FinTech and Crime: Evidence from Banks' Partnering with Zelle *

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Abstract

We study how the rapid adoption of FinTech payment technology, Zelle, affects crime in the United States. We collect a novel dataset of Zelle's banking partners by using an internet archive tool - Wayback machine. We find a higher Zelle penetration is associated with a lower robbery rate and motor vehicle theft rate at the county level. To address the endogeneity, we exploit the fact that Zelle was launched by the seven largest US banks in 2017. The difference-in-difference analysis shows that the counties with large exposure to the seven largest US banks before 2017 experienced a large decline in robbery rate and motor vehicle theft rate. The negative effect on the robbery rate was more pronounced in counties with higher education levels, more affluent areas proxied by higher GDP and lower poverty rates, larger population, and a higher ratio of people over 65 years old. Our findings shed light on the social impact of FinTech adoption.

JEL: E24; E32

Keywords: FinTech; Crime; Payment System;

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1 Introduction

The rapid growth in mobile payments driven by the Fintech revolution has not only altered consumer habits but also significantly reduced the dependence on cash (Snellman et al. (2001)). This shift has led to various societal changes. In this paper, we investigate how the rapid adoption of payment technology, Zelle impacts crime in the US.

Zelle is the most widely used person-to-person (P2P) digital payment technology in the US (Balyuk and Williams (2021)). As Zelle is integrated into the mobile banking applications of its partnering banks, it encourages users to engage in online transactions[1]. Since its establishment in 2017, Zelle has experienced a steadily growing adoption rate, and by 2022, it was partnered with more than 1,800 U.S. banks and credit unions, covering about 80 percent of all U.S. bank accounts[2]. As a result of the continuous expansion of partnering banks, it may lead to a decline in the amount of physical currency circulating on the streets. This reduction in cash circulation might decrease the prevalence of street crimes, as there are fewer prime targets for criminals.

The main empirical challenge is to collect the historical Zelle banking partners' information. As Zelle's official website only provides the current banking partners without information about when the bank first joined the Zelle network. We overcome this problem by leveraging an internet archive tool - Wayback machine. The Wayback machine enables us to collect information when the banking partner first appears on Zelle's website. We use the quarter the bank first appeared on the Zelle website as its time to join the Zelle network. We use the FDIC summary of deposit data to construct a county-level Zelle penetration ratio. We use the FBI University Crime Report (UCR) data to construct the county-level crime rate.

Our baseline specification finds that a higher Zelle penetration ratio is associated with a lower robbery rate and motor vehicle theft rate. To over the identification problem, we exploit the fact that Zelle was owned and launched by the seven largest US banks. Our identification assumption is that the launch of Zelle is uncorrelated with the local crime conditions and, thus, should be orthogonal to the crime rate. We construct the big 7 banks' county-level exposure before 2017 and

[1]This is facilitated by the convenience and safety provided by Zelle for small savings, payments and money transfers. They are free, fast and convenient

[2]Kate Fitzgerald, "Zelle's Rocky Rise in 2022", American Banker, December 22, 2022, https://www.americanbanker.com/payments/list/zelles-rocky-rise-in-2022.

use the difference-in-difference (DiD) analysis to see whether the launch of Zelle impacts crime. Indeed, we find counties with a higher presence of 7 initiator banks experienced a decline in robbery rate and motor vehicle theft rate. We test the parallel trend assumption by conducting the dynamic event study.

The heterogeneous analysis finds that the decline in the robbery rate is more pronounced in counties with higher education levels, more affluent counties indicated by higher GDP and lower poverty rates, more population, and counties with a larger population over 65 years old.

This paper is related to two strand of literature. The first strand of literature is about the social and economic impact of FinTech adoption. (Find more literature about how fintech adoption impacts banks, firms, consumers.) The fintech revolution officially began with the widespread adoption of smartphones in 2010. Since 2015, awareness and adoption of fintech services have increased significantly, effectively improving social welfare level. For banks, the application of fintech has enhanced stability and risk management capabilities, while also improving capital adequacy and management efficiency. For publicly listed companies, advancements in fintech have effectively alleviated information asymmetry, reducing financing constraints. Additionally, fintech has provided more opportunities for small and startup enterprises, ensuring a fair distribution of financial resources between urban and rural areas as well as across various industries. Also, fintech activities have significantly enhanced consumer welfare by offering more convenient and affordable financial services, increasing service convenience and speed. The widespread adoption of mobile payment systems has strengthened households' ability to share risks, raised per capita consumption levels, and improved consumer welfare. Moreover, as a transparent and cost-effective financial system, fintech has driven economic growth in underdeveloped regions and enhanced financial inclusion for vulnerable groups. Fintech enables financial institutions to serve economically disadvantaged groups at a lower cost, enhancing the ability of impoverished populations to access financial services. This paper contributes to this strand of literature by looking into the impact of FinTech adoption on crime. Our findings provide more evidence about the positive welfare effect of FinTech adoption.

This paper contributes to a strand of literature studying the impact of cashless society on crime. (The literature review how debit card, electronic payment system affects crime). With the spread of electronic payment, numerous research studies have revealed that non-cash payments have a significant substitution effect on cash (Cabezas and Jara (2021);Deutsche Bundesbank (2017); Klee (2006);Pietrucha and Maciejewski (2020); Pintér et al. (2022)). Due to cash's inherent characteristics, such as anonymity, liquidity, and untraceability (Dalinghaus (2017); Gladisch (2017); Pridemore et al. (2018)), it has historically facilitated certain types of crimes, particularly acquisitive crimes such as street robberies and burglar (Armey et al. (2014); Warwick (1993); Gandelman et al. (2023); Pridemore et al. (2018); Rainone (2023); Wright et al. (2017)). As consumer behavior shifts from cash and check payments to digital methods, including credit cards, online transactions, and mobile banking(Brown et al. (2022); Cabezas and Jara (2021); Federal Reserve Services, 2021; Klee (2008); Pietrucha and Maciejewski (2020); Pintér et al. (2022); Pridemore et al. (2018)), the underground economy, money laundering, and tax evasion have diminished(Dalinghaus (2017); Deutsche Bundesbank (2017); Foley (2011); Giammatteo et al. (2021); Gladisch (2017); Kruisbergen et al. (2019); Kuchciak (2013); Soudijn and Reuter (2016); Warwick (1993)). Our findings complement their existing literature by showing the rapid adoption of payment technology can indeed reduce the street crime in a cashless society.

Driven by advancements in financial technology, the evolution of payment methods in the United States has transitioned from cash to digital platforms over the years (Rogoff (2017)). In the 1950s, credit cards were first introduced as an electronic payment revolutionized consumer spending by allowing deferred payments (Alvarez et al. (2022)). The 1970s saw the advent of debit cards, offering direct access to bank funds and reducing the need for cash (Snellman et al. (2001)). The 1990s internet boom led to online payment systems, facilitating e-commerce transactions (Hassan et al. (2020); Klee (2006); Mallat (2007); Pal et al. (2018)) although there are some threats and challenges (Dalinghaus (2017); Mallat (2007); Wang et al. (2016)). This digital shift continued with the growth of online and mobile banking (Liébana-Cabanillas et al. (2016); Patil et al. (2020); Ramos-de Luna et al. (2016); Singh et al. (2020)), culminating in the development of Peer-to-Peer (P2P) payment systems like Zelle in 2017 (Hassan et al. (2020)). Globally, P2P payment methods are considered to have strong market competitiveness along with growth and potential. This global trend is mirrored in the United States, where the market for P2P payments has grown remarkably[3].

[3] According to Borasi, P., Khan, S., and Kumar, V. (2021) in their report titled P2P Payment Market Transaction Mode: Global Opportunity Analysis and Industry Forecast from 2021 to 2030, the U.S. market size for P2P payment methods was valued at 1889.16 billion dollar in 2020 and is projected to grow to 9097.06 billion dollar by 2030.

Among those P2P payment methods, Zelle has become a notable example of the shift towards more efficient, secure and instant financial transactions in this expanding market (Kalinic et al. (2019); Lara-Rubio et al. (2021); Belanche et al. (2022); Li et al. (2021)). Zelle stands out as a most widely used digital payment platform designed to facilitate quick and secure money transfers among individuals through over 2000 participating banks and credit unions. This feature reflects a broader trend towards simplified and user-friendly financial services, in line with the global trend towards digitisation of financial transactions[4]. Its convenience makes it a preferred choice for peer-to-peer payments, bill splitting, and various financial transactions. Therefore, Zelle transactions can serve as an indicator of contemporary digital financial activity, reflecting the consumers and business payment behavior on electronic payment.

Moreover, the spread of electronic payment systems can reduce citizen's cash use. Numerous research studies have revealed that non-cash payments have a significant substitution effect on cash (Cabezas and Jara (2021);Deutsche Bundesbank (2017); Klee (2006);Pietrucha and Maciejewski (2020); Pintér et al. (2022)), which is prevalent in many countries (Cabezas and Jara (2021); Snellman et al. (2001)). While the citizen's demand for cash in the United States is not trending downwards (Brown et al. (2022); Deutsche Bundesbank (2017); Gladisch (2017); Pietrucha and Maciejewski (2020)), influenced by both domestic and international factors (Deutsche Bundesbank (2017)), recent trends indicate a shift in preferences. International demand, which constitutes a significant portion of overall demand, has been particularly affected by crises and political uncertainties. However, domestically, there has been an increase in the growth rate of demand for large-denomination cash and a decline in demand for small-denomination cash, suggesting a decline in domestic cash demand (Cabezas and Jara (2021); Dalinghaus (2017); Deutsche Bundesbank (2017); Pietrucha and Maciejewski (2020)). Furthermore, consumer behavior has shifted away from cash and check payments towards mobile payments (Brown et al. (2022); Cabezas and Jara (2021); Federal Reserve Services, 2021; Klee (2008); Pietrucha and Maciejewski (2020); Pintér et al. (2022); Pridemore et al. (2018)), facilitated by Peer-to-Peer transactions due to their convenience (Klee

[4] According to the Zelle website (2023) and Experian (2020) in their article Here's What You Need to Know About Zelle: The Mobile Payment App That Rivals Venmo, Zelle has gained popularity since its establishment in 2017 for its real-time transaction capabilities. With a network volume reaching up to 1.4 trillion dollar, Zelle enables users to send funds directly from their bank accounts via a mobile app or online banking.

(2006); Pietrucha and Maciejewski (2020)). This shift has resulted in a reduction in cash holding (Cabezas and Jara (2021); Snellman et al. (2001)). Despite the growth importance and benefits of mobile payments, people are unlikely to give up cash completely in the short term (Cabezas and Jara (2021); Deutsche Bundesbank (2017); Pietrucha and Maciejewski (2020); Pintér et al. (2022)).

Furthermore, numerous articles espouse that the transition from cash to digital payments plays a role in decline of crime rates. The characteristics of cash, including its anonymity, liquidity and untraceability (Dalinghaus (2017); Gladisch (2017); Pridemore et al. (2018)), have historically facilitated certain types of crimes, particularly acquisitive crimes such as street robberies and burglar (Armey et al. (2014); Warwick (1993); Gandelman et al. (2023); Pridemore et al. (2018); Rainone (2023); Wright et al. (2017)). On the other hand, the increasing digitization of payments, represented by the growing use of credit cards, online transactions and mobile banking, corresponds with a decrease in cash-related crimes. This shift has diminished the underground economy, money-laundering and tax evasion (Dalinghaus (2017); Deutsche Bundesbank (2017); Foley (2011); Giammatteo et al. (2021); Gladisch (2017); Kruisbergen et al. (2019); Kuchciak (2013); Soudijn and Reuter (2016); Warwick (1993)). Overall, the behaviour of people and businesses tends to shift from paper cash towards electronic payments, which is effective in reducing cash holding and thus controlling crime.

Previous research on the link between payment methods and crime has focused on point-of-sale transactions, credit and debit cards. However, there has been little research on mobile payments, which have emerged in recent years with the development of financial technology. Moreover, few studies have examined the impact of electronic payment applications on crime across the entire United States. Therefore, this study aims to fill these gaps by focusing on Zelle, a P2P platform that has significantly influenced the way people make payments. Consequently, informed by previous articles, we propose the following hypotheses to explore the extent of Zelle's impact on crime rates in the United States:

2 Data

2.1 Zelle Data

We assemble a novel data set that contains a list of Zelle-partnering banks from Zelle's current and historical websites.[5] Specifically, we use each bank's website provided by Zelle to obtain information about its headquarters and geographic location. If the linked website for each bank on Zelle is not accessible, we turn to Facebook, Twitter, and LinkedIn to find its headquarter and location information through the logo in the pop-out window on Zelle's website. Using each Zelle-parterning bank's headquarters and location information, we are able to match its record to find its unique identity number (RSSD ID) on the Federal Financial Institutions Examination Council (FFIEC) website. In total, there are 998 Zelle-partnering banks over the sample period of 2017Q3 to 2021Q4, among which 987 are successfully matched with their unique RSSD identified. The outcome from our matching process is comparable with Balyuk and Williams (2021), in which 1.7% of Zelle-partnering banks are not matched in FFIEC. Figure Fig. 1 plots the number of Zelle-partnering banks over time. The total number has increased rapidly after the pandemic in 2020Q1 (vertical line in Fig. 1).

We use the Summary of Deposits data from FDIC to construct the county-level Zelle penetration ratio and the county-level Zelle 7 intiators exposure measure. We standardized these two measures to ease our coefficient interpretation.

2.2 Crime Data

The crime data are collected from the Uniform Crime Reporting (UCR) Program of the Federal Bureau of Investigation (Federal Bureau of Investigation Crime Data Explorer, 2024). Initiated in 1908, this program provides standardized and reliable crime data from law enforcement agencies nationwide (5 Reasons Why the FBI Is So Effective, 2024). It offers a solid foundation for analyzing and understanding crime trends on a national scale.

This investigation assembles the US county-level annually data from 2012 to 2021. To compare crime rates before and after the launch of Zelle in 2017, we analyze data from the five years

[5] We use WayBack machine, a digital archive of the World Wide Web, to trace Zelle's historical websites.

preceding its inception and compared it with data from the following five years. Data on offences include total crime, violent crimes including murder and nonnegligent manslaughter, rape, robbery, and aggravated assault, as well as the property crimes consisting of burglary, larceny-theft, motor vehicle theft and arson. Definition for each crime rate is presented on Appendix A. Arson data are excluded from this study due to its limited availability and lower relevance to cash transaction. Additionally, observations are cleaned depending on footnotes of original dataset, particularly deleting observations which were claimed as underreported, overreported or incomparable to previous years' data.

The crime rates are calculated on 100,000-person level. For each kind of crime in a county, it is figured out by number of offenses divided by the population, then multiplied by 100,000. The population data were collected on United State Census Bureau website[6] on an annual county-level.

Table 1 illustrates the total observation, mean, standard deviation, maximum value and minimum value for each kind of the crime rates in the sample. The annually total crime rate is on average 732 per 100,000 persons per county. Property crime makes up a large share of total crime, followed by larceny-theft and burglary. Murder and robbery the are the least common offenses in the datasets, with averages of approximately 1.7 and 5.5 incidents per 100,000 persons per county, respectively.

Figures 1 and 2 show the trends in total crime rate and rates of each crime, respectively. Overall, crime rates fell during the period of 2012 to 2021. Similarly, there were a decline in the crime rates of Burglary, Larceny Theft, Property Crime and Robbery during the analyzing period. Meanwhile, the patterns see an increase trend in the crime rates of Aggravated Assault, Motor Vehicle Theft, Murder, Rape and Violent Crime.

2.3 Control Variable Data

According to the previous empirical literature on crime, crime rates may vary according to socio-demographic characteristics. Therefore, we add several control variables that may be important contributors to crime rates. These variables include the law enforcement employee rate, GDP, personal income, unemployment rate, bachelor ratio and poverty rate. Law enforcement employee

[6] United States Census Bureau (2024). https://data.census.gov/table.

rate illustrates ratio of number of law enforcement employees per 100,000 persons in each county. Data for this variable is sourced from Uniform Crime Reporting (UCR) Program of the Federal Bureau of Investigation (FBI)[7]. The remaining variables are all collected from U.S. Bureau of Economic Analysis (BEA)'s data archives[8]. Definitions of each of the control variables are provided on the Appendix B.

In Table 2, it summarizes the list of control variables together with the descriptive statistics. Specially, it shows the observation, mean, standard deviation, minimum value and maximum value for each control variable on a county level. We consider all these variables as pre-established and exogenous.

3 Methodology

3.1 Baseline

Our baseline specification is as follows:

$$y_{c,t} = \alpha + \beta ZellePen_{c,t-1} + X_{c,t-1}\gamma + \alpha_c + \alpha_t + \varepsilon_{c,t} \tag{1}$$

where the dependent variable is all different types of crime rate in county c in the year t. $ZellePen_{c,t-1}$ is the Zelle penetration ratio in county c in year t-1. We lag one period to deal with the endogeneity issue. We standardized the Zelle penetration measure to ease coefficient interpretation. $X_{c,t-1}$ is a vector of control variables, including the law enforcement employee rate, GDP, personal income, unemployment rate, bachelor ratio, and poverty ratio. We include the county and time fixed effects and the standard deviation is clustered at county level.

3.2 Difference-in-Difference Specification

The baseline specification might suffer the reverse causality issue. It could be possible that the crime rate could impact the adoption of Zelle. To address this endogeneity issue, we exploit the fact

[7]Federal Bureau of Investigation Crime Data Explorer (2024). https://cde.ucr.cjis.gov/LATEST/webapp/#/pages/home.

[8]United States Census Bureau (2024). https://data.census.gov/table.

that Zelle is launched by the seven largest US banks. These seven largest banks operate nationally. The local crime rate is unlikely to be the main reason that these seven largest banks decided to launch the Zelle service. We construct the seven largest US banks county level penetration using the Summary of Deposit from FDIC. Thus, we have the following specifications:

$$y_{c,t} = \alpha + \gamma Post_t \times ZellePenBig7_c + \Gamma X_{c,t-1} + \pi_c + \tau_t + \epsilon_{ct} \tag{2}$$

Where $Post_t$ is a dummy variable that is 1 after 2017 and 0 otherwise, the sample period for this specification is from 2012 to 2021. $ZellePenBig7_c$ is the seven largest US banks' penetration ratio in county c as of 2017. We use the same control variables as in our baseline specification.

3.3 Event Study

We employ dynamic event study analysis to examine the parallel trend assumption in the DiD analysis. We only conduct dynamic event studies for the crime rate that are significantly impacted by the Zelle adoption in the county-level.

3.4 Zelle Penetration and Counties Characteristics

We investigate the heterogeneous effects of Zelle adoption on the crime rate at county level. The specification is as follows:

$$\begin{aligned} y_{c,t} =& \alpha \times Post_t \times ZellePenBig7_c \times X_{ct} + \gamma \times ZellePenBig7_c \times Post_t \\ &+ Post_t \times X_{ct-1} + \Gamma X_{ct-1} + \pi_c + \tau_t + \epsilon_{ct} \end{aligned} \tag{3}$$

holding everything else the same as the DiD model, the model adds an interaction term for each control variable in our model, including the law enforcement employee rate, GDP, personal income, unemployment rate, bachelor ratio and poverty ratio.

4 Result and Discussion

4.1 Benchmark Specification

In Table 2, it presents the result of baseline specification. The values are the magnitudes outcomes of the effects that the adoption of Zelle has on the total crime rate as well as each of the nine crime rates from 2016 to 2021. The estimated parameter in column (1) indicates that the Zelle exposure did not have a significant effect on the overall crime rates. According to column (5) and column (10), the coefficients of robbery rate and motor vehicle theft rates are negative and statistically significant, which could provide validation of our hypothesis 1 that increasing of adoption of Zelle can reduce some kinds of crime rates. Specifically, 1 unit of change in standard deviation in Zelle exposure is associated with decline of 0.289 percent in robbery rate per 100,000 persons, which is statistically significant at the ten percent level. Regarding motor vehicle theft rates, the effect is even more sizeable, suggesting a decline of 2.324 reduction in such kind of criminal rate, which is statistically significant at the five percent level. As for property crime rates, burglary rates and larceny-theft rates, the estimates are all negative but not statistically significant. Additionally, the results provide reassurance, as a significant portion of the variation in crime rates among counties can be accounted for by both Zelle exposure and control variables. This is evident from the R-squared values, which exceed three-quarters for most crime rates. Specifically, the R-squared values for robbery rate and motor vehicle theft rates, our primary explanatory variables, reaching 0.777 and 0.828 respectively.

Overall, the benchmark results show that the adoption of Zelle has a statistically significant and negative effect on robbery rate as well as motor vehicle theft rate, while it does not have significant effect on total crimes and other forms of crime such as violent crime rate, murder rate, rape rate, aggravated assault rate, property crime rate, burglary rate and larceny-theft rate. This is likely because robbery and motor vehicle theft are predominantly motivated by the pursuit of cash and valuables. Victims are often the pedestrians carrying significant amounts of cash on the streets. Therefore, the shift in payment methods resulting from the emergence of electronic payment method like Zelle leads to a reduction in cash circulation on the streets, thereby decreasing criminals' opportunities. Consequently, the robbery rate and motor vehicle theft rate are likely to decline with the continuous development of Zelle. These finding can validate our hypothesis 1. These two types of crime constitute only a small fraction of overall criminal activities. Also, given the diverse nature of criminal motivations, which can extend beyond paper cash, Zelle's emergence and development have had a minimal impact on the total crime rate and other forms of crime. The results in the benchmark model are consistent with some literature which claims payment behavior shift toward electronic financial transactions may reduce some categories of crime, such as robbery (Armey et al. (2014); Pridemore et al. (2018); Wright et al. (2017)). However, there are some differences from the conclusions in literature. Firstly, as Wright et al. claimed in their article (Wright et al. (2017)), government-based cashlessness system had a negative and significant effect on the overall crime rate while in this model, Zelle affects the total crime rate negatively but not significantly. The reasons for the distinguish might be the different definitions of overall crime rates. In this previous paper, it included five categories of cash-related crime, whereas in the model, total crime includes almost all the forms of crime rates where street crime only account for a small amount. Secondly, numerous papers (Armey et al. (2014); Pridemore et al. (2018); Wright et al. (2017)) found a significant and adverse relationship between cashlessness payment method and burglary rate, which is not significance in this model. This may be attributed to short period of timeframe and some economic upheaval caused by the 2020 pandemic. Another factor that could potentially explain the differing results is the distinct nature of the research objectives. In the previous literature, e-payments were introduced by the government as a means of welfare support, whereas in this article, Zelle is a profit-seeking payment method introduced by commercial banks. Moreover, this model finds that Zelle exposure has a significant and negative effect on motor vehicle theft rate which has seldom been mentioned in previous articles. This indicates that Zelle has a significant impact on motor vehicle theft rates, an effect not observed with previous electronic payment methods.

4.2 Endogeneity

The results of Difference-in-Difference model are exhibited in Table 3. Significant coefficients are denoted with starts, while standard errors clustered at the county level are presented within parentheses below the coefficients. The values show how a 1 standard deviation increase in Zelle exposure in the establishment year affects the total crime rate and each specific crime rates during the analyzed period. Among all the dependent variables, only those with significant results were retained in the table.

The estimates in column (1) and column (2) shows the impact of Zelle shock is negative and statistically significant for murder rates and motor vehicle theft rates. Specifically, the introduction of Zelle in 2017 was linked to a decrease in robbery rates, amounting to a statistically significant drop of 0.515 percent per 100,000 individuals. Similarly, motor vehicle theft rates declined by 1.360 percent, a reduction that was statistically significant at the five percent level. The consistency of these results in Table 2 and Table 3 further validates the effectiveness of the conclusions drawn in the baseline model.

Moreover, the estimated parameter of the interaction term between Zelle establishment and the dummy variable Post in the regression of total crime is not included in the table, indicating that the establishment of Zelle does not have a significant effect on overall crime rates.

4.3 Event Study

This part conducts an event study, which extends the equations in the Difference-in-Differences (DiD) model with a time coefficient. Each coefficient represents the interaction of a treatment indicator with individual year dummies specific to Zelle-exposed and non-Zelle-exposed counties. The coefficients associated with the four periods before and the four periods after Zelle adoption were plotted. In this context, year 0 of the time to treatment is 2017 when Zelle was founded, and year 0 is also the time that the Zelle status changes from zero to one. The baseline period, the year before Zelle adoption, is omitted in this model as the reference period. The vertical bands bounding each yearly estimate represent 95percent confidence intervals. To address the potential correlation of observations within counties, standard errors were clustered at the county level.

For the Robbery and Motor Vehicle Crime which are significant in the DiD model, Figure 3 and Figure 4 plots these coefficients of crime rates which are the results of an event study analysis in the US.

In both figures, there are no significant deviations from zero prior to the event. However, in the second year following the event, significant and lasting negative effects are observed. This indicates a delayed impact of Zelle on robbery rates and motor vehiche crime rates, likely due to the gradual adoption of Zelle as a payment method, which takes time to influence criminal behaviors associated with robbery and motor vehiche crime.

The patterns mentioned above provide evidence for validity of our parallel trend assumption, showing no evidence of systematic changes in crime rates in the years before the Zelle system was established, and suggesting that our results do not merely reflect trends in long-term changes in crime rates. The patterns also show a downward trend in crime rates for those crime types following establishment of Zelle. Therefore, these offences can be seen as meaningful in the previous DiD model results. Combining the findings of the DiD model, we determined that the results for only two crime categories were valid and significant - robbery rate and motor vehicle theft rate - which proves that Zelle's establishment had a real and significant impact.

4.4 Zelle Penetration and Counties Characteristics

For further research, this model is designed to explore the impact of Zelle penetration on crime that are associated with the social characteristics. Crimes are chosen which have significant results in DiD model and pass the parallel trend at the same time. Specifically, robbery rate and motor vehicle theft rate met both criteria. Based on the DiD model, this model adds the interaction term of Zelle establishment standard deviation and each control variable.

Table 4 and 5 display the results of a regression analysis that examines the relationship between the crime rate and the lagged interaction between Zelle penetration and social characteristics. The variables are winsorized at the 1th and 99th percentiles. Only significant coefficients of the interaction are presented in the tables.

In both tables, interaction of Bachelor Ratio and Zelle penetration has a significant negative effect on the Robbery rate. This is reasonable since populations with a higher Bachelor Ratio are more likely to adopt new technologies and payment methods, such as Zelle. As Zelle becomes more widespread, the reduction in cash transactions decreases the number of potential robbery targets. The adoption of digital payments is likely to be more pronounced in highly educated groups, thereby having a stronger suppressive effect on Motor Vehicle Crime rates and Robbery Rates.

In Table 4, the estimated coefficients is negative significant in the interaction of Zelle Penetration and LnGDP, the results indicate that Zelle penetration has greater effect on counties with higher

GDP. One possible explanation is that in counties with higher GDP and lower poverty, there may be more resources invested in crime prevention and security measures, including strengthening police patrols and installing surveillance systems. These measures may have effectively reduced the motor vehicle theft rates and robbery rates, thereby attenuating the impact of Zelle penetration on these criminal activities. Additionally, in more wealthy counties, citizens may face less economic stress and poverty, reducing their incentives to engage in criminal activity. Similarly, the estimated coefficients of the interaction term between ZellePenBig7 and poverty rate demonstrate a positive and statistically significant relationship. The results suggest that impact of Zelle penetration is stronger in the region with higher poverty. This could make sense since income inequality is more pronounced in areas with high poverty rates. As a result, people living in poverty are more prone to resort to cash robbery in order to survive. The introduction of Zelle has effectively reduced the circulation of cash on the streets, and therefore has the potential to more effectively impact the cash-related crime rate in impoverished areas.

*********since the Post*Zelle Pen is not significant, in Table 4 population and age over 65 rate have not been analysed, in Table 5, branch density*******************

5 Conclusion

With advancements in technology, payment behavior has shifted from paper cash to electronic methods. In the last decade, the development of financial technology (Fintech) has further driven this shift towards instant peer-to-peer mobile payments. While enormous literature suggests that cashless payment methods may contribute to social transformations, such as a decrease in street crimes, we aim to investigate whether peer-to-peer electronic payments, like Zelle, affect crime rates in the US. Therefore, we pose the research question: What is the impact of Zelle adoption on crime rates across different counties in the United States, and how does this impact vary across various categories of criminal activities?

Based on previous literature, we gain some insights about the relationship between electronic payment and crime rates, thus propose the following hypotheses: H1: Zelle payment adoption has a significant impact on total crime rate in the US from 2017 to 2021; H2: Impact of Zelle payment adoption is specifically significant on acquisitive crime rates.

In order to find the relationship between Zelle and crime rates, this paper employees a Ordinary Least Squares model in the baseline specification. Regarding Zelle data, calculated the Zelle exposure on the annually county level from 2017 to 2021, which is the independent variable in this model. Additionally, this paper investigates total crime rates and nearly all forms of crime per 100,000 persons. Each type of crime rate serves as an independent variable in the OLS model, resulting in ten outcomes. Results in this specification shows that Zelle exposure did not have a significant effect on total crime rate. This contracts the result in previous study. One of the main reasons for this may be different definition of total crime rates between this model and previous literature. Another factor could be the difference in electronic payment issuers. In previous studies, government support aimed to enhance public welfare, while Zelle in this model represents a profit-seeking strategy for banks. Moreover, adoption of Zelle did affect some acquisitive crime rates, such as robbery rate and motor vehicle theft rates. This result is in line with the first hypothesis. This could make sense and it provides evidence that Zelle effect on such acquisitive crime rates.

Furthermore, several previous articles are struggled with endogeneity problem between electronic payment and crime rates. To deal with such concern, a Difference-in-Difference (DiD) model is introduced in the expansion model. In this model, Zelle exposure in the establishment year was taken as an exogenous shock, as primary goal of Zelle establishment was profit generation rather than reduction of crime rates. The interaction of Zelle exposure in the establishment year and dummy variable Post serves as independent variables in this model, holding everything else the same. Also, an event study is taken for each formula in DiD to test the parallel trends of the treatment group before the shock and after the shock. Results from event study suggest that only the results on several forms of crimes are meaningful, including total crime rate, motor vehicle theft rate, property crime rate, rape rate and robbery rate. Combined with the results in DiD model, they indicate that Zelle did not have effect on total crime rate while it did make negative and statistically significant impact on motor vehicle theft rate, property crime rate and robbery rate. These results are largely consistent with those in the baseline model, also providing effectiveness for the first hypothesis.

In addition, this study seeks to explore interesting variations in the impact of Zelle penetration on different crime rates, which are influenced by the specific attributes of the counties adopting Zelle. To achieve this, it enhances the Difference-in-Differences (DiD) model by incorporating an interaction variable between BankZellePen7 and a set of county characteristic factors. The results indicate that in more prosperous counties, e.g. higher GDP and higher personal income, the influence of Zelle on robbery rates is weaker, possibly due to enhanced crime prevention measures and reduced economic stress. Conversely, in areas with higher unemployment rate, Zelle's establishment is associated with a stronger significant reduction in motor vehicle theft. In addition, in counties with higher poverty rates, Zelle establishment has a greater impact on robbery rates and motor vehicle theft rates. However, this paper exists some limitations such as impact of the COVID-19 pandemic-induced economic downturn on crime rates, inter causality problem between the dependent and independent variables. Therefore, future research directions could explore more precise economic indicators, models, and data. Another significant research direction could investigate the causal relationship between street crime and cash holdings over the years.

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Appendix A: Figures and Tables

Figure 1: The Number of Zelle Partners over Time

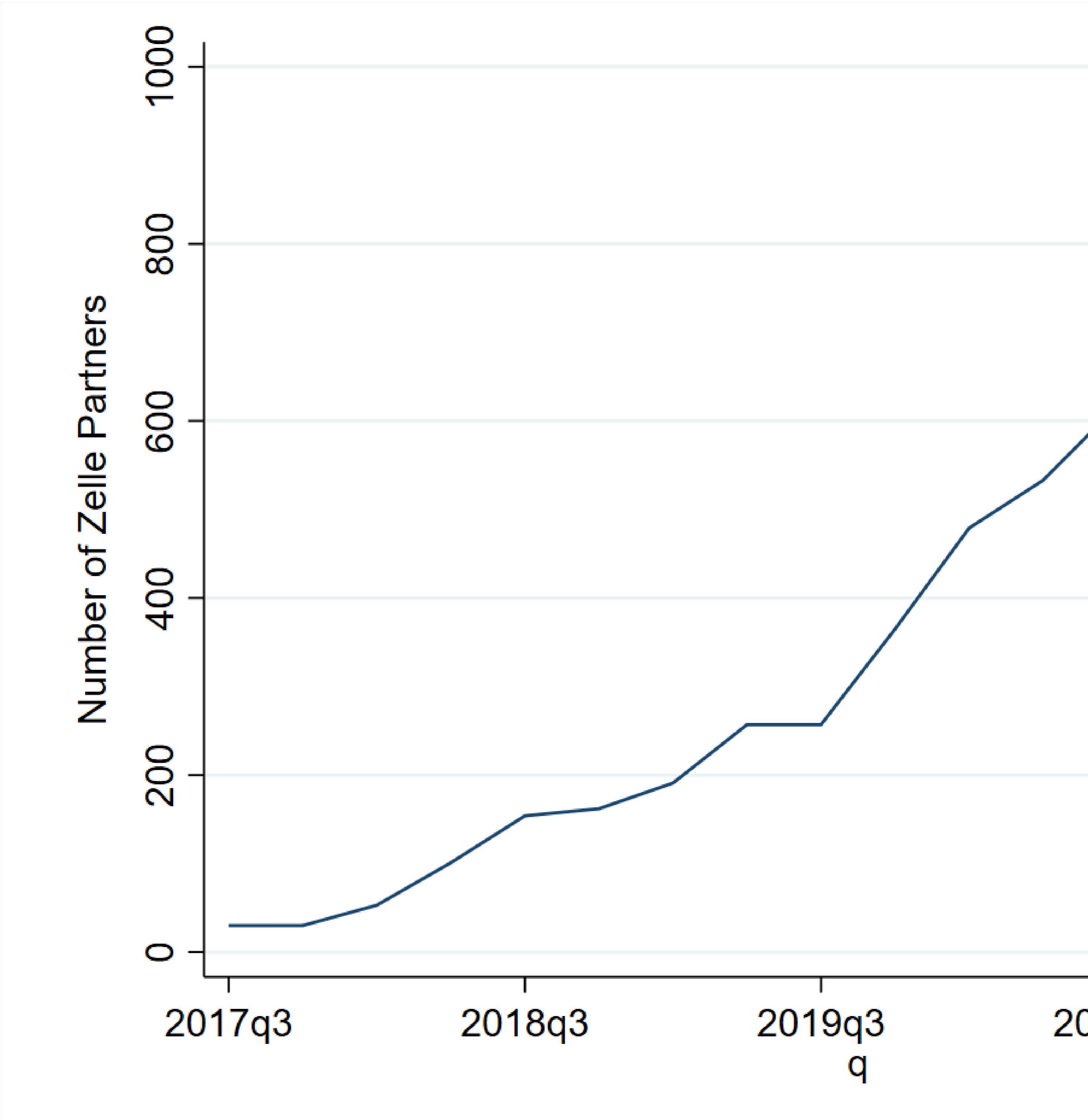

Figure 2: County Zelle Penetration in 2021

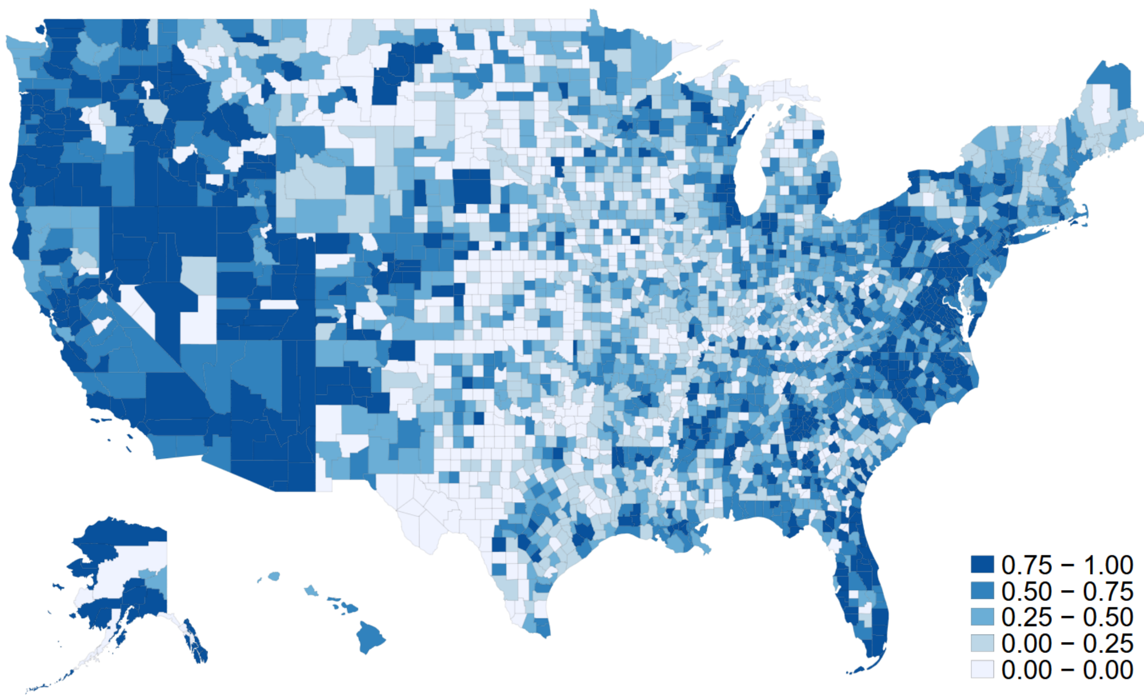

Figure 3: Event-study Estimates for Robbery Crime Rates in the US

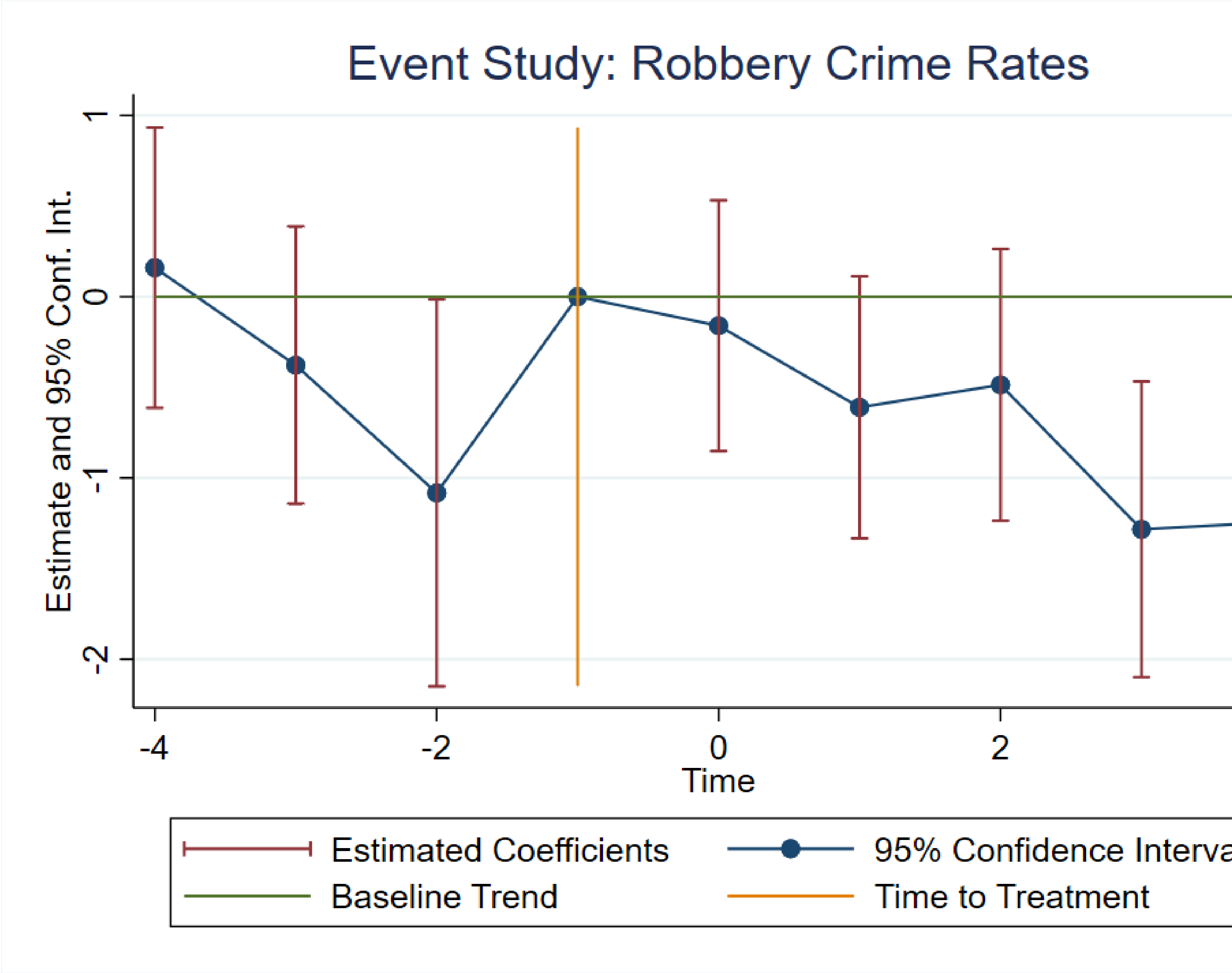

Figure 4: Event-study Estimates for Motor Vehicle Crime Rates in the US

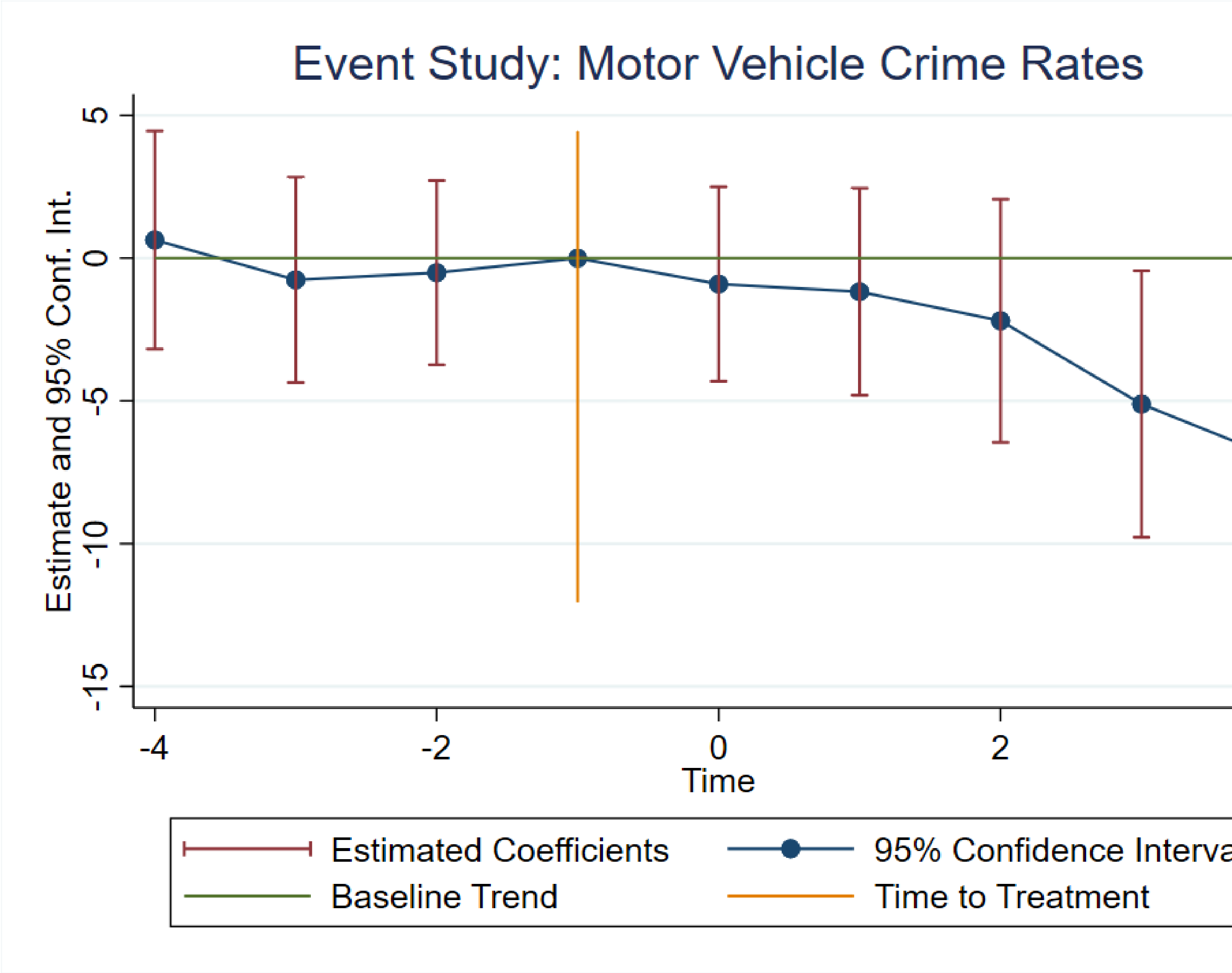

Table 1: Summary Statistics

This table presents the summary statistics of the analysis sample. We keep banks with at least two branches in our sample. All continuous variables are winsorized at the 1th and 99th percentiles. We list the definition of the variables in appendix B Table **??**.

	mean	p50	min	max
Robbery Rates	5.499518		0	409.2769
Burglary Rates	186.1774		0	3921.569
Larceny-theft Rates	389.3615		0	35294.12
Motor Vehicle Theft Rates	54.02948		0	5882.353
Law Enforcement Employee Rate	4.022326		.0785978	2857.143
Branch Density	43.58893		3.753096	339.3665
Bachelor Ratio	13.91501		0	48
Ln. GDP	14.02696		8.75005	22.14832
Ln. Population	10.37417		3.931826	18.27925
Poverty Rate	16.43725		0	67.1
Age over 65 Rate	17.91428		3.08425	81.53846

Table 2: Zelle Penetration and Crime

This table reports the regression results of different types of crime on the Zelle penetration in the county-level. The ZellePen is county-level Zelle penetration calculated as the ratio of Zelle partner's deposit in the county. ZellePen is standardized. p-values in parentheses. ***, **, and * denote statistical significance level at 1 percent, 5 percent, and 10 percent levels. The standard deviation is clustered at county-level.

	(1) Robbery	(2) Burglary	(3) LarcenyTheft	(4) MotoTheft
L.ZellePen	-0.559***	-0.842	-1.610	-2.012**
	(0.000)	(0.789)	(0.589)	(0.012)
L.LawEmployee	0.156*	0.248	4.071	1.145
	(0.089)	(0.884)	(0.110)	(0.187)
L.Branch Density	-0.0952	1.066***	0.744	0.302
	(0.118)	(0.009)	(0.398)	(0.120)
L.Bachelor	0.00157	-1.096	-0.0616	-1.883***
	(0.985)	(0.592)	(0.981)	(0.003)
L.LnGDP	-2.962**	36.40	38.07	-5.543
	(0.036)	(0.241)	(0.221)	(0.559)
L.LnPop	8.675*	-279.1**	-341.9***	-30.31
	(0.067)	(0.044)	(0.009)	(0.385)
L.Poverty Rate	0.00734	1.553	-0.123	-0.774**
	(0.897)	(0.167)	(0.927)	(0.042)
L.Age over 65 Ratio	-0.0124	-6.236*	-3.985	0.603
	(0.940)	(0.079)	(0.369)	(0.566)
L.Unemployment Rate	0.0878	3.599**	2.490	-0.551
	(0.522)	(0.021)	(0.367)	(0.560)
County FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Observations	8669	8669	8620	8669
Adj R^2	0.690	0.743	0.862	0.735
RMSE	5.513	77.16	114.5	31.00

Table 3: ZellePenBig7 and Crime

This table reports the regression results of different types of crime on the Zelle penetration in the county-level. The ZellePen is county-level Zelle penetration calculated as the ratio of Zelle partner's deposit in the county. ZellePen is standardized. p-values in parentheses. ***, **, and * denote statistical significance level at 1 percent, 5 percent, and 10 percent levels. The standard deviation is clustered at county-level. The variables are defined in Table **??** and Table **??**, Appendix B.

	(1) Robbery	(2) MotoTheft
ZellePenBig7*Post	-0.488***	-1.538**
	(0.001)	(0.025)
L.LawEmployee	0.00514	-0.0195
	(0.127)	(0.163)
L.Branch Density	-0.0114	0.247**
	(0.392)	(0.024)
L.Bachelor	-0.0303	-1.181***
	(0.597)	(0.005)
L.LnGDP	0.0508	10.16**
	(0.939)	(0.037)
L.LnPop	-0.221	-35.76**
	(0.926)	(0.016)
L.Poverty Rate	-0.0345	-0.268
	(0.341)	(0.253)
L.Age over 65 Ratio	-0.107	0.790
	(0.220)	(0.163)
L.Unemployment Rate	0.207***	-1.403***
	(0.002)	(0.001)
County FE	Yes	Yes
Year FE	Yes	Yes
Observations	19270	19270
Adj R^2	0.629	0.669
RMSE	6.724	32.78

Table 4: Zelle Penetration and Counties Characteristics

This table presents the results of regressing the Robbery rate on the interation of ZellePenBig7 and counties' one-year lagged characteristics. All continuous variables are winsorized at the 1th and 99th percentiles. All continuous variables are winsorized at the 1th and 99th percentiles. The standard deviation is clustered at the bank level. The variables are defined in Table **??** and Table **??**, Appendix B. p-values in parentheses. ***, **, and * denote statistical significance levels at 1 percent, 5 percent, and 10 percent levels.

	(1) Robbery Rate	(2) Robbery Rate
L.ZellePen	-0.561***	-1.018***
	(0.000)	(0.001)
L.ZellePen*L.LawEmployee	0.00125**	
	(0.022)	
L.ZellePen*L.Bachelor		0.0298**
		(0.045)
County FE	Yes	Yes
Year FE	Yes	Yes
llawemprate	Yes	Yes
Observations	8669	8669
Adj R^2	0.690	0.690
RMSE	5.514	5.512

Table 5: Zelle Penetration and Counties Characteristics

This table presents the results of regressing the Motor Vehicles Crime rate on the interation of ZellePenBig7 and counties' one-year lagged characteristics. All continuous variables are winsorized at the 1th and 99th percentiles. All continuous variables are winsorized at the 1th and 99th percentiles. The standard deviation is clustered at the bank level. The variables are defined in Table ?? and Table ??, Appendix B. p-values in parentheses. ***, **, and * denote statistical significance levels at 1 percent, 5 percent, and 10 percent levels.

	(1) Moto Theft	(2) Moto Theft
ZellePen*Post	0.183	-5.129***
	(0.883)	(0.003)
Post*ZellePen*L.Branch Density	-0.0739*	
	(0.066)	
Post*ZellePen*L.Bachelor Ratio		0.300***
		(0.002)
County FE	Yes	Yes
Year FE	Yes	Yes
control	Yes	Yes
N	19270	19270
R^2	0.715	0.715

Appendix B: Variable Definitions

The Law Enforcement Employees dataset consists of yearly gathered data on law enforcement officers and non-officer personnel working within law enforcement agencies. It includes details on the count of officers and civilians employed, as well as the ratio of law enforcement employees per county population. According to the Uniform Crime Reporting (UCR) Program, law enforcement officers are defined as individuals typically equipped with firearms and badges, possessing full arrest authority, and receiving payment from designated governmental funds allocated for sworn law enforcement roles.

Real GDP data is annually available for each county, presented in thousands of chained 2017 dollars. It consists of the total GDP of all industries, including both private industries and government sectors within each county.

Population data provides estimates of the number of individuals, including both civilian and military, residing in each county. Personal Income refers to the total income received by individuals, consisting of earnings from their provision of labor, land, and capital used in current production, along with other sources of income such as personal current transfer receipts.

Unemployment rate represents the percentage of the labor force that is unemployed within each county. Specifically, individuals are classified as unemployed if they do not have a job, have actively searched for work in the preceding four weeks, and are currently ready to take on employment.

The Ratio of Bachelor's degree represents the estimated proportion of individuals aged 25 years and over who have attained a bachelor's degree within each county. The percentage is calculated by dividing the number of individuals in this age group with a bachelor's degree by the total number of individuals aged 25 years and over.

The Poverty Rate denotes the percentage of individuals below the poverty level within each county. Following the guidelines outlined in the Office of Management and Budget's (OMB) Statistical Policy Directive 14, the Census Bureau utilizes a set of income thresholds that vary based on family size and composition to ascertain poverty status. If a family's total income lower than the designated threshold, all members of that family are classified as living in poverty.