Quarter_s$ stands for *s*th quarter after the technology shock, with $Quarter_0$ representing April to June of 2017. The marginal coefficients θ_0, θ_1, and θ_2 measure the additional change in average card sales for small merchants in respective quarters.

4. Results

4.1 Direct Effect on Mobile Wallet Usage

We first examine the direct response for mobile wallet usage. We observe a significant increase in mobile wallet usage from Singapore consumers after the QR code payment introduction. Figure 1 plots the time trend of the monthly mobile wallet transactions, using the monthly ATM transactions as benchmark. For both the transaction amount (Panel A, Figure 1) and transaction counts (Panel B, Figure 1), the mobile wallet transactions stay relatively flat before April 2017. Upon the introduction of new QR code payment technology, the monthly transaction amount and count start to trend up almost immediately. In contrast the ATM monthly withdrawals stay flat all over the year, which suggests the rise of mobile wallet transactions is not simply driven by a reduction in cash usage.

[Insert Figure 1 about Here]

Similarly, Table 1 shows that the weekly mobile wallet transaction amount and count both doubled after the QR code payment introduction, compared to the pre-event period.

[Insert Table 1 about Here]

As the QR code payment technology mainly intends to replace small-size payments, which were typically completed by cash before (Cohen and Rysman, 2013; Wang and Wolman, 2016); we should see a stronger increase in the small-size transactions. In Figure 2, we divide all mobile wallet transactions into small-size transaction and large-size transaction by the threshold of SGD100, and plot the time trend separately. From the transaction amount perspective (Panel A, Figure 2), it appears that large-size transactions increase more than the small-size ones. However, the trend in transaction counts (Panel B, Figure 2) shows clearly that the increase in the number of small-size transactions greatly outnumbers that of large-size ones, suggesting that the increase in large-size transaction amount is driven by the transaction size instead of transaction frequency. Panel B of Table 1 shows that the summary statistics based on weekly data presents a similar pattern.

[Insert Figure 2 about Here]

In summary, there is compelling direct evidence that consumers indeed respond to the new payment technology by using the mobile wallet more frequently, especially for the small-size transactions.

4.2 Card Sales Response

This section shows whether such change in consumer payment behavior spills over to merchants' sales through other cashless payment instruments (i.e., bankcards). The estimated average effects are reported in Table 2.

[Insert Table 2 about Here]

Columns (1) of Table 2 shows that the small merchants, defined as those merchants with median monthly sales in 2016 lower than 50th-percentile within each merchant category, experience on average an increase of 3.5 percent in the amount of monthly card sales more than their larger counterparties during the 9 month period upon the QR code payment technology shock, compared to the first two months prior to the shock.[13] This number is around 3.4 percent for transaction count increase (Column (2), Table 2). The effects are both statistically and economically significant. Moreover, the close-to-zero pre-trend estimations further confirm that the differences in card sale

[13] The estimated coefficient for log of total sales amount in column (1) of Table 2 is 0.034, which is equivalent to a percentage increase of 3.5 percent (= exp(0.034) – 1). All subsequent percentage effect interpretations for log dependent variables follow the same formula.

changes are attributable to the new QR payment technology. F-tests suggest that the estimated coefficients for Pre_1 and *Post* are statistically different at 1 percent level, for both sales amount and count of transactions.

In columns (3)-(6), we change the threshold used to classify the small versus large merchants. Specifically, in columns (3)-(4), we lower the threshold to 25th-percentile of the 2016 median monthly card sales within each merchant group. The estimated difference in sales increase is even greater under this definition: 5.1 percent for increase in monthly sales, and 4.3 percent for increase in monthly transaction count. In columns (5)-(6), we raise the threshold to 75th-percentile, which means that only the one quarter of merchants with highest median monthly sale in 2016 are classified as large merchants. The estimated effects are naturally smaller in this case: 2 percent for increase in monthly sales amount and 2.5 percent for increase in monthly transaction count. All results in Table 2 suggest that the larger increases of small merchants in monthly sales count and in monthly sales amount are robust to the classification of small versus large merchants.

The dynamic response in Figure 3 shows that the card sales increase of small merchants relative to large ones mainly takes effect in the first quarter after the technology shock, and the effect continues in the second quarter. Take the sales amount as an example, compared to the first two months in 2017, the monthly small-merchant card sales amount is estimated to be 1.4 percent higher per month than that from large merchants in the shocked quarter (p value =0.356), 4 percent higher in the first quarter after the shock (p value =0.015), and 5.3 percent higher in the following quarter (p value =0.002). Thus, the spillover effect on card sales happens slightly later than the mobile wallet usage itself. Still, the adjustment speed is relatively fast – within one quarter.

[Insert Figure 3 about Here]

4.3 Card Sales Response: By Transaction Size

Previous studies have documented that consumers tend to use cash for small-size payments, and cashless instruments for large-size transactions (Cohen and Rysman, 2013; Wang and Wolman, 2016). The QR code payment technology makes small transactions easier and may raise consumers' tendency to make more cashless payment in small purchases. The dramatic increase of small-size mobile wallet transactions in Figure 2 is consistent with the postulation. We therefore examine in this sub-section whether the positive spillover on card payments stemming from adopting QR code payment technology is also more pronounced in small-size transactions. Following the results in Table 2, we expect to see the spillover effect on card sales with small merchants driven by the ones featuring small-size transactions.

To investigate, we further divide the small merchants into two sub-groups according to their median transaction size per purchase in 2016. Specifically, we define the small merchants with median transaction size in 2016 below the 50th-percentile as the small transaction size type and expect them to exhibit the strongest increase in card sales. Results reported in Table 3 are consistent with our expectation. The change in log sales amount after the technology shock is indistinguishable between large merchants and small merchants with large transaction size (coefficient=-0.011, *p* value=0.538). In contrast, the small merchants with small transaction size register 8.5 percent increase (= exp(0.082)-1) in card sales amount than their counterparties with large transaction size, and the difference is statistically significant at the 1 percent level. Similar result is found for the card transaction counts: only the small merchants with small transaction size exhibit a significant increase in card sales count of 6.7 percent (= exp(0.072-0.007)-1) relative to large merchants.

[Insert Table 3 about Here]

4.4 Drivers of the Sales Growth: New Businesses

Gains from the lower-cost and higher-convenience payment technology are likely to be greater for new businesses. They tend to run on a smaller scale with a higher marginal benefit from a reduced transaction cost and improved transaction efficiency. In addition, new merchants possess a less stable customer base, leading to a greater impact of the increased consumer traffic. We find consistent evidence.

We proxy a merchant's stage of business by the time of first sale it has generated in 2016. Specifically, we classify merchants in our sample with their first sale happening in the second half of 2016 (i.e., during 2016:07-2016:12) as new merchants and the rest as old merchants. As reported in Table 4, although the small old merchants increase around 2.1 percent (2.0 percent) in card sales amount (count) relative to large merchants after the technology shock, the rise of card sales amount (count) for small new merchants are 8.7 percent (8.0 percent) higher than the relatively older ones. F tests suggest the difference in both sales amount and sales count are statistically significant.

[Insert Table 4 about Here]

4.5 Economic Mechanism: New Customer Acquisition

After showing that the new payment technology is really helping the small merchants who need it most both directly (through the mobile wallet usage) and indirectly (through the positive externality on card sales), we investigate where the incremental card sales come from. As the new payment technology enhanced transaction convenience (the Visa survey in July 2017 shows that more than two-thirds respondents in Singapore are comfortable to go cashless for a whole day), the location constraint for consumption is loosened. We postulate that consumers are more likely to explore new areas and shop at new stores.

For each merchant, we define the customers from a new postal sector (measured by the 2-digit postal code of residence) as new customers, where a new postal sector is the one which never produces any sale to that merchant in the whole year of 2016. In Table 5, we check whether the small merchants experience larger increase in the fraction of new customer number (defined as count of new customers scaled by total count of customers), in the fraction of sales amount from new customers (defined as card sales amount from new customers scaled by total card sales amount), and in the fraction of transaction counts from new customers (defined as card sales transaction count from new customers scaled by total card sales count). As expected, column (1) of Table 5 shows that the fraction of new customer counts increases 1.8 percent more for the small merchants compared to their large counterparties (p value<0.001). Similarly, columns (2)-(3) shows that both sales amount and sales count from new customers increase 1.7 percent more for small merchants (both p values<0.001). Given an average fraction of new customer count (and new customer sales) of around 28 percent, this translates into an increase of more than six percent in new customer count fraction (and new customer sales fraction), which is economically significant. This result also suggests that the positive effect reflects genuine business growth instead of the substitution effect whereby consumers simply switch from cash to cards.

[Insert Table 5 about Here]

4.6 Heterogeneity by Goods Sold

In this section, we examine the extent of spillover effect on different types of merchant defined by their goods sold. As validated above that card sales increase mainly works through new small merchant and in small-size transactions, it is unlikely that the sales of visible goods (used to signal status), which are typically expensive from well established brands, will be affected to a large extent. Following the definitions in Agarwal, Qian, and Zou (2018b), we group the merchants as visible goods sellers and non-visible goods sellers, and separately check their sales response.[14] As reported in Panel A of Table 6 (columns (1)-(2)), the small merchants, relative to the large merchants, selling non-visible goods register significantly more increase in card sales amount (coefficient=0.073, p value<0.001), while the difference in card sales growth between small and large merchants selling visible goods are statistically indistinguishable from zero (coefficient=-0.023, p value=0.255). Chi-test suggests the difference between visible goods sellers and non-visible goods sellers are statistically significant at 1 percent level.

[Insert Table 6 about Here]

We also examined whether there's difference between merchants selling discretionary goods versus non-discretionary goods. We define merchants mainly selling goods in "local conveyance & taxi", "supermarkets", and "food & beverage stores" as non-discretionary goods sellers, and the rest as discretionary goods sellers. In columns (3)-(4) of Panel A, Table 6, we find that the small merchants selling discretionary goods register a significant 3.9 percent increase in card sales amount relative to their large counterparties; this effect is an insignificant 2 percent for the non-discretionary sellers. Chi-test suggests that the difference is insignificant (Chi-test statistic=0.08, p value=0.773).

Besides classifying merchants into broad binary types, we further classify merchants into six categories: supermarket, apparel, dining entertainment, travel, and personal care. As reported in Panel B of Table 6, card sales for dining merchants experience the strongest spillover effect: small

[14] Specifically, we classify merchants mainly selling the following types of goods as visible goods sellers: specialty retail, automotive-related, rental, apparel, department stores, watches & jewelry, home/office furnishing & appliances, electronic and computer, music, entertainment & recreational, dining, associations/memberships, pets.

merchants exhibit 12.6 percent more increase in total card sales amount than large merchants. This area is indeed where consumers used to pay cash before, especially for small-size payments.

5. Conclusion

This paper employs a unique, proprietary dataset containing the credit card, debit card, and mobile wallet transactions information from 250,000 consumers in Singapore to analyze the effect of a technology shock in mobile wallet payment. The introduction of QR code payment technology on 13th April 2017 enables mobile wallet users to receive and make payments by generating QR codes. This makes the digital payments, especially the small-size payments, more convenient. We first confirm that the mobile wallet usage itself immediately trends up upon the new technology introduction, and the small-size transactions are leading the usage increase.

The resultant transaction convenience in small size payments moves consumer traffic and raises similar consumption with recognizable spillover benefits. We use a difference-in-difference identification to estimate the spillover effect on merchant's monthly card sales. Small merchants, where consumers used to, or have to, pay cash before, are expected to benefit more from the improved payment convenience. We find the card sales for small merchants increased significantly more than the large merchants after the QR code payment technology shock: relative to the first two months in 2017, small merchants' card sales amount (count) averagely increased 3.5 percent (3.4 percent) more during the 9-month period upon the technology shock. We further show that the spillover effect arrives fast: in the quarter after the QR code payment technology is introduced.

As the new payment technology for mobile wallet mainly benefits and changes consumers' behavior towards small-size transactions, we find the spillover effect is driven by the small merchants featuring small-size transactions. Additionally, we show that the new entrepreneurs who just started their business benefit more from the low-cost, convenient new technology. A possible mechanism for the spillover effect is the increased retail traffic due to improved payment convenience, as we find a large increase in the fraction of new customer (sales) explains the post-shock sales growth. As for the type of goods sold, spillover manifests among the non-visible goods sellers, and shows up in both discretionary goods sellers and non-discretionary goods sellers. Dining providers experienced the largest spillover effect in card sales.

Overall, the paper’s findings contribute to the fintech and digitization literatures on cashless payment by providing novel insights on the real effect of improved payment efficiency. We show that the enhanced convenience in mobile wallet payment fosters business growth, especially for the small, entrepreneurial firms.

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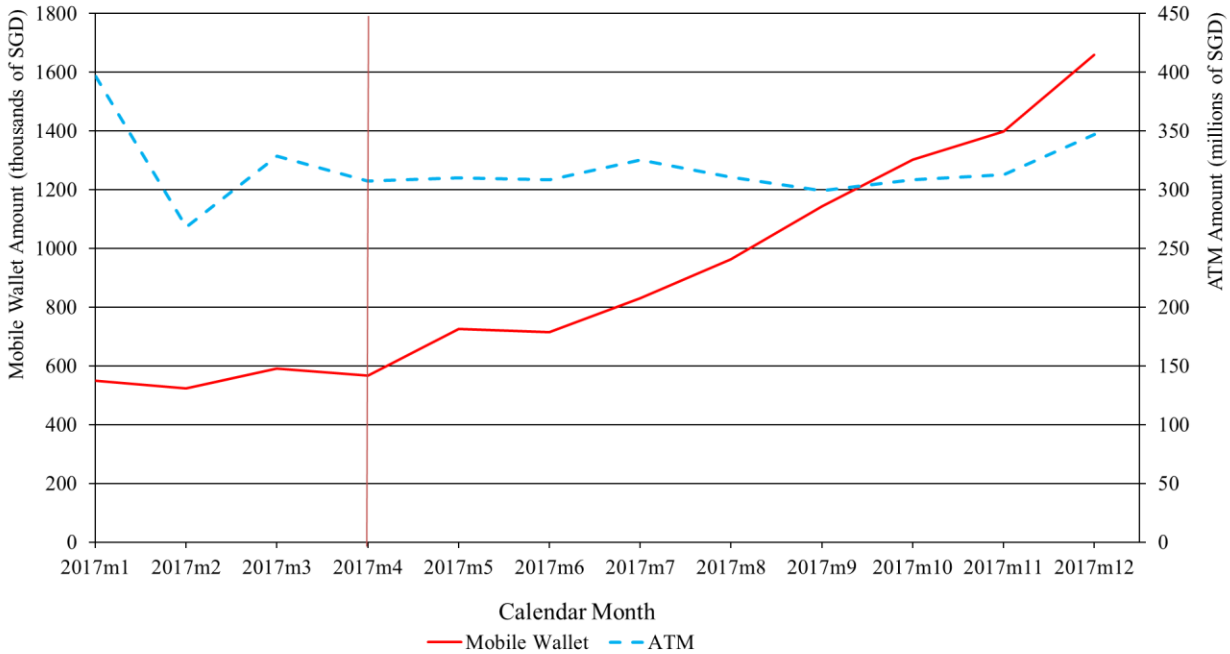
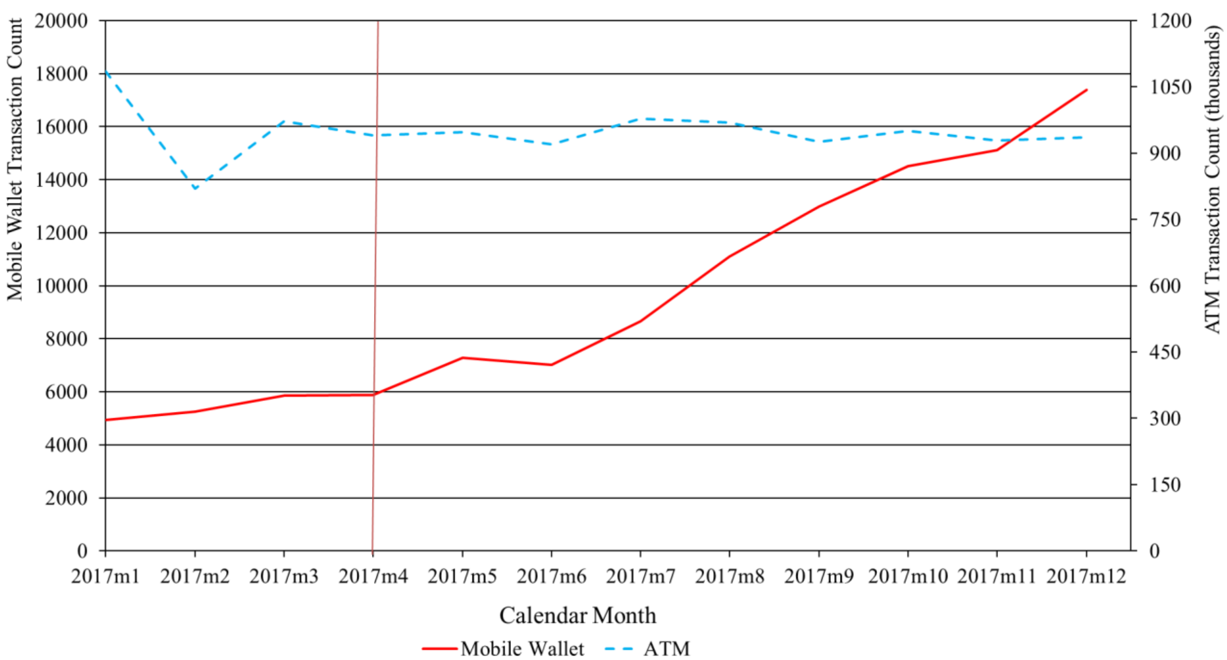
Figure 1. Time Trend of Mobile Wallet and ATM Transactions

A. Transaction Amount



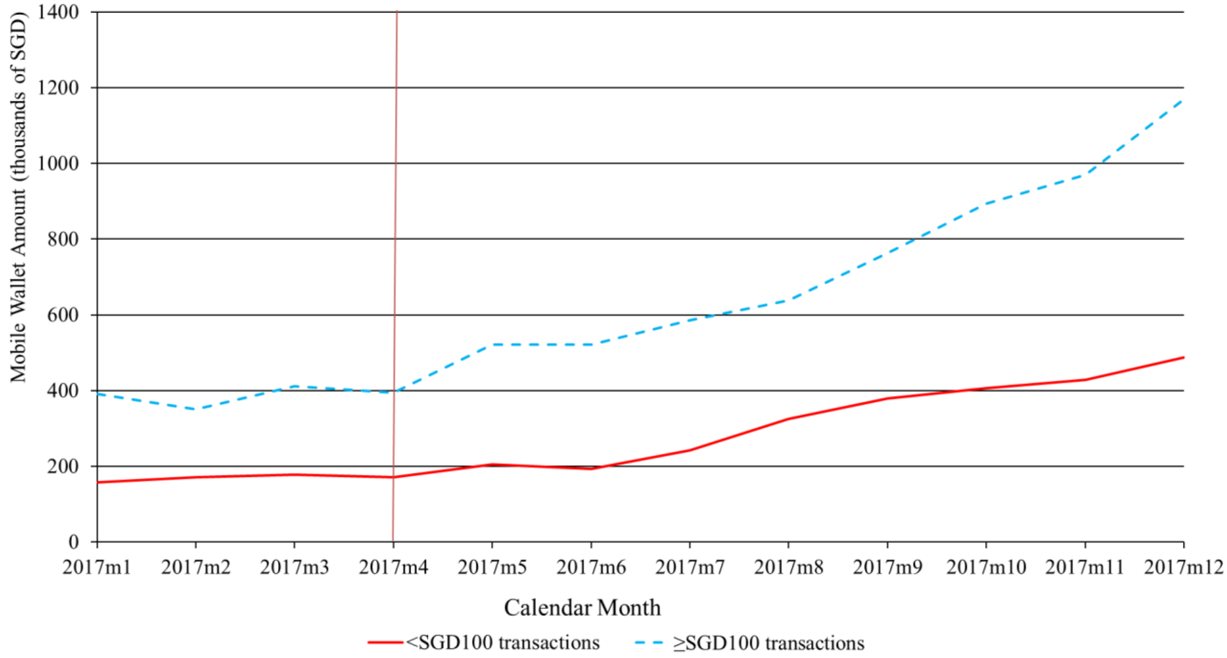
B. Transaction Count



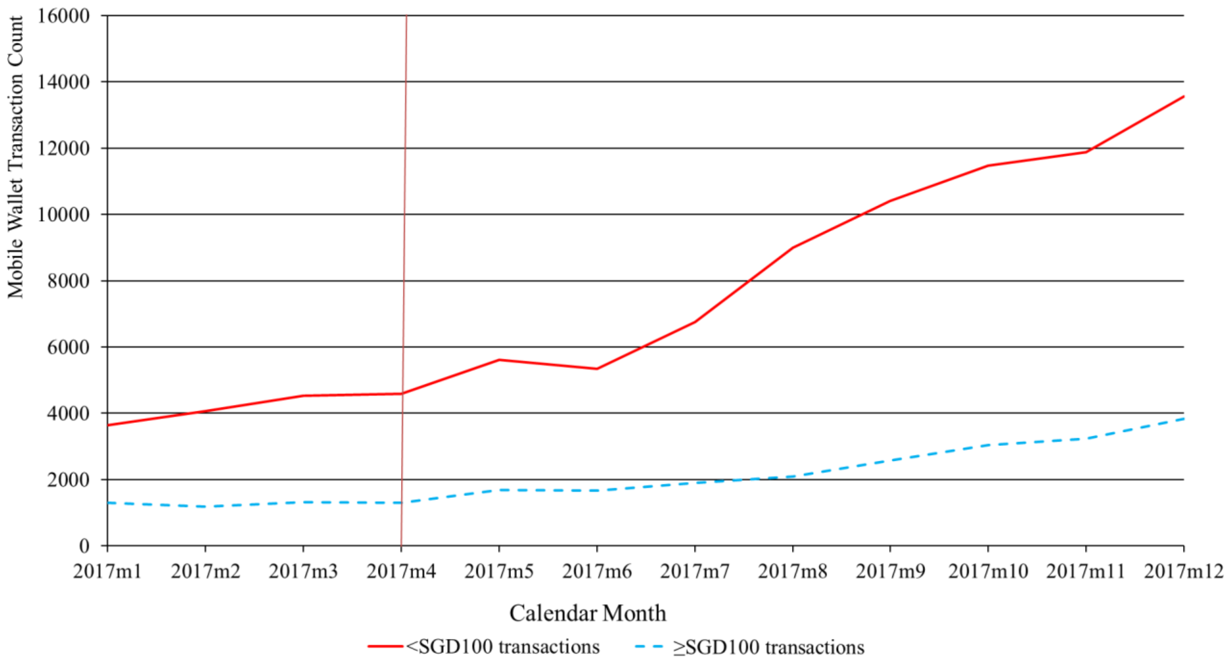
Note. This figure plots the time trends for Mobile Wallet and ATM transactions in 2017. The vertical line indicates the introduction month of first local QR code payment instrument in Singapore (2017:04). The x-axis denotes the *m*th month after the QR code payment introduction, and the y-axis shows the transaction amount in Panel A, and the transaction count in Panel B.

Figure 2. Time Trend of Small-size vs. Large-size Mobile Wallet Transactions

A. Transaction Amount



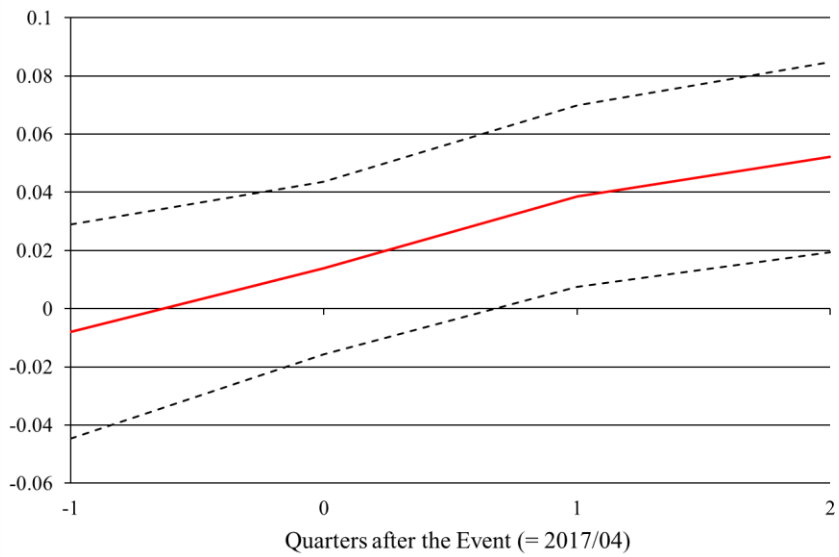
B. Transaction Count



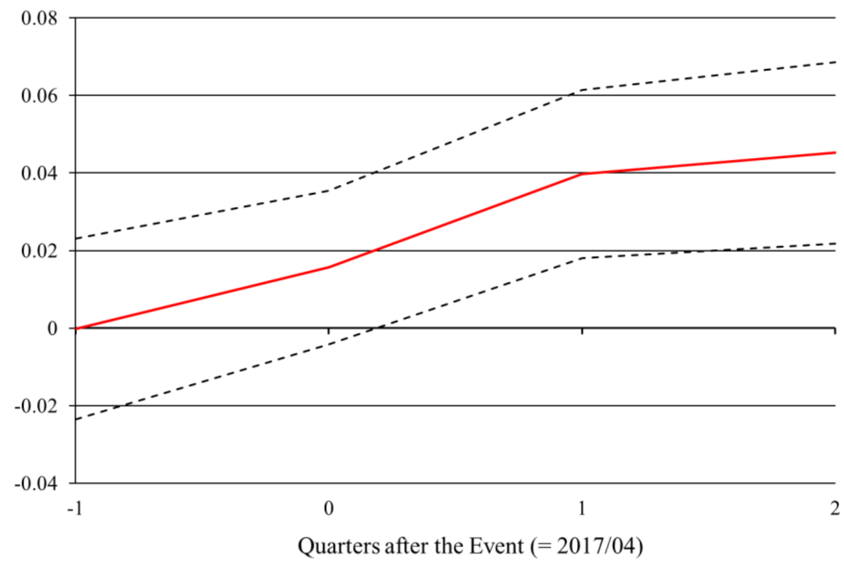
Note. This figure plots the time trends for small-size (i.e., transaction size <SGD100) vs. large-size (i.e., transaction size ≥SGD100) Mobile Wallet transactions in 2017. The vertical line indicates the introduction month of first local QR code payment instrument in Singapore (2017:04). The x-axis denotes the *m*th month after the QR code payment introduction, and the y-axis shows the Mobile Wallet transaction amount in Panel A, and the Mobile Wallet transaction count in Panel B.

Figure 3. Dynamic Response of Log Sales

A. Log (Sales Amount)



B. Log (Sales Count)



Note. This figure plots the dynamic response of log card sales estimated from Equation (2), for the one month before and three quarters on and after the first introduction of QR code payment technology. The x-axis denotes the qth quarter after the first QR code payment introduction, and the y-axis shows the response of log sales amount in Panel A, and log sales count in Panel B.

Table 1. Mobile Wallet Transactions before and after QR code Payment Introduction

	[-1,-14 week] window	**[1,37 week] window**	**Difference in means (2)-(1)**
	(1)	(2)	(3)
Panel A. All Mobile Wallet Transactions			
Transaction amount (SGD)	130,502	243,856	113,353***
Transaction count (#)	1,260	2,623	1,363***
Panel B. Small-size vs. Large-size Mobile Wallet Transactions			
Transaction amount (SGD)			
Small-size transactions	39,645	74,424	34,779***
Large-size transactions	90,858	169,461	78,574***
Difference in means: small-large	-51,213***	-95,008***	-43,795
Transaction count (#)			
Small-size transactions	962	2,063	1,101***
Large-size transactions	297	560	262***
Difference in means: small-large	665***	1,503***	838
Number of weeks	14	37	

Note. This table compares the amount and count of Mobile Wallet transactions in 14 weeks before and 37 weeks after the first QR code payment introduction in week 15 of 2017. Panel A pools all transactions, while Panel B separates small-size transactions (i.e., transaction size <SGD100) and large-size transactions (i.e., transaction size ≥SGD100). ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

Table 2. Average Card Sale Response to the QR code Payment Introduction

	Small merchants as median monthly sales in 2016 lower than:					
	50th-percentile		**25th-percentile**		**75th-percentile**	
	Log(Total Sales Amount)	**Log(Total Sales Count)**	**Log(Total Sales Amount)**	**Log(Total Sales Count)**	**Log(Total Sales Amount)**	**Log(Total Sales Count)**
	(1)	(2)	(3)	(4)	(5)	(6)
Small Merchant × Pre$_1$	-0.008	-0.000	0.009	0.014	-0.008	0.005
	(0.42)	(0.02)	(0.38)	(0.92)	(0.44)	(0.47)
Small Merchant × Post	0.034**	0.033***	0.050***	0.042***	0.020	0.025**
	(2.47)	(3.39)	(2.80)	(3.27)	(1.43)	(2.53)
Constant	6.884***	1.898***	6.884***	1.898***	6.884***	1.898***
	(889.62)	(366.10)	(889.67)	(365.99)	(889.32)	(366.02)
Fixed Effects	Merchant, year-month					
Observations	148,460	148,460	148,460	148,460	148,460	148,460
R-squared	0.81	0.91	0.81	0.91	0.81	0.91

Note. This table shows the average card sale response (Equation (1)) of small merchants compared with large merchants to the first QR code payment introduction in the period from 2017:01 to 2017:12. *Small Merchant* is a binary variable equal to one for the small merchants. In columns (1)-(2), small merchants are defined as merchants with median monthly sales lower than the 50th-percentile within each MCC in 2016; in columns (3)-(4), and columns (5)-(6), the cutoffs for small merchants are 25th-percentile and 75th-percentile respectively. Pre_1 is a binary variable equal to one for the one month before the first QR code payment introduction (i.e., 2017:03). *Post* is a binary variable equal to one for the nine months on and after the first QR code payment introduction (i.e., 2017:04 - 2017:12). *Total Sales Amount* is computed by adding all monthly card sales amount for each merchant. *Total Sales Count* is computed by counting monthly count of card purchases for each merchant. Merchant and year-month fixed effects are included, and standard errors are clustered at the merchant level. T-statistics are reported in parentheses under the coefficient estimates. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

Table 3. Heterogeneity by Transaction Size

	Log(Total Sales Amount)	Log(Total Sales Count)
	(1)	(2)
Small Merchant × Pre$_1$	-0.008	-0.001
	(0.44)	(0.06)
Small Merchant × Post	-0.011	-0.007
	(0.62)	(0.62)
Small Merchant × Small Transaction Size × Post	0.082***	0.072***
	(4.33)	(5.51)
Constant	6.885***	1.899***
	(889.30)	(366.70)
Fixed Effects	Merchant, year-month	
Observations	148,460	148,460
R-squared	0.81	0.91

Note. This table reports the heterogeneity in average card sale response by the size of card transaction. *Small Merchant* is a binary variable equal to one for the small merchants, which is defined as merchants with median monthly sales lower than the 50th-percentile within each MCC in 2016. *Small Transaction Size* is a dummy variable equal to one for the merchants with median transaction size per purchase lower than 50th-percentile among the small merchants in 2016. Pre_1 is a binary variable equal to one for the one month before the first QR code payment introduction (i.e., 2017:03). *Post* is a binary variable equal to one for the nine months on and after the first QR code payment introduction (i.e., 2017:04 - 2017:12). *Total Sales Amount* is computed by adding all monthly card sales amount for each merchant. *Total Sales Count* is computed by counting monthly count of card purchases for each merchant. Merchant and year-month fixed effects are included, and standard errors are clustered at the merchant level. T-statistics are reported in parentheses under the coefficient estimates. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

Table 4. Response of New Entrepreneurs

	Log(Total Sales Amount) (1)	**Log(Total Sales Count)** (2)
Small Merchant × Pre_1	-0.008	-0.001
	(0.44)	(0.05)
Small Merchant × Post	0.021	0.020**
	(1.45)	(2.05)
Small Merchant ×New Merchant × Post	0.083***	0.077***
	(3.22)	(3.91)
Constant	6.884***	1.898***
	(889.96)	(366.24)
Fixed Effects	Merchant, year-month	
Observations	148,460	148,460
R-squared	0.81	0.91

Note. This table reports the heterogeneity in average card sale response by the stage of the merchant business. *Small Merchant* is a binary variable equal to one for the small merchants, which is defined as merchants with median monthly sales lower than the 50th-percentile within each MCC in 2016. *New Merchant* is a dummy variable equal to one for the merchants with first sale occurs in the later half year of 2016 (i.e., later than 2016:06). Pre_1 is a binary variable equal to one for the one month before the first QR code payment introduction (i.e., 2017:03). *Post* is a binary variable equal to one for the nine months on and after the first QR code payment introduction (i.e., 2017:04 - 2017:12). *Total Sales Amount* is computed by adding all monthly card sales amount for each merchant. *Total Sales Count* is computed by counting monthly count of card purchases for each merchant. Merchant and year-month fixed effects are included, and standard errors are clustered at the merchant level. T-statistics are reported in parentheses under the coefficient estimates. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

Table 5. Response of New Customer Sales

	New postal customer # / total customer # (1)	**New postal customer sales amount / total sales amount** (2)	**New postal customer sales count / total sales count** (3)
Small Merchant × Post	0.018***	0.017***	0.017***
	(4.76)	(4.36)	(4.51)
Constant	0.281***	0.278***	0.276***
	(120.30)	(110.65)	(117.71)
Fixed Effects		Merchant, year-month	
Observations	148,460	148,460	148,460
R-squared	0.59	0.55	0.59

Note. This table reports the response of sales from customers in new postal areas. Columns (1)-(3) shows the response of new customer count fraction, new customer sales amount fraction, and new customer sales count fraction, respectively. New postal area is defined as the postal area that doesn't produce any sale for a merchant in 2016, but produces sale in 2017. *New postal customer #* is the monthly count of unique customers from new postal areas for a merchant. *Total customer #* is the monthly count of all unique customers. *New postal customer sales amount* is the monthly total card sales from new postal areas for a merchant. *Total sales amount* is computed by adding all monthly card sales amount for each merchant. *New postal customer sales count* is the monthly total count of card purchase from new postal areas for a merchant. *Total sales count* is computed by counting monthly count of card purchases for each merchant. *Small Merchant* is a binary variable equal to one for the small merchants, which is defined as merchants with median monthly sales lower than the 50th-percentile within each MCC in 2016. *Post* is a binary variable equal to one for the nine months on and after the first QR code payment introduction (i.e., 2017:04 - 2017:12). Merchant and year-month fixed effects are included, and standard errors are clustered at the merchant level. T-statistics are reported in parentheses under the coefficient estimates. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

Table 6. Heterogeneity by Goods Sold

Panel A

	Log(Total Sales Amount) Merchants sell			
	Visible vs. non-visible goods		**Discretionary vs. non-discretionary goods**	
	Visible	**Non-visible**	**Discretionary**	**Non-discretionary**
	(1)	(2)	(3)	(4)
Small Merchant × Post	-0.023	0.073***	0.038***	0.020
	(1.14)	(5.02)	(3.13)	(0.32)
Constant	6.808***	6.932***	6.886***	6.819***
	(504.78)	(745.60)	(876.13)	(154.66)
Fixed Effects	Merchant, year-month			
Observations	56,931	91,529	143,656	4,804
R-squared	0.78	0.83	0.81	0.90

Panel B

	Supermarket	**Apparel**	**Dining**	**Entertainment**	**Travel**	**Personal care**
	(1)	(2)	(3)	(4)	(5)	(6)
Small Merchant × Post	0.020	-0.027	0.119***	0.008	-0.020	-0.059
	(0.32)	(0.85)	(6.62)	(0.17)	(0.34)	(1.57)
Constant	6.819***	6.832***	6.911***	6.594***	7.435***	6.625***
	(154.66)	(327.03)	(622.35)	(216.95)	(201.27)	(263.11)
Fixed Effects	Merchant, year-month					
Observations	4,804	21,469	45,089	10,634	9,169	15,651
R-squared	0.90	0.81	0.86	0.80	0.85	0.71

Note. This table reports the heterogeneity in average card sales amount response by type of goods sold by merchants. Panel A divides all merchants into binary groups by the visibility of goods sold in columns (1)-(2), or the sale of discretionary versus non-discretionary goods in columns (3)-(4). Please refer to Section 4.6 for detailed classifications. Panel B further checks the average sales amount response for merchants selling six categories of goods: supermarket goods, apparel, dining, entertainment, travel, and personal care. *Small Merchant* is a binary variable equal to one for the small merchants, which is defined as merchants with median monthly sales lower than the 50th-percentile within each MCC in 2016. *Post* is a binary variable equal to one for the nine months on and after the first QR code payment introduction (i.e., 2017:04 - 2017:12). *Total Sales Amount* is computed by adding all monthly card sales amount for each merchant. Merchant and year-month fixed effects are included, and standard errors are clustered at the merchant level. T-statistics are reported in parentheses under the coefficient estimates. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.