ON THE EFFECTS OF THE AVAILABILITY OF MEANS OF PAYMENTS: THE CASE OF UBER*

FERNANDO ALVAREZ AND DAVID ARGENTE

We use three quasi-natural experiments in Mexico and one in Panama to estimate the effects of having the option to pay with cash on Uber rides. The ability to pay in cash affects the demand for rides, which is reflected in large changes in the total number of trips, fares, miles, and number of users after Uber introduced cash payments, particularly in lower-income city blocks. On the other hand, the effects on prices, estimated times of arrival, and competitor pricing are negligible, consistent with the supply of trips being very elastic. Although cash payments naturally increase the fraction of users that pay exclusively with cash, more than half of the users have access to both cards and cash, and alternate between payment methods. We find evidence consistent with cash and card payments being imperfectly substitutable at both the intensive and extensive margins, which magnifies the effect of policies that restrict the availability of payment methods. *JEL Codes:* E4, E5.

I. INTRODUCTION

For a number of economists and policy makers, the persistence of cash as a form of payment is potentially problematic.

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Some have called for the elimination of large-denomination bills, in part because such currency is often the primary transaction method for organized crime and tax evasion (see Rogoff 2017 and the ensuing scholarly debate about whether to stage a "war on cash," Deutsche Bundesbank 2017). India's demonetization effort in 2016 was a concrete policy that expressed this line of thinking.

Nonetheless, for millions of people who have no credit or debit cards or who are disinclined to use them, cash is essential for facilitating economic activity. Chodorow-Reich et al. (2020), for instance, estimate that a contraction in employment and economic output as measured by night lights data following India's demonetization translated into a 2% decline in the country's quarterly growth rate. Economically disadvantaged households tend to use cash much more than others, so policies that restrict the use of cash limit economic access for the poor and can have important distributional consequences. For this reason, several cities in the United States have discussed or implemented a ban on cashless stores.[1]

Uber accepts cash payments in more than 400 cities worldwide; however, some governments have restricted cash payment for ride-hailing services. In Mexico, cash was originally not allowed in several cities (e.g., Mexico City or Querétaro) and was temporarily banned in the cities of Puebla and San Luis Potosí. Recently, the Mexican Supreme Court ruled local jurisdictions' prohibitions on cash payments for select services as unconstitutional.[2] Cash payments have been restricted in other countries, such as Panama and Uruguay.

In this article, we estimate the effect of the availability of cash as a payment option on the intensive and extensive margins of Uber trips in Mexico. We use three quasi-natural experiments in Mexico and one in Panama to estimate how cash payments affect rides, prices, and the use of other payment methods. The introduction (ban) of cash has a substantial effect on quantities (e.g., number of trips, number of users), including for users that have access to cards, but no effects on prices. We also find evidence of imperfect substitutability across means of payments at the extensive and intensive margins.

1. "Cities and States Are Saying No to Cashless Shops," NPR (2020).

2. See the decision of the Suprema Corte de Justicia de la Nacion in the case of Ley de Movilidad Sustentable pare el Estado de Colima, October 2018.

First, we take advantage of the asynchronous entries of cash payments across cities in Mexico.[3] We consider the introduction of cash payments in the Uber app as a demand shock to Uber trips. Since Uber is merely connecting riders with drivers, we analyze the entry of cash as a change in an industry equilibrium. The entry of cash leads to large increases in quantities (i.e., it doubles the number of trips, fares, riders, drivers) but does not increase prices (i.e., surge multiplier, estimated time of arrival (ETA), prices of taxis). This evidence is consistent with an elastic supply of drivers (in terms of number of active drivers as well as hours worked per driver), which implies that the entry (or ban) of cash has small effects on riders that pay for their trips exclusively with cards or on the producer surplus. Importantly, even though prices do not change, we observe a small decrease in the number of trips paid by card, which is consistent with a certain degree of substitutability across the two means of payment.

Second, we use the differences in the availability of payment methods across contiguous city blocks in greater Mexico City to validate our findings about cash payments under a different set of identification assumptions. Using geolocalized trip information, we show that the entry of cash substantially increases the fraction of users that pay for rides exclusively with cash and disproportionately increases the number of rides that begin in lower-income city blocks. We again find no effect on the prices of Uber rides or those of regular taxis. Using data from the application EC Taximeter, we document that the wait times for regular taxis were also unaffected by Uber's introduction of cash payments. Consistent with the results of our event study, we observe a decrease in the number of trips paid for with a card in the city blocks in which Uber was active before it accepted cash payments.

Last, we study bans on cash payments for ride-hailing services that took place in two cities: Puebla and Panama City. Consistent with our evidence about the introduction of cash payments, we do not find any evidence of changes in prices. The ban on cash in Puebla immediately reduced the number of trips. We distinguish between the effect on riders that use both payment

3. Currently, there are more than 40 cities in Mexico where cash is available as means of payment for Uber trips. Greater Mexico City, which is composed of Mexico City and its adjacent municipalities in the State of Mexico, is one of the 10 largest metropolitan areas in the world in terms of the gross number of Uber trips.

methods (mixed riders), and the effect on riders who do not register a payment card in the app (pure-cash riders). Approximately half of Uber users in Mexico pay with both cash and card. Using this quasi-natural experiment, we estimate an elasticity of substitution across means of payments between 3 and 5. Consistent with cash and credit being far from perfect substitutes, we find that mixed users that paid for more trips in cash before the ban took fewer trips on Uber after the ban. Cash and credit are also imperfect substitutes at the extensive margin; only about a third of pure-cash users registered a card with Uber after the ban, in excess of the normal rate of migration from cash to credit. Data about Panama City's ban on cash payments show that, as happened in Mexico, the prices of competing ride-hailing companies and public transport options were unaffected by the change in payment options for Uber rides. Although the data from Panama is relatively limited in scope and granularity, it offers the advantage of observing both the ban on cash payments and the reentry of cash payments months later.

Our focus on Uber rides offers two advantages. First, we are able to exploit several quasi-natural experiments to study the changes in the supply and demand of the same good that can be paid for with varying means. An Uber user can, in principle, alternate between paying with cash or card, and Uber tracks which was used. Second, Uber measured specifics about how prices and quantities of rides changed with changes in payment options. The richness of the data allows us to follow users' decisions with fine geographic and spatial resolution. Our results from city-level, block-level, and individual-level data all point to the same conclusions qualitatively (if not quantitatively) and are robust to different methodologies and identification strategies (i.e., event study, coarsened exact matching, regression discontinuity, and synthetic control methods).

In summary, Uber users pay with cash very often when the option is available, and the availability of cash payment has no significant effect on prices, either monetary or nonmonetary (i.e., wait times), or on the prices of Uber's competitors (i.e., prices and wait times for taxis). We find evidence that cash and credit are imperfectly substitutable at the extensive and intensive margins of a change in the availability of cash payments. Our results indicate that policies restricting the use of cash have a negative effect on the fares of pure-cash riders and on the fares paid by riders who use both payment methods, which are the majority of users in Mexico. We use a stylized model based on a constant elasticity of substitution (CES) preference system to estimate the consumer surplus lost for mixed users in the event of a complete ban on cash across all goods. We estimate a consumer surplus loss of about 3% of GDP for the United States and a much higher estimate for countries where cash is more prevalent. The imperfect substitutability of cash as means of payment also indicates that the recent increase in contactless payments due to the health risks associated with COVID-19 is not without cost (e.g., Alvarez and Argente 2021).

Our work contributes to the literature about the continued prevalence of consumers who mix their use of cash and card payments in the broader marketplace. One possibility is that households use multiple payment methods to diversify the source and timing of funding among different means of payment (Shy 2019). Another alternative is that using cash payments for other goods makes the use of cash complementary, even for those users that own cards. Thus, cash-management decisions are relevant for payment instrument choice. Deviatov and Wallace (2014) develop a model in which some fraction of the population is unbanked and uses only cash; for this reason, in equilibrium, even those who have access to banking services find it convenient to hold and use cash. Briglevics and Schuh (2020) find that consumers with very large amounts of cash in their wallets are more likely to use cash and that consumers try to postpone withdrawals until a favorable opportunity is available. Similarly, Arango, Hogg, and Lee (2015) use shopping diaries from Canada with information on consumers' payment choices and find that "cash burns," meaning that the more cash individuals hold at the beginning of a three-day shopping period, the more likely they are to use cash even when they have access to debit/credit cards. They also find that consumers dislike the possibility of running out of cash, since they face costs in terms of time, effort, and fees to get more. Alvarez and Lippi (2017) construct a decision-making model in which cash and credit are used simultaneously in a way that is consistent with the evidence from developed countries in Arango, Hogg, and Lee (2015). We present evidence consistent with this mechanism for Uber rides. Households behave as if cash burns; they are more likely to pay with cash if they have it available, and otherwise they use other payment methods. The fact that the behavior of mixed users in Uber Mexico is similar to that found in other sectors and countries suggests that the elasticity of substitution that we estimate can be informative in other settings. Koulayev et al. (2016) shows evidence for substitution across payment methods, particularly between cash and debit cards. Consistent with their evidence, we find that a fraction of users switch to cards after the use of cash is made less attractive, but the degree of substitution we observe is far from perfect. This evidence is complementary to evidence reported in Alvarez and Argente (2020), who find similar results using field experiments in Mexico.

We believe that understanding both the reasons for the prevalence of mixed users and their adjustments following changes to the availability of payment methods is relevant for the theoretical literature in cash-credit and for evaluating the effect of policies that restrict or enable various means of payment. We find substantial heterogeneity across countries in the welfare costs of such policies, which crucially depend on the prevalence of cash and the substitutability across payment methods. In the next section we briefly summarize the four quasi-natural experiments we study.

I.A. Entry of Cash across Mexican Cities

For the entry of cash, we use two different strategies. First is an event study of the asynchronous entry of cash to 15 different cities where Uber had previously only accepted payment via credit or debit card. This part of the analysis is described in Section IV. Our understanding of Uber's decision to introduce cash in these cities is that after the successful introduction of cash in May 2015 in Hyderabad (India), Uber decided that cash could be introduced to all cities in developing countries where it was allowed. Thus, we assume that the entry is quasi-random since the difference in the timing reflects only differences in the local regulations.[4] We follow a standard event-study design and estimate weekly effects of the outcome variables mentioned above for a period of about one year after the introduction of cash to each city. As is standard, we include time and city fixed effects and time-varying city-level controls, which we construct for this study. We find statistically significant and economically large increases in the total number of trips and in the total fares after the entry of cash; both trips and fares more than doubled after a year. There are also large increases in the sign up of riders and drivers and in the number of active riders and drivers (those with

4. Consistent with this hypothesis, after the Supreme Court's decision, Uber decided to introduce cash in the cities where it was not previously allowed.

positive trips in a week). The overall number of drivers and the number of new drivers increased less quickly than the number of riders, but we also find that drivers increase their weekly hours by approximately the same percentage as total fares. The number of trips paid in credit decrease slightly, consistent with some substitutability across payment methods. We find no statistically significant effects on prices (or the average surge) or on the average wait time for Uber riders after the introduction of cash. We also find no changes in the prices of taxis. Our interpretation of these findings is that the long-run supply of drivers per hour is very elastic, which is consistent with findings across U.S. cities by Hall, Horton, and Knoepfle (2017).[5]

I.B. Entry of Cash in Greater Mexico City

The second quasi-natural experiment we study is the introduction of cash to the metropolitan area of Mexico City, a city of more than 20 million people and one of the largest cities in terms of Uber trips in the world. This area includes both Mexico City (Cuidad de México) and the remaining part of the greater metropolitan area, which we refer to as the State of Mexico (Estado de México). Uber entered greater Mexico City in 2013 but was unable to introduce cash until the end of 2016. In particular, Uber trips starting in the State of Mexico were allowed to be paid for in cash, but not those starting in Mexico City. We geolocalized all the trips that took place in greater Mexico City during August 2016, 2017, and 2018. We merge these trips with census information at the census block level. We use these data for three purposes. First, we find that the share of trips paid for in cash in 2017–2018 in different census blocks of the State of Mexico decreases with any of the census block-level observables related to the households' income level (such as average number of years of education, fraction of houses with internet connection, or fraction of houses with a car).[6] Second, we match each census block in the State of Mexico with a similar census block in Mexico City using coarsened exact matching. We estimate the average treatment effect of the entry of cash on the growth rate of the total trips in the

5. Our study focuses on riders since we have much more detailed data for them. While our results imply a small effect of the entry or ban on cash payments on drivers, our evidence comes mostly from this event study.

6. We find the same across the census blocks of the city of Puebla when cash was allowed.

State of Mexico (relative to the matched census blocks in Mexico City) to be about 100%. We find a small decrease in the number of trips paid in credit in the city blocks with Uber customers before the introduction of cash, consistent with our event study evidence. Third, we complement this last estimate with a local treatment effect of the change in trips around the boundary between the State of Mexico and Mexico City. This last estimate has the advantage of controlling for unobservables, which vary continuously around the boundary. For this estimate, we use a standard regression discontinuity design. We find that the growth rate of trips jumps 40% from one side to the other side of the city. We attribute the difference between the average treatment effect (100%) and this local treatment effect (about 40%) to the fact that the effect from the entry of cash is heterogeneous across census blocks in the State of Mexico. This heterogeneity is consistent with the distribution of observables—the poorer areas of the State of Mexico where cash has a greater effect are farther away from the frontier with Mexico City. We find no difference in the prices paid for Uber rides around the boundary between the State of Mexico and Mexico City before or after the introduction of cash. We complement this evidence by exploring the effect of the introduction of cash on the nonmonetary costs of taxis, such as wait times. We use data from the application EC Taximeter, which provides estimated times of arrival for regular taxis in Mexico City. We find that the estimated time of arrival of taxicabs was not affected by the introduction of cash as a payment method. We report these results in Section V.

I.C. Ban of Cash in Puebla

The third quasi-natural experiment uses the ban on cash in the city of Puebla in December 2017. In September 2017 a young woman, Mara Castilla, was kidnapped and later killed, allegedly by a Cabify driver. Cabify is another ride-hailing company that matches drivers and riders using an app similar to Uber. As a consequence of the crime, a law was passed that temporarily suspended Cabify and ended up banning the use of cash as a means of payment for Uber in Puebla. The ban entered into effect at the beginning of December 2017. We use a synthetic control approach that considers many cities of Mexico which at that time had already adopted cash and credit as payment to create a counterfactual path for the Uber trips taken in Puebla if the ban had not existed. As is standard in this method, the effect of the ban is estimated by comparing the actual behavior in Puebla with the counterfactual version of the city. We find that the ban immediately reduces the trips by more than 60% and had no effect on ride prices. In a short period of time, some of the previously cash-only users had registered a credit card. As a result, the total number of trips decreased by about 40%. We find similar results when we match each census block in Puebla with a similar census block in the State of Mexico and use coarsened exact matching to estimate the average treatment effect of the ban on cash. We also find that 22% to 35% of those that were pure-cash riders before the ban registered a card with Uber after the ban, in excess of the normal migration from cash to credit that was observed in the past. In addition, consistent with cash and credit having a certain degree of substitutability, we found that riders that used cash more heavily before the ban took fewer Uber rides after the ban. To put these numbers in perspective and compare them with the event study, we note that Puebla and the State of Mexico are two cities with closer to the smallest share of trips paid for in cash in Mexico (about 40%) among those where cash is allowed, with some other cities having a cash share twice as large. These estimates are described in Section VI.

I.D. Ban of Cash in Panama

The fourth quasi-natural experiment uses the ban on cash Uber payments in Panama City that took place in September 2019 and the subsequent reintroduction of cash payments on February 2020. In October 2017, a decree imposing restrictions on Uber was put in place. The decree included a prohibition on cash as a payment method for trips taken by Uber. The decree went into effect on January 2, 2018. Uber negotiated extensions of the deadline for the ban, which were eventually not renewed on September 30, 2019. We collected data before, during, and after the implementation of the ban, recording prices, ETAs, and time to location for all transportation methods available in Panama, including Uber, Cabify, and public transport. The data was collected at the same time of the day, every day, using Google Maps, and includes 20 addresses spread over the Panama City metropolitan area. Using this natural experiment we verified that Uber prices and ETAs did not change after the ban on or reintroduction of cash, and that the prices of its close substitutes also remained stable.

We use this evidence to provide further evidence that the supply curve for Uber trips is very elastic. These results are presented in Section VI.E.

II. Institutional Background

II.A. Cash Payments in Mexico

In Mexico, around 95% of all transactions below US$25 and 87% of transactions above US$25 are conducted in cash. The share of transactions paid for in cash is above 90% for most goods in the economy. Some examples are housing rent (90%), taxes (92%), public services (95%), private services (91%), and public transport (98%).[7] The lack of access to banking services throughout the population, particularly the poor, is a potential explanation for why Mexicans rely so much on cash to pay for goods and services. Yet 54% of the population between 18 and 70 years of age has a financial product (i.e., a bank account, some form of formal credit, retirement savings), 50% have a debit card, and approximately 31% own a credit card. Thus, a large fraction of the population in Mexico has a credit/debit card and still uses cash as their main means of payment. Alvarez et al. (2022) document, using information from the National Survey of Household Income and Expenditure, that Mexicans who have a credit/debit card still pay for almost 90% of all goods and services in cash.[8] Because users can use a credit or debit card to pay for Uber rides, in the rest of the article we refer to card payments as those conducted with either a debit or a credit card. Smartphones are more widely available in Mexico than financial products are. Approximately 65% of the population owns a smartphone; this share is higher for students, high-income individuals, or those with higher levels of education. Online Appendix E provides a detailed decomposition of the demographics of Mexicans who use both a smartphone and a debit/credit card.

7. Financial Inclusion Database (BDIF), Mexico 2018.

8. When those who own a card were asked in the National Survey of Financial Inclusion (ENIF), "Why do you prefer cash?," 35% respond that they are used to it, 20% respond that it allows them to have better control of their finances, 15% respond that they only make payments in small amounts, 15% respond that they do not trust cards, 10% respond that they use cash because it is widely accepted, 2% respond that they want to avoid card fees, and the rest had other reasons.

II.B. Uber Mexico

Although Uber went live in 2010, it did not accept cash payments until May 2015, when the company first introduced cash as a payment option in Hyderabad, India. Following its success, Uber extended the option to four more cities in India that year. By the end of 2016, the cash payment option became available in over 150 cities, and by 2018 this number grew to over 400 cities and 60 countries. This includes most Latin American countries, including Brazil and Mexico, the two largest in terms of population.[9]

Uber launched in Mexico in 2013. The first city with the service was greater Mexico City, which is composed of Mexico City and its adjacent municipalities in the State of Mexico. As of 2018, Uber was in more than 40 cities in Mexico. Greater Mexico City is one of the top 10 most active cities in the world in terms of rides for the company. Cash as a payment option was introduced in Mexico in 2016 after the experience in India. Users can select the cash option in the payment tab of their application. Then, when the trip ends, they pay the amount shown in the application directly to the drivers.[10] Although Uber is a service mostly consumed by middle- to high-income groups (see Online Appendix Figure C2), cash is used heavily when users have the option; almost half of the trips taken are paid for in cash and half of the total fares collected are in cash in cities that allow cash payment. In the State of Mexico, for instance, one of the areas with the lowest share of cash fares, approximately 25% of users (approximately 30% of fares) only use a card, 50% of users (50% of fares) are mixed, and 25% of users (25% of fares) only pay in cash.[11]

A few local governments nonetheless prohibited Uber from accepting cash payments at first. Cash payments for Uber rides were not allowed in Mexico City as the local government

9. Uber has been launching cash progressively in many countries. Recently the company has been launching the cash option in several high-income countries, such as Germany, Spain, France, Turkey, and Chile.

10. Drivers accept both payment methods and do not know the payment method chosen by riders when the trip is requested. If the user cancels a trip and is charged a cancellation fee, this amount is added to her next trip fare. On this subsequent trip, her total paid to the driver will add her trip fare and the cancellation fee from the previous trip.

11. The accounts of the users selecting cash are verified by Uber using information gathered from other methods of payment they have enabled in the app. The accounts of pure-cash users are verified using social media information.

prohibited drivers from receiving any payments in cash. The same occurred in the city of Querétaro, which is midsize and near Mexico City. In Puebla, payments were limited to electronic payments, but the government did not enforce this rule until the alleged murder of a young student by a driver of Cabify, another ride-hailing firm. The ban on cash payments in the city of Puebla took place in December 2017. In November 2018, the Mexican Supreme Court struck down a state ban on cash fares for ride-hailing firms that set a national precedent for Uber and other firms. By a vote of 8–3, the court ruled that a ban on cash payments for ride-hailing services in the small western state of Colima was unconstitutional. After the court's decision, Uber began accepting cash payments in Mexico City and Querétaro and reintroduced the option in Puebla.

Figure I charts the entry date of Uber in the cities in Mexico along with the date cash payments were introduced. The black lines mark the periods in which the only payment available in the application was a credit card. The gray lines denote the periods when cash became available in the cities. The figure shows that cash became available in most cities where Uber was active in the middle of 2016.[12] After that period, in each city where Uber launched its services, the application offered the option of cash payment from the beginning.[13]

III. Data

III.A. Uber Mexico

We construct a panel of daily-level data for all cities in Mexico where Uber was active until June 2018. The data include information on the number of trips, fares, miles, active riders, active drivers, rider sign ups, driver sign ups, and driver hours, along with more-specific data like the average surge multiplier, the share of trips surged, the average estimated time of arrival, and cancellation rates. The data include information about each service Uber provides in Mexico; more than 97% of all trips in Mexico use the UberX service.

12. The only other ride-hailing firm in Mexico during this period was Cabify, which had, at the time, a lower market share and did not launch cash payments during the time covered by our study. Regular taxicabs, on the other hand, mainly accept cash as a payment method.

13. Uber suspended service in December 2017 in Cancun and Campeche due to animosity from taxi unions and because of its tense relationship with regulators.

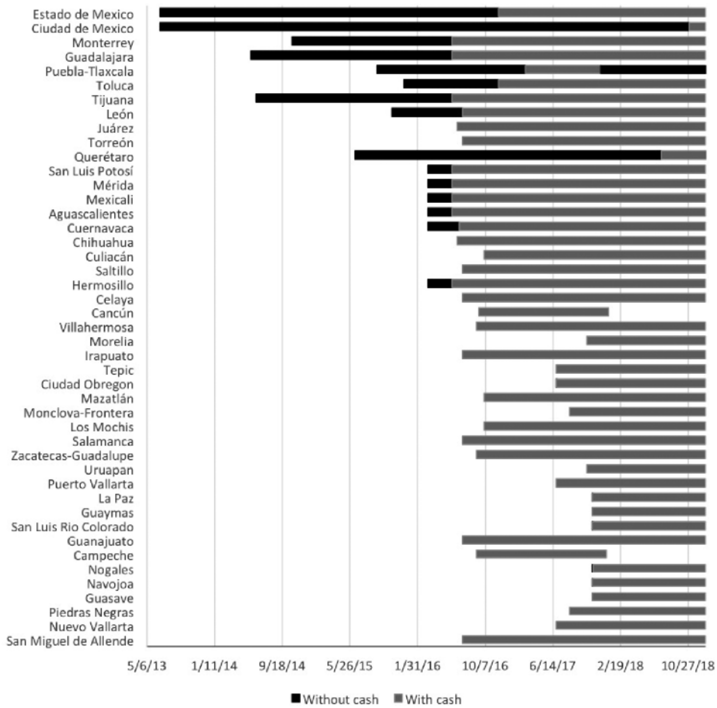

FIGURE I

Uber Mexico: Timing of the Introduction of Cash as a Payment Method

The figure shows the entry date of Uber in each city in Mexico. The black parts of the bars indicate the period when only card payment was available to riders. The gray bars show the periods when both card and cash were available as payment methods. The cities are ordered from top to bottom by the size of their population.

We also use geolocalized information about every trip taken in greater Mexico City during the months of August 2016, August 2017, and August 2018. The data include the date, time, and the pickup and drop-off locations (i.e., latitude and longitude) of every trip during this period as well as the total fare paid and an indicator for whether the trip was paid for in cash. As we describe below, we use these trips not only to obtain the demographic information about cash users from the census but also to be able to compare similar census blocks in Mexico City and in the State of Mexico before and after the introduction of cash. This data set is complemented with weekly data at the user level of all trips taken in greater Mexico City since Uber was launched until November 2018. The data contain the total fares paid, the method of payment, and an indicator for whether the trip started in Mexico City or the State of Mexico. We use geolocalized information about trips that took place in Puebla in August 2016, August 2017, and August 2018. These data include the date, time, pickup and drop-off locations (i.e., latitude and longitude), fares paid, and method of payment for every trip taken during these periods. We use the data to explore the implications of the introduction and subsequent ban of cash in this city, controlling for observable characteristics of the census blocks.

III.B. Google Maps: Panama

Uber launched in Panama in February 2014. The firm introduced cash payments in Panama in August 2016, partly due to low credit card penetration among Panama's population. Within a year, more than half of Uber trips were paid for in cash. In October 2017, Panamanian authorities imposed restrictions on Uber, which included a prohibition on cash payments. The decree went into effect in January 2018. Uber negotiated several extensions of this deadline, but on September 30, 2019, the government banned all ride-hailing companies from accepting payments in cash. Panama's Supreme Court voided this prohibition two months later, and Uber reintroduced cash as a method of payment on February 6, 2020.

We collected data for Panama from Google Maps public-transit information. As a result, we obtain information on all transportation methods (i.e., Uber, Cabify, and public transport). We began collecting data before the ban on cash was announced and continued collection until after the cash option was available again. The data were collected at the same time daily (9:00 am EST). We specified 20 different addresses across Panama City in Google Maps (depicted in Online Appendix Figure F2) as the origin addresses and the Plaza de la Independencia, a main public square located in the city's old town, as the destination address. Once a user selects the public-transit option, Google Maps displays information about several transport modes available (see Online Appendix Figure F1) including (i) departure time, (ii) time to the location using public transport, (iii) time to the location using ride-hailing services, (iv) estimated time of arrival of ride-hailing services, and (v) price of the trip using ride-hailing services. Since both Uber and Cabify were available in Panama during the period of interest, we obtained the prices and ETAs for both companies. Our data cover the period from September 2019 to March 2020.

III.C. EC Taximeter: Mexico

To study whether the wait times for regular taxis changed after the introduction of cash payments in Uber, we use taximeter data from the application EC Taximeter. This application is available in several Latin American cities and allows users to verify that they are being charged fairly for a regular taxi ride. Based on the user's location calculated using their phone's GPS and destination, the application calculates the cost of the taxi ride and allows the user to start a taximeter in their own phone and contact drivers directly. Several useful indicators are displayed to the user during the ride and are included in our data set, such as distance, duration of the trip, and, crucially for us, wait time. The data also include the latitude and longitude of the pickup and drop-off locations.

We use data for greater Mexico City from June 2016 until July 2017; cash was introduced as a payment method for Uber rides in November 2016. The data contain information about 12,238 rides starting or ending in Mexico City and the State of Mexico from three regular taxi services: (i) Radio Taxi, which covers the entire city and lets users hail a cab with a phone call; (ii) Taxi Libre, which are regular cabs driving throughout the city picking up passengers; and (iii) Taxi de Sitio, which are taxicab stands with queue areas on the street where taxis line up to wait for passengers.

III.D. Other Data Sources

We complement the Uber data with data from several sources that we describe in detail in Online Appendix F. These data sets were used to either report statistics or build different controls for our regressions. They include (i) the Financial Inclusion Database (BDIF), which we use to report and control for variables related to financial inclusion at the municipality level (e.g., bank branches, ATMs, total number of credit/debit cards); (ii) the National Survey of Household Income and Expenditure (ENIGH), which we use to obtain time-varying sociodemographic information such as income per capita; (iii) the National Survey of Financial Inclusion (ENIF), from which we obtain information about access to and use of payment methods as well as cell phones; (iv) the Census and Inter-Census Survey (EI), from which we obtain demographic information at the census block level; (v) the National Statistical Directory of Economic Units (DENUE), from which we obtain geolocalized information about banks and ATMs; (vi) the National Employment Survey (ENOE), from which we obtain information about employment rates in each municipality; (vii) the Statistical Compendium from the Ministry of Tourism (SECTUR), from which we obtain information on the number of foreign tourists in each city; (viii) the Criminal Incidence from the Executive Secretariat of the Public Security National System (SESNSP), from which we obtain information on the prevalence of crimes such as homicides and thefts; and (ix) precipitation data gathered on a daily basis by the National Water Commission (CONAGUA), which we use to control for factors that might temporarily affect Uber prices.

IV. Event Study

We begin our analysis by studying how the introduction of cash payments affected Uber rides in several Mexican cities. We use an event study approach to compare several outcome variables before and after the introduction of cash payments. Our sample covers the 15 cities in which Uber was operating before the firm introduced cash payments. This sample choice includes a preperiod before the introduction that allows us to check for possible trends that preceded the event of interest. We use data from cities like Querétaro and Mexico City that did not allow cash payments during the sample period (i.e., never treated) to serve as comparison. For this analysis, our sample period covers from April 2016 to the beginning of December 2017, the week that cash payments were banned in the city of Puebla. Let Y_{it} be an outcome variable for city i and time t (e.g., number of trips, total fares, average surge multiplier, number of active riders, number of active drivers). The specification for our event study is as follows:

$$Y_{it} = \alpha + \sum_{k=-\infty}^{\infty} \gamma_k \mathbb{1}\{K_{it} = k\} + \theta_i + \lambda_t + \zeta X_{it} + \epsilon_{it}, \tag{1}$$

where θ_i are city fixed effects and λ_t are time effects. K_{it} denotes the number of periods relative to the introduction of cash payments so that γ_k for $k < 0$ corresponds to pretrends and $k \geqslant 0$ corresponds to dynamic effects k periods after the introduction of cash payments. X_{it} represent a set of city-specific time-varying controls such as the unemployment rate, the level of rainfall, the average income of the population in city i at time t, the total number of foreign tourists, and the time elapsed since Uber launched operations in the city. Because the error term might be both serially and cross-sectionally correlated, we use Driscoll and Kraay standard errors.

Figures II and III plot our outcome variables before and after the introduction of cash payments. The graphs show that conditional on city and time fixed effects, no pretrends appear at least 20 weeks before the introduction of cash. This pattern is consistent with the timing of the introduction of cash being randomly assigned conditional on the city and time fixed effects. The identification assumption of this exercise is precisely that the entry of cash in these cities was not anticipated in riders' or drivers' behavior.[14] The graphs also show that the numbers of trips and fares more than double after the introduction of cash.[15] This increase is accounted for by increases in the number of new rider sign ups and in the number of trips taken by riders who were already using the application. Between 55% and 60% of the increase in the number of trips is explained by existing riders hailing rides more frequently.

Figure II, Panels E and F show that the number of driver sign ups and the number of driver hours per week also increased

14. In private conversations, the Uber team that launched cash in Mexico asserted that, once cash became an option, they launched it in all the cities where local regulation allowed Uber to do so, without targeting cities with specific attributes. Furthermore, the cash acceptance policy was not heavily advertised by Uber before its implementation; at the time, the company had no marketing department in the country. This can be confirmed by the popularity of "Uber cash" in Google before the introduction of cash in Online Appendix Figure K1. Nonetheless, given that cash was not launched earlier in Puebla and Toluca due to local regulation, the term "Uber cash" was more searched in these cities before the introduction of cash. Our results are not sensitive to excluding these cities from the analysis. These results can be found in Online Appendix I.2.

15. For the variables trips and fares, we are able to separate the State of Mexico from Mexico City; we have weekly data at the user level of all trips taken in greater Mexico City, which includes an indicator for whether the trip started in Mexico City or the State of Mexico. Querétaro is the only untreated city for the rest of the variables since the State of Mexico and Mexico City are combined as greater Mexico City in the data.

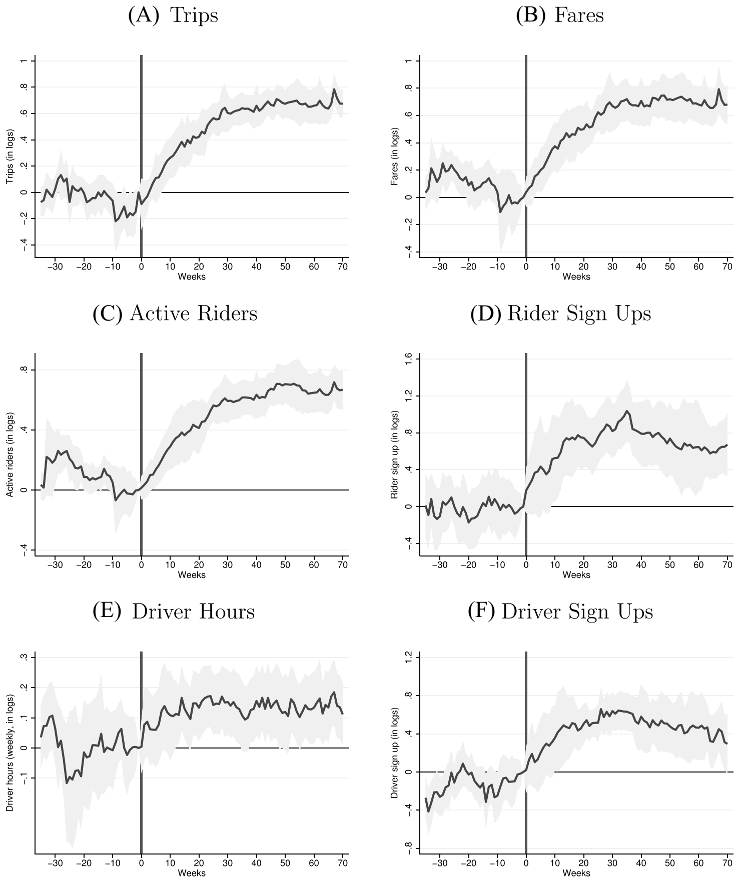

FIGURE II

Event Study: Extensive and Intensive Margin for Riders and Drivers

The graph shows the evolution of the number of trips, total fares, active riders, rider sign ups, driver hours, and driver sign ups before and after the introduction of cash. The panels plot the coefficients of γ_k after estimating equation (1). The vertical line marks the week that cash payments were introduced. The gray area depicts the 95% confidence interval computed using Driscoll and Kraay standard errors.

substantially, by 40% and 20%, respectively. The increase in the number of drivers was not enough to fully cover the increase in demand, but we can see that existing drivers responded by driving for more hours. As a result, both the ratios of active riders per

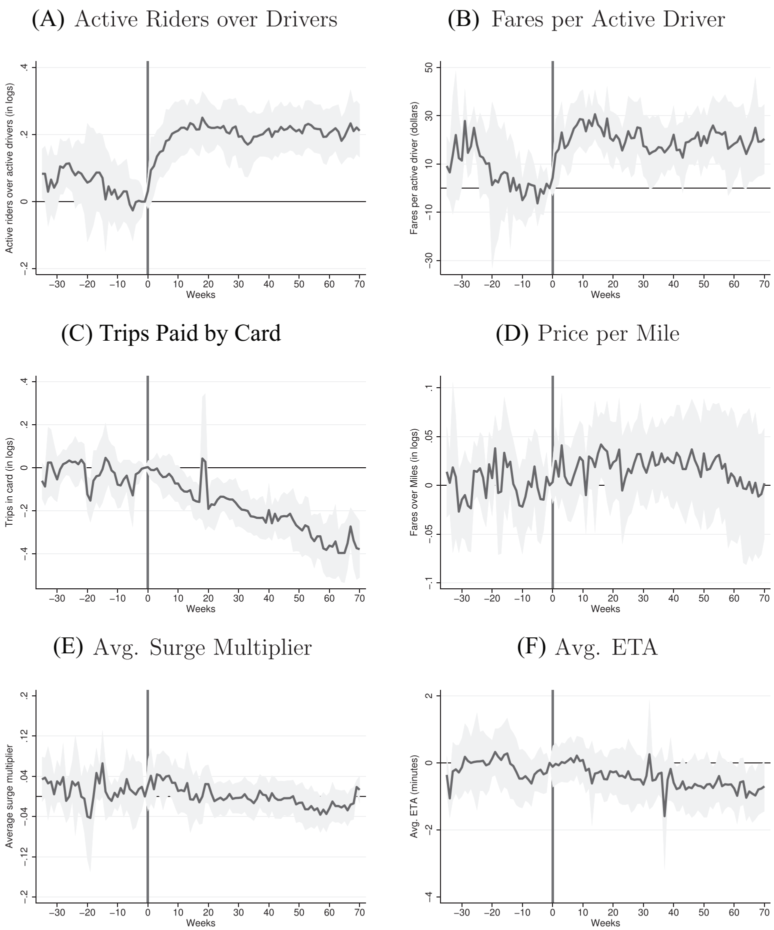

FIGURE III

Event Study: Riders over Drivers and Prices

The graph shows the evolution of the ratio of active riders over drivers, fares per active driver, trips paid by card, price per mile, average surge multiplier, and average estimated time of arrival before and after the introduction of cash. The panels plot the coefficients of γ_k after estimating equation (1). The vertical line marks the week that cash payments were introduced. The gray area depicts the 95% confidence interval computed using Driscoll and Kraay standard errors.

driver and fares per active driver increased. Figure III, Panels A and B show that the ratio of active riders to drivers increased by 20% after the introduction of cash payments, and fares per active driver increased by an average of US$20 a week, which is an increase of 12–15% in each driver's total weekly fares. Nevertheless, the drivers' income per hour (total fares divided by total driver hours) did not change after the introduction of cash payments, as shown in Online Appendix Figure A2.

Figure III, Panel C shows that slightly fewer trips were paid for with a card after the introduction of cash payments. This result suggests that cash and cards are partially substitutable, especially because we do not observe any change in prices per mile. Interestingly, the increase in the number of drivers and the increase in the average weekly hours per driver, when taken together, fully compensate for the increase in the demand that followed the introduction of cash payments. This compensatory result shows up in the trend of average prices per mile of Uber trips following the introduction of cash. Figure III, Panels D and E show that neither the average price per mile nor the average surge multiplier increased after the introduction of cash. Given that any effect on prices might not be reflected in pecuniary costs but might show up instead in wait times, we also study the patterns in drivers' estimated time of arrival after a ride is hailed. As shown by Panel F, this variable remains unchanged after the introduction of cash payments.[16] Online Appendix Figure A1 shows that the introduction of cash payments also did not lead to any increase in average taxicab prices.[17]

These findings suggest that the supply curve for Uber rides is very elastic, which entails a very low producer surplus. Hall, Horton, and Knoepfle (2017) also found that the driver supply of labor to ride-sharing markets is highly elastic and argued that this is likely the case because drivers are unrestricted in how many hours they may supply and new drivers face minimal barriers to entry.

16. In Online Appendix B we show similar results using the methodology developed by De Chaisemartin and D'Haultfœuille (2020), which implements two-way fixed effects and allows for robust dynamic effects in staggered designs.

17. Online Appendix Figure A1, Panel (a) shows that the rate of ride cancellations remains fairly constant after the introduction of cash.

V. Greater Mexico City: Neighboring Regions Approach

The analysis in this section exploits a geographical difference in the availability of cash payments around Mexico City to further support the findings reported already. Uber introduced cash payments in the State of Mexico in November 2016, although Mexico City did not allow cash payments until the Supreme Court ruling of November 2018. Between November 2016 and November 2018, cash trips could be requested within the limits of the State of Mexico but not within the limits of Mexico City. During this period, approximately 26% of trips that started in the State of Mexico ended in Mexico City.

This analysis uses information about all trips that took place in August 2016, August 2017, and August 2018. Our sample of users are those whose most frequent city of origin for an Uber request is greater Mexico City.[18] We have information about the latitude and longitude of the origin and destination and the payment method used for each trip.

The latitude and longitude coordinates allow us to assign each trip to a census block. Census blocks are the finest level of geographic aggregation provided by the Mexican census and consist of an 80 m^2 area on average. This step allows us to use demographic information from the census to determine the average characteristics of groups of Uber users while identifying users that are more likely to use cash for payment.

We use two empirical approaches to determine the effect of the introduction of cash on the number of trips, prices of rides, and fares collected. First, we use coarsened exact matching to find the appropriate counterfactual for each census block in the State of Mexico where cash was introduced. Second, we use a regression discontinuity approach to compare census blocks on the line between Mexico City and the State of Mexico. This approach allows us to control for observable and unobservable characteristics of the census block. The average treatment effect of the introduction of cash payments on the number of trips is about 100%. At the boundary, we find a local treatment effect on the number of trips of about 40%. Consistent with the evidence from our event

18. In the case of a user having taken fewer than three trips or in the case of a tie, we use the sign-up location of the user to determine their most-frequent city of origin.

study, we find that in the blocks where Uber was present before the entry of cash, slightly fewer trips were paid for using a card after the introduction of cash payments. The introduction of cash payments again has no effect on the average ride price or the price of a regular taxicab.

V.A. Matching Trips to Census Blocks

The Mexican census provides shapefiles containing the coordinates of the polygons surrounding each census block.[19] The coordinates of each point of this polygon are provided in the Lambert conformal conic projection (LCC). To match the geolocalized trips to census blocks, we convert the Uber coordinates to LCC coordinates (Elipsoide: GRS80).[20] We use the longitude and latitude of the centroid of each census block as its location.[21] Then we match each Uber trip to the closest census block by minimizing the Euclidean distance between the two. We use the latitude and longitude of the origin of the trip since this location determines the availability of cash payment. To minimize measurement errors, we correct for potential differences in Uber's geofence (the polygon that defines the area of cash acceptance, shown in Figure IV) and the actual political boundaries of the State of Mexico using the shapefiles of the geofence generated by Uber. Online Appendix Figure C1 shows the distribution of distances between the trips and the centroids of the closest census blocks. The median distance of each trip to the centroid of the closest census block is 50 m.

V.B. Demographics of Cash Users

Using demographic information from the 2010 Mexican census, we compute the observable characteristics of each census block. Figure V plots the share of cash Uber rides as a function of four observables: the average education in the census block,

19. Mexico has 32 federal entities (31 states plus Mexico City), 2,456 municipalities, basic geostatistical areas (Área Geoestadistica Básica (AGEB), sets of 1 to 50 census blocks), census tracts (population greater than or equal to 2,500), and census blocks. The country includes 2.3 million census blocks, with more than 100,000 in greater Mexico City.

20. Details can be found in Online Appendix C.1.

21. The centroid of the polygon that minimizes the sum of squared Euclidean distances between itself and each point in the set.

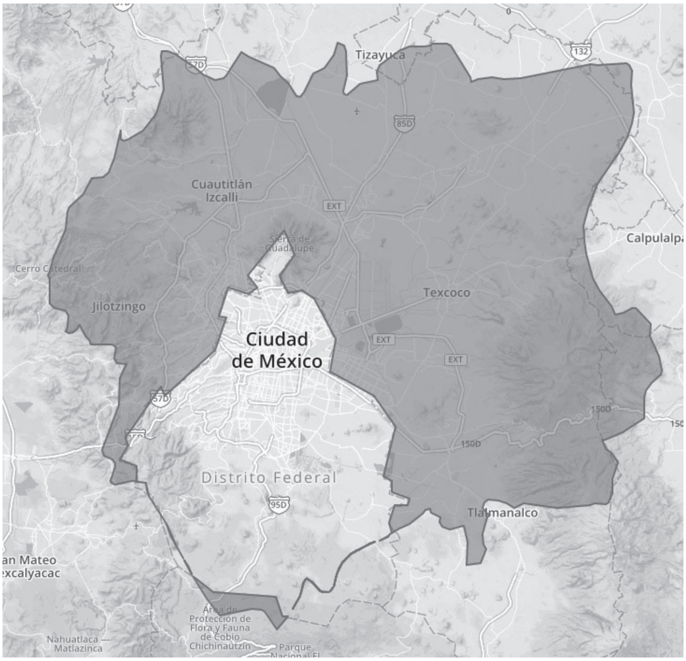

FIGURE IV

Limits of Cash Payments in Greater Mexico City

The figure shows the geofence that limits cash payments in the area covering greater Mexico City. Cash is allowed as a method of payment in the darker areas, outside the official limits of Mexico City.

the share of households with internet access, the share of households with a cell phone, and the share of households that own a car. These observables are correlated with the income level of the households in each census block. The figure shows that the share of trips paid for in cash is negatively correlated with all these variables. The negative correlation between the share of cash payments and different measures of proxies for income is consistent with the previous literature (e.g., Klee 2008; Arango, Hogg, and Lee 2015) and persists when we use the first principal component of these variables or the income per capita at the municipality level, as shown in Online Appendix C.2. More trips are paid for

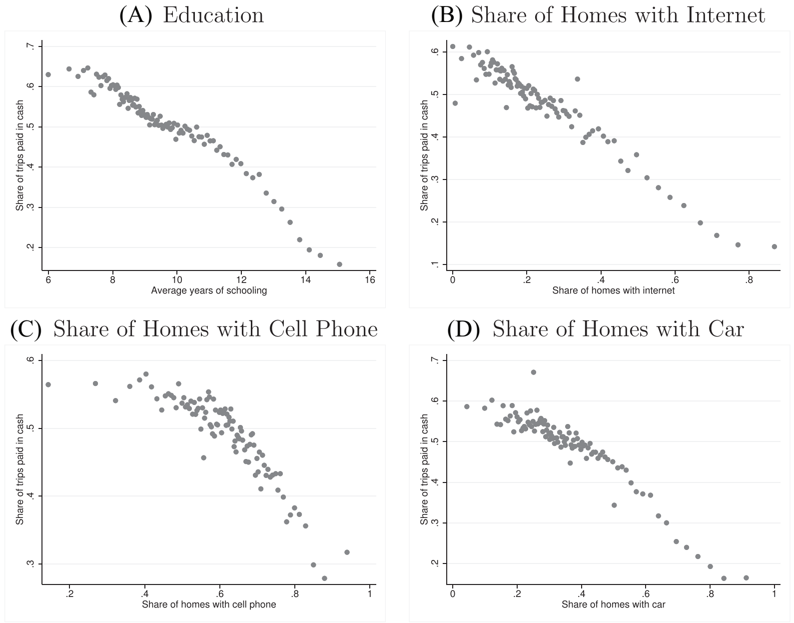

FIGURE V

Shares of Cash Fares by Demographics

The figure shows the relationships between the share of cash trips and several demographic variables taken from the Mexican census. The share of trips paid for in cash is calculated for those trips that took place in each census block in August 2017, after the introduction of cash payments in the State of Mexico. The demographic variables included are the average years of schooling, the share of homes with internet, the share of homes with cell phone, and the share of homes with a car. The census blocks are grouped into 100 equal-sized bins.

in cash in municipalities with less access to banking services, as measured by debit cards per capita, credit cards per capita, bank branches per capita, or ATMs per capita (Online Appendix C.3). The share of cash trips is also larger in suburban regions of the State of Mexico (Online Appendix C.5) and in census blocks with less developed infrastructure, as measured by the availability of street lights, pavement, or whether the census block has access to public transport (Online Appendix C.4).

V.C. Coarsened Exact Matching

We exploit the fact that cash was introduced only in the State of Mexico to compare census blocks that did and did not have the option to pay for Uber rides in cash. Given that the State of Mexico neighbors Mexico City, we can use the census blocks of Mexico City as counterfactuals for those in the State of Mexico, conditional on observables. To do so, we use coarsened exact matching (CEM) to identify the appropriate counterfactual for each census block where cash was introduced.[22] CEM allows us to choose the maximum imbalance between the treated and control groups ex ante. Essentially, the process coarsens each control variable for the sake of matching. Then, all blocks are sorted into strata, each of which has the same values of the coarsened observable variables. Each stratum prunes the blocks that do not include at least one treated and one control block from the data set. We use the share of households with internet access, the share of households with a car, the share of households with a cell phone, the number of retail banks, and the average years of education at the census block level as observable characteristics for CEM. We choose a Sturges rule to coarsen each observable into 20 bins. Approximately 94% of all census blocks could be matched using this procedure.

Table I reports the average treatment effect when comparing blocks in the State of Mexico with those in Mexico City. The dependent variable is either the change in the number of trips (columns (1)–(3)) or the change in total fares (columns (4)–(6)), each calculated as in Davis and Haltiwanger (1992), that is, $\frac{2(y_t - y_{t-1})}{y_t + y_{t-1}}$. This choice facilitates the study of census blocks becoming active or inactive in terms of Uber trips after the introduction of cash payments.[23] The number of trips doubled after the introduction of cash (a value of 0.66 in $\frac{2(y_t - y_{t-1})}{y_t + y_{t-1}}$ corresponds to a growth rate of approximately 100%). We break up the growth rate into the contribution from the intensive margin in column (2) and that from

22. In Online Appendix J.1, we conduct this analysis using ordinary least squares (OLS) regression. The Online Appendix show results for trips and fares and decomposes the effect of the introduction of cash payments into results at the intensive margin (trips in census blocks that were active before the introduction of cash) and at the extensive margin (trips in census blocks that became active after the introduction of cash). The results using CEM and OLS are quantitatively very similar. The conclusions are also similar when we control for pairs of origin and destination at the level of basic geostatistical areas. These results are presented in Online Appendix Table J13.

23. This growth rate is symmetric about zero and it lies in the closed interval $[-2, 2]$ with census blocks activated after the introduction of cash corresponding to the right endpoint.

TABLE I

CEM: Effect of the Entry of Cash on Trips, Fares, and Prices

	$\Delta Trips$ (1)	$\Delta Trips_I$ (2)	$\Delta Trips_E$ (3)	$\Delta Fares$ (4)	$\Delta Fares_I$ (5)	$\Delta Fares_E$ (6)	$\Delta Price$ (7)
State of Mexico	0.657***	0.377***	0.280***	0.517***	0.237***	0.280***	0.003
	(0.006)	(0.004)	(0.006)	(0.006)	(0.005)	(0.006)	(0.002)
Observations	81,931	81,931	81,931	81,929	81,929	81,929	63,132
R^2	0.137	0.081	0.026	0.088	0.031	0.026	0.00
Margin	All	Intensive	Extensive	All	Intensive	Extensive	All

Notes. The table reports the results of an OLS regression that estimates the effect of the introduction of cash payments in census blocks in the State of Mexico relative to those in Mexico City. The weights of the regression are computed using coarsened exact matching and a Sturges rule. The observable characteristics we used are the average education of each census block, the share of households with cell phones, the share of households with internet access, the share of the population that is economically active, and the share of households that own a car. Columns (1)–(3) report the results using the change in the total number of trips as the dependent variable, and columns (4)–(6) report the results using the change in total fares as the dependent variable. Columns (2) and (5) report changes in the intensive margin (trips and fares in census blocks that were active before the introduction of cash), and columns (3) and (6) report changes in the extensive margin (trips and fares in census blocks that became active after the introduction of cash). Column (7) reports changes in prices calculated using the ratio of total fares to the total driving distance of each trip. ***, **, and *, represent statistical significance at 1%, 5%, and 10% levels.

the extensive margin in column (3), so that both add up to the total effect. Approximately 55% of the increase in the number of trips is accounted for by census blocks already using the application before the introduction of cash and 45% is accounted for by census blocks that started using the application after cash payment was introduced. The results are very similar when we use the change in the total fares as the dependent variable, shown in columns (4)–(6). The last column shows the changes in prices before and after the introduction of cash, where the price per mile is calculated as the fare paid divided by the total driving distance of the trip.[24] Column (7) shows that the method of this subsection

24. We use the origin and destination coordinates of each trip to obtain the driving distance using Google Maps API. Because of the large number of trips that took place in August 2016 and August 2017, we use a random sample of 1% of the trips and use the driving distance of these trips to impute the driving distance on the rest. To do so, we predict the driving distance with a second-order polynomial of the Euclidean distance between the origin and destination coordinates and a second-order polynomial of the distance between the origin of the trip and the border between Mexico City and the State of Mexico, and we interact these variables with a dummy that indicates if the trip started in the State of Mexico. A regression of the driving distance on these variables has an R^2 of 96.4%.

TABLE II

CEM: Effect of the Entry of Cash on Trips and Fares Paid with Cards

	$\Delta Trips^{card}$ (1)	$\Delta Trips_I^{card}$ (2)	$\Delta Trips_E^{card}$ (3)	$\Delta Fares^{card}$ (4)	$\Delta Fares_I^{card}$ (5)	$\Delta Fares_E^{card}$ (6)
State of Mexico	0.088***	−0.011**	0.099***	0.021***	−0.078***	0.099***
	(0.007)	(0.004)	(0.006)	(0.007)	(0.005)	(0.006)
Observations	78,654	78,654	78,654	78,654	78,654	78,654
R^2	0.002	0.000	0.003	0.000	0.004	0.003
Margin	All	Intensive	Extensive	All	Intensive	Extensive

Notes. The table reports the results of an OLS regression that estimates the effect of the introduction of cash in census blocks in the State of Mexico relative to those in Mexico City. The weights of the regression are computed using coarsened exact matching and a Sturges rule. The observable characteristics used are the average education of each census block, the share of households with cell phones, the share of households with internet access, the share of economically active population, and the share of households that own a car. Columns (1)–(3) report the results using the change in the total number of trips paid with card and columns (4)–(6) the results using the change in total fares paid with cards as the dependent variable. Columns (2) and (5) report changes in the intensive margin (trips and fares in census blocks that were active before the introduction of cash), and columns (3) and (6) changes in the extensive margin (trips and fares in census blocks that became active after the introduction of cash). ***, **, and *, represent statistical significance at 1%, 5%, and 10% levels.

reveals no significant change in prices after the introduction of cash.

Table II shows that the increase in the number of trips and fares paid by card is much smaller and entirely driven by the extensive margin. In fact, for the census blocks that had Uber users before the introduction of cash payments, the total number of trips and fares paid by card decreased, as shown in column (2) and column (5). This trend indicates that some pure-card users started paying for some trips in cash once cash payments became available.[25] Online Appendix Figure C4 shows that the extent to which a user switches from purely card payments to mixed payments is negatively correlated with income.

These results are consistent with those of our event study. Taken together, the results show that, even controlling for census block observables, the introduction of cash payments has a large effect on the number of trips and on total fares, has no effect on prices, and leads some users to substitute payment methods, although this substitutability is imperfect. This last point

25. The average trip paid in cash is shorter, consistent with previous work documenting that lower-value transactions tend to be paid in cash (e.g., Hayashi and Klee 2003; Bounie and François 2006; Klee 2008). Online Appendix Figure I1 shows a slight decline in the length of the average trip (in miles) after the introduction of cash.

about substitutability is relevant since the State of Mexico does not have a large share of trips paid for in cash, relative to other states.

V.D. Regression Discontinuity

The second empirical approach uses an RD design to estimate the effect of the introduction of cash on each side of the border of Mexico City and test whether the introduction of cash caused discontinuous changes in the number of trips near the border. This design allows us to control for unobserved determinants of the number of trips that are continuous across the border between Mexico City and the State of Mexico.[26] If the relevant assumption is valid, adjustment for a sufficiently flexible polynomial in distance from the border or a local linear regression on either side of the border will remove all potential sources of bias.

Figure VI illustrates the effect of cash payments at the border by showing the relationship between the growth in the numbers of users and trips before and after the introduction of cash payments and the distance to Mexico City. As before, the changes in users are computed as in Davis and Haltiwanger (1992). The graph shows that allowing a flexible polynomial to differ on each side of the border yields a significant discontinuity at the border both in the change in the number of users (Panel A) and in the change in the number of trips (Panel B).[27] This is also the case when we examine the change in trips from 2016 to 2018 (Panel C). The graphs show that regions farther away from Mexico City experience more-significant increases in users and trips. Importantly, Panel D shows no discontinuity at the border if we examine the change in trips between 2017 and 2018, the years that followed the introduction of cash but which were before the Supreme Court ruling.

26. Online Appendix C.7 shows that the observable variables have no discontinuities at the border between the State of Mexico and Mexico City.

27. To determine the growth of users in each census block, we assign each user to the census block where most of his or her trips originated. In case of ties we assigned users to the census block where the majority of her trips started in the morning (before noon) and where the majority of her trips ended at night (after 5 pm). Our results are not sensitive to switching the order of these criteria.

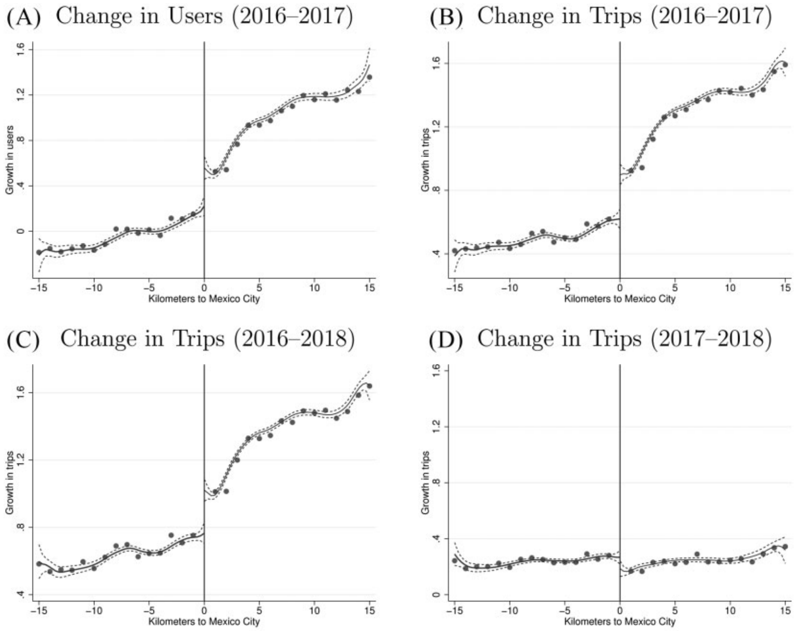

FIGURE VI

Percent Change in Numbers of Users and Trips

Panel A shows the relationship between the growth in users between 2016 and 2017 and the distance to Mexico City. Panel B shows the relationship between the growth in trips between 2016 and 2017 and the distance to Mexico City. Panel C shows the relationship between the growth in trips between 2016 and 2018 and the distance to Mexico City. Panel D shows the relationship between the growth in trips between 2017 and 2018 and the distance to Mexico City. Negative numbers on the x-axis indicate the census block is in Mexico City. Each bin corresponds to 1 km. The dots show the average growth in users (trips) in each bin. The line is a kernel-weighted (Epanechnikov) local polynomial of degree three. The dashed lines mark 99% confidence intervals.

We estimate the following equation to test for the impacts of the introduction of cash payments in the State of Mexico:

$$\Delta y_i = \alpha + \beta\, StateMexico_i + f(d_i;\gamma^e) + StateMexico_i \times f(d_i;\gamma^d) + \lambda X_i + \epsilon_i, \tag{2}$$

where i denotes a census block, Δy_i is the change in the outcome variable, and $StateMexico_i$ is an indicator variable equal to 1 if the census block is located in the State of Mexico. In other words, if $StateMexico_i = 1$, cash payments were allowed. $f(\cdot\,;\gamma)$ is a kernel-

TABLE III

Regression Discontinuity Approach: Effect on Trips

	(1)	(2)	(3)	(4)	(5)
State of Mexico	0.390***	0.313***	0.216***	0.173***	0.239***
	(0.013)	(0.018)	(0.023)	(0.029)	(0.034)
Observations	87,036	87,036	87,036	87,036	87,036
R^2	0.351	0.352	0.353	0.354	0.354
Controls	Yes	Yes	Yes	Yes	Yes
Distance	All	All	All	All	All
Degree	1	2	3	4	5

Notes. The table reports the results for the coefficient of β after estimating equation (2). The estimates report the local treatment effect at the border between the State of Mexico and Mexico City of the introduction of cash as a payment method. Each column reports the results using kernel-weighted local polynomials of different degrees. The dependent variable is the change in the total trips from each census block. The standard errors are clustered at the level of basic geostatistical areas (AGEBs). ***, **, and *, represent statistical significance at 1%, 5%, and 10% levels.

weighted local polynomial in meters relative to the border between Mexico City and the State of Mexico that satisfies $f(0; \gamma) = 0$. X_i is a vector of the census block characteristics that might affect the number of Uber trips, such as the average education of the block and the share of homes that own a cell phone. The parameter of interest is β, which provides an estimate of whether the outcomes are discontinuous. If the RD assumptions hold, estimates of β will provide an unbiased estimate of the change in the number of trips and fares that follows the introduction of cash payments.

The results are reported in Tables III and IV for the changes in the number of trips and fares, respectively. At the boundary

TABLE IV

Regression Discontinuity Approach: Effect on Fares

	(1)	(2)	(3)	(4)	(5)
State of Mexico	0.283***	0.245***	0.154***	0.118***	0.187***
	(0.011)	(0.016)	(0.021)	(0.026)	(0.031)
Observations	87,033	87,033	87,033	87,033	87,033
R^2	0.249	0.250	0.251	0.251	0.251
Controls	Yes	Yes	Yes	Yes	Yes
Distance	All	All	All	All	All
Degree	1	2	3	4	5

Notes. The table reports the results for the coefficient of β after estimating equation (2). The estimates report the local treatment effect of the introduction of cash payments at the border between the State of Mexico and Mexico City. Each column reports the results using kernel-weighted local polynomials of different degrees. The dependent variable is the change in the total fares of each census block. The standard errors are clustered at the level of basic geostatistical areas (AGEBs). ***, **, and *, represent statistical significance at 1%, 5%, and 10% levels.

we find a local treatment effect of 40% in the number of trips and a slightly lower effect for total fares. The tables also show that our results are robust if we use polynomials of different degrees and are not sensitive to the inclusion of controls. Online Appendix Table C1 and Table C2 show that our results are also robust if we restrict the sample of census blocks on each side of the border to be within 5 km of the border.[28] Last, Online Appendix Table C5 shows that, consistent with the event study and with the CEM evidence, the regression discontinuity approach reveals no significant effect on prices.

V.E. *Taxi Prices*

Although our event study (Section IV) found that introducing cash payments for Uber rides had no effect on taxi prices, taxi prices might be regulated, and thus unlikely to be responsive to changes in demand in the short run. If taxi prices were fixed, other nonpecuniary costs like wait times may have responded to the change in demand. We analyze data from the application EC Taximeter to address this concern.

As discussed already, EC Taximeter lets users verify that they are being charged fairly for a regular taxi ride. Our data set contains information about the trips taken by regular taxicabs, including those that can be called on the phone, those circulating in the street, and those queued up at taxi stands. The data include the distance, duration, and wait times of more than 12,000 trips that took place in the greater Mexico City area before and after the introduction of cash payments by Uber.[29]

We use the following specification:

$$\ln \mathrm{ETA}_{ijt} = \alpha + \beta\, Cash_t + \gamma\, Cash_t \times StateMexico_j + \zeta X_{ijt} + \theta_j + \epsilon_{ijt}, \tag{3}$$

28. The trips are geolocalized based on where the driver started and ended the trip. As a result, we are able to detect and adjust our estimates for riders that might have requested a cash trip in the State of Mexico but whose trip in fact started in Mexico City. On the other hand, it is possible that some riders in Mexico City crossed to the State of Mexico to request cash trips. Our results are very similar if we exclude trips that started less than 100 m from the border (see Online Appendix Tables C3 and C4).

29. Online Appendix Table C6 presents summary statistics of the average duration of a trip, distance, and wait time. The average wait time in Mexico City is 10 minutes and in the State of Mexico is 9.5 minutes.

TABLE V

TAXIS' ESTIMATED TIME OF ARRIVAL AFTER THE ENTRY OF CASH

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Cash	−0.463***	−0.404***	−0.238***	−0.390**	−0.356***	−0.361***	−0.198*
	(0.109)	(0.095)	(0.036)	(0.153)	(0.122)	(0.128)	(0.106)
State of Mexico	−0.060	−0.119	−0.285	−0.213	−0.266	−0.838	−0.924
× cash	(0.230)	(0.223)	(0.204)	(0.252)	(0.232)	(0.584)	(0.720)
Observations	1,884	2,749	12,117	1,613	2,364	1,345	1,260
R^2	0.062	0.058	0.053	0.234	0.225	0.435	0.403
Distance	<1 km	<2 km	All	<1 km	<2 km	<1 km	<1 km
Controls	N	N	N	Y	Y	Y	Y
Region	Mun.	Mun.	Mun.	Mun.	Mun.	AGEB	Block

Notes. The table shows the results of estimating equation (3). The dependent variable is the ETA for taxis in the greater Mexico City area. $Cash_t$ is an indicator variable that equals 1 if cash has been introduced and $StateMexico_j$ is an indicator variable that equals 1 if the pickup location is in the State of Mexico. The vector of controls X_{ijt} includes the duration of the trip, the distance of the trip, and several demographic variables about the pickup location, such as the average education of each census block, the share of households with cell phones, the share of households with internet access, and the share of households that own a car. Columns (1)–(5) includes municipality fixed effects of the pickup locations. Column (6) includes AGEB fixed effects, and column (7) includes block fixed effects. Columns (1), (4), (6), and (7) consider trips in the State of Mexico and those that started less than 1 km away in Mexico City. Columns (2) and (5) consider trips that started less than 2 km away from the State of Mexico. Column (3) considers all trips. All data are drawn from EC Taximeter. ***, **, and *, represent statistical significance at 1%, 5%, and 10% levels.

where ETA_{ijt} is the estimated time of arrival of trip i from pickup location j on day t. $Cash_t$ is an indicator variable that equals 1 if cash has been introduced, and $StateMexico_j$ is an indicator variable that equals 1 if the pickup location is in the State of Mexico. The vector of controls X_{ijt} includes the duration of the trip, the distance of the trip, and several demographic variables about the pickup location such as the average education level, the share of households with cell phones, the share of households with internet access, and the share of households that own a car. Table V reports several specifications of the location fixed effects θ_j.

Column (1) considers trips that started in the State of Mexico and compares them with those that started less than 1 km away but in Mexico City. The estimates for β indicate that the wait time for taxis in the greater Mexico City area has decreased considerably over time. Our coefficient of interest is the interaction term, represented by the coefficient of γ, which shows that the estimated time of arrival did not increase more in the State of Mexico, where cash was introduced, than it did in Mexico City. This result is robust to the inclusion of all trips that took place in the greater Mexico City area and is robust to the inclusion of the

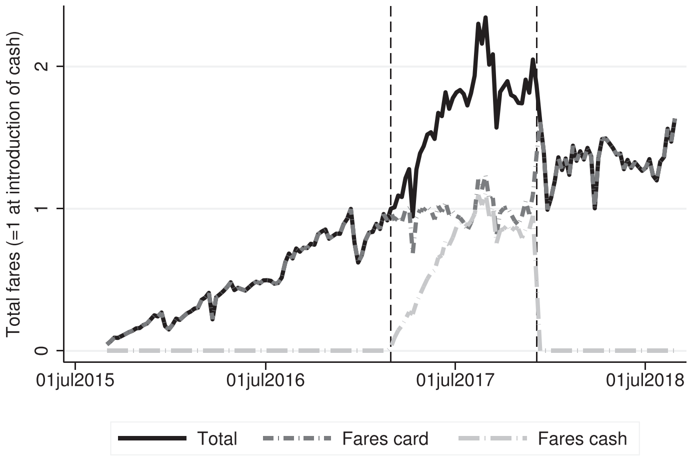

FIGURE VII

Puebla: Total Fares by Payment Method

The figure shows the evolution of the total fares paid by Uber users in Puebla as well as the fares paid in card and cash. The dashed vertical lines mark the introduction and ban of cash as a payment method in the city. Total fares are normalized to 1 during the period of the introduction of cash.

controls shown in columns (2)–(4). We find no significant changes in taxi wait times in the State of Mexico relative to Mexico City if we include AGEB fixed effects or block-level fixed effects shown in columns (6) and (7). Overall, despite the large increase in demand for Uber rides that followed the introduction of cash payments, we find that the entry of cash payments had no significant effect on the prices (Online Appendix Figure A2) or ETAs of taxis. This implies that welfare estimates of policies encouraging or precluding the use of cash depend only on the prices/quantities of Uber and not on those of other complements or substitutes to Uber such as taxis.[30]

VI. BAN ON CASH

Uber launched in Puebla in September 2015, but it did not introduce cash payments until March 2017. Figure VII shows

30. This is the case, for instance, under quasi-linear preferences since the marginal utility of income is constant.

the total fares collected in the city of Puebla, split by payment method. The graph shows that the total fares almost doubled after the introduction of cash. Although Puebla was one of the least cash-intensive cities in the country, nearly the same amounts of fares were paid with cash and with cards by 2017. On September 15, 2015, a student was kidnapped and subsequently murdered, allegedly by a Cabify driver. In consequence, the local government decided to ban Cabify in the city and ban cash as a payment method for all ride-hailing services.[31] The ban was announced on October 31 and implemented on December 8. Figure VII shows that during the ban on cash, the total fares in the city decreased substantially. We study these patterns in detail in the next sections. Consistent with the previous sections, in Section VI.A we show the large impact of the ban on the number of trips using a synthetic control approach. Section VI.B shows similar findings when we use geolocalized data of Puebla and CEM. The next two sections split riders into pure-cash users and mixed users to study the degree of substitutability across payment methods at the extensive (Section VI.C) and intensive (Section VI.D) margins.[32] We do not find evidence that the ban affected the prices of trips in Puebla. Section VI.E presents complementary evidence studying a ban on cash that took place in Panama; it shows that the ban on cash had no significant effect on the prices of Uber substitutes either.

VI.A. Synthetic Control Method

To study the effect of Puebla's ban on cash payments on the number of trips and prices, we use the synthetic control method proposed by Abadie and Gardeazabal (2003). We construct a weighted average of 32 cities in Mexico to act as a pseudo-city

31. The decision was also made in response to the pressure imposed by the taxi drivers' union on the state government, which argued that Uber cash rides competed directly with traditional taxis. In fact, during the ban on cash, the local government launched its own application Pro-taxi, with traditional taxis as its audience and where cash payments were allowed. After the Mexican Supreme Court ruled against the prohibition of cash, Uber reintroduced cash as a payment method in July 2019.

32. A more recent ban on cash occurred in the city of San Luis Potosí on July 17, 2019. The ban was a consequence of changes in local transportation regulations. Unlike Puebla, San Luis Potosí is a cash-intensive city, where approximately 75% of the total fares were paid for in cash. More details on the patterns of fare payments in San Luis Potosí are provided in Online Appendix G.

whose data mimics the patterns observed in the city of Puebla before the ban on cash. Let $J + 1 \in \mathbb{N}$ be the total number of cities including Puebla observed during $T \in \mathbb{N}$ periods. The ban on cash affects only Puebla from period $T_0 + 1$ to period T, where $T_0 \in (1, T) \cap \mathbb{N}$. Let Y_{jt}^N be the potential outcome (e.g., number of trips, prices) that would be observed for city j in period t if cash was not banned as a payment method and let Y_{jt}^I be the potential outcome that would be observed if city j faced a ban on cash. We define $\alpha_{jt} \equiv Y_{jt}^I - Y_{jt}^N$ as the effect of the ban for city j in period t. Then, the observed outcome for city j in period t is:

$$Y_{jt} \equiv Y_{jt}^N + \alpha_{jt} D_{jt},$$

where D_{jt} is a dummy variable that equals 1 if city $j = 1$ (Puebla) faces the ban on cash in period t and is 0 otherwise. We estimate Y_{1t}^N using the synthetic control method to find the estimator α_{1t} defined as $\hat{\alpha}_{1t} \equiv Y_{1t} - \hat{Y}_{1t}^N$.

We use daily city-level panel data from August 2017 to March 2018. The ban on cash payments was enacted December 8th, 2017, in the middle of this period. Our sample of cities includes the 32 cities in Mexico in which Uber was active in the week of the ban on cash in Puebla, after splitting Mexico City from the State of Mexico. We use the difference between an outcome variable and its counterpart in the synthetic pseudo-city to estimate the effects of the ban on the total number of trips per capita and on prices. For the preban characteristics, we rely on variables related to the number of trips and the use of cash as a payment method: trips paid for in cash per capita, total fares per trip, and the total trips per capita on August 15 and September 1, 2017.[33] The synthetic Puebla is a weighted average of Guanajuato (0.453), State of Mexico (0.425), Mexico City (0.072), and Querétaro (0.051) with weights reported in parentheses. All other cities are assigned weights of 0. The root mean square prediction error (RMSPE) is 0.00152. Table VI compares the preban characteristics of Puebla to those of synthetic Puebla. Overall, the table shows that the synthetic Puebla is very similar to the actual Puebla in terms of trips and fares.

Figure VIII, Panel A shows the evolution of the number of daily trips before and after the ban on cash payment. The graph

33. The results are unchanged when we include low-frequency variables, such as the unemployment rate or the income level of the city, as preban characteristics.

TABLE VI

PREDICTOR BALANCE WITH STATE OF MEXICO

	Puebla	Synthetic
Trips paid for in cash per capita (daily)	0.0019	0.0019
Total fares per trip (daily)	3.4698	3.4748
Total trips per capita (Sept. 1, 2017)	0.0220	0.0202
Total trips per capita (Aug. 15, 2017)	0.0148	0.0148

Notes. The table reports the average values of the predictors used to define the synthetic control for the city of Puebla. The variables reported in per capita terms are computed using the population of the city of Puebla as of 2017.

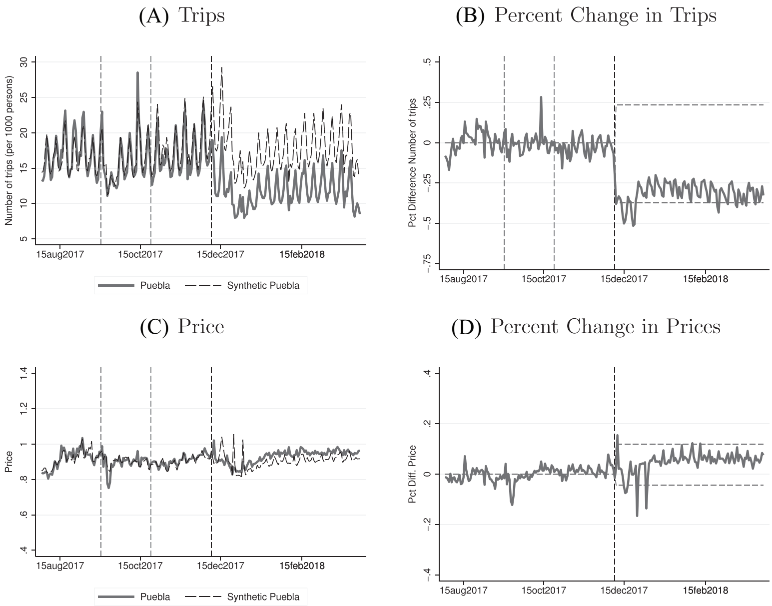

FIGURE VIII

Puebla: Synthetic Control, Trips

Panel A shows the evolution of daily trips per 1,000 people in the city of Puebla (solid gray line) and the evolution of trips of the synthetic city constructed using the synthetic control method (dashed black line). Panel B shows the percent difference in daily trips between the data of Puebla and the synthetic city. Panel C shows the evolution of prices in the city of Puebla (solid line) and the evolution of trips of the synthetic city constructed using the synthetic control method (dashed line). Panel D shows the percent difference in prices between the data of Puebla and the synthetic city. The black dashed vertical line marks the date of the ban on cash. The horizontal dashed lines in Panels B and D show the 95% confidence interval computed using permutation tests as in Firpo and Possebom (2018).

shows that our synthetic Puebla shows well-matched daily fluctuations in trips before the ban including brief spikes in the number of trips during weekends. The figure also shows that after the ban on cash, the number of trips decreased significantly. Panel B shows the percent difference of the number of trips between the synthetic Puebla and the actual Puebla. The figure shows that the total number of trips decreased more than 60% immediately after the ban. The number of trips rebounded after approximately four weeks, mainly due to cash users migrating to credit after the ban, but remained lower than the level before the ban in cash. The horizontal dashed lines in Panel B show the 95% confidence interval, indicating that the change is not only large but also significant relative to the distribution of the effects estimated for the cities that did not experience the ban. In Online Appendix D.1 we describe our inference procedure, which follows the permutation tests described in Firpo and Possebom (2018) and analyze the size and the power of 11 different test statistics. In all tests, the change in the number of trips before and after the ban is statistically significant.[34] In contrast, we do not find significant changes in ride prices, as shown in Figure VIII, Panels C and D. We also do not find significant difference in the ETAs or in the prices of taxis, shown in Online Appendix Figure D2.

VI.B. Coarsened Exact Matching

The ban on cash payments' effect on the number of trips is similar if, instead of a synthetic control method, we use a CEM procedure to compare the census blocks that experience the ban in Puebla with comparable blocks in the State of Mexico, where cash payments were allowed.[35] For this analysis, we use geolocalized data from Puebla for the months of August 2017 and August 2018. Given that cash was banned in all census blocks in Puebla, we use census blocks in the State of Mexico as counterfactuals.

34. We repeat the analysis using only data prior to the ban, such as data until the date of the murder or the date the ban was announced (dashed vertical lines in Figure VIII), we do not find a significant difference between the synthetic Puebla and the actual Puebla until the day the ban was implemented (Online Appendix Figure D1). Public interest in both events, according to the Google Trends weekly data, was mostly local and lasted only one week.

35. Online Appendix D.4 shows the basic geostatistical areas in Puebla that experience larger changes in the number of trips after the introduction and subsequent ban of cash. The maps show that suburban areas farther away from the center of the city experienced larger changes.

The State of Mexico is a particularly useful counterfactual for Puebla because the cities are close geographically and had similar shares of trips paid for in cash before the ban. We use the same characteristics for matching as we did above. We also include the total trips per capita in 2017 and the average price per mile in 2017 at the census block level. In this case, approximately 67% of approximately 19,000 census blocks in Puebla were matched. Table VII reports the average treatment effect of comparing blocks in Puebla after the ban on cash payments with those in the State of Mexico. The dependent variable is again either the change in the number of trips (columns (1)–(3)) or the change in total fares collected (columns (4)–(6)). Consistent with the findings of the previous section, both decreased more than 50%.

In this case, most of the decrease is explained by the intensive margin. In most census blocks in Puebla, at least one user remained active in the application after the ban of cash. On the other hand, columns (7) and (8) show that the number of trips and fares paid by card increased substantially. The table shows that there was substitution from users paying with cash to users paying by card after the ban. This substitution is not perfect because it does not fully compensate for the total reduction in trips and fares after the ban. Consistent with the evidence of the previous sections, column (9) shows that the effect of the ban on prices is very limited relative to the changes in the number of trips and fares.[36]

VI.C. Extensive Margin: Pure-Cash Users

The decrease in the total number of trips after the ban on cash in Puebla was attenuated in part by the fact that many pure-cash users (approximately 30% of users) kept using the application, registering a payment card. Figure VIII shows, for example, that within two weeks the number of trips recovered somewhat after the sudden decline in the week of the ban. To quantify the

36. As before, we approximate the prices per mile by dividing the total fares paid in a trip by the total driving distance of the trip. We randomly select 1% of all trips that took place between August 2017 and August 2018 in Puebla and use the driving distance of these trips obtained using the Google Maps API to impute the driving distance of the rest. We predict the driving distance with a second-order polynomial of the Euclidean distance between the origin and destination coordinates and a second-order polynomial of the distance between the origin of the trip and the center of the city. A regression of the driving distance on these variables has an R^2 of 97%.

TABLE VII

CEM: EFFECT OF THE BAN ON CASH PAYMENTS ON TRIPS, FARES, AND PRICES

	$\Delta Trips$ (1)	$\Delta Trips_I$ (2)	$\Delta Trips_E$ (3)	$\Delta Fares$ (4)	$\Delta Fares_I$ (5)	$\Delta Fares_E$ (6)	$\Delta Trips^{card}$ (7)	$\Delta Fares^{card}$ (8)	$\Delta Price$ (9)
Puebla	-0.484^{***}	-0.449^{***}	-0.035^{***}	-0.489^{***}	-0.453^{***}	-0.035^{***}	0.305^{***}	0.259^{***}	-0.025^{***}
	(0.011)	(0.006)	(0.009)	(0.011)	(0.006)	(0.009)	(0.008)	(0.009)	(0.002)
Observations	43,119	43,119	43,119	43,116	43,116	43,116	30,031	30,031	34,452
R^2	0.045	0.127	0.000	0.043	0.111	0.000	0.046	0.027	0.005
Margin	All	Intensive	Extensive	All	Intensive	Extensive	All	All	All

Notes. The table reports the results of an OLS regression that estimates the effect of the ban of cash in census blocks in Puebla relative to those in the State of Mexico. The weights of the regression are computed using coarsened exact matching and a Sturges rule. The observable characteristics used are the average education of each census block, the share of households with cell phones, the share of households with internet access, the share of economically active population, the share of households that own a car, and the trips per capita in 2017. Columns (1)–(3) report the results using the change in the total number of trips. Columns (4)–(6) reports the results using the percent change in total fares as the dependent variable. Columns (2) and (5) report changes in the intensive margin (trips and fares in census blocks that were active before the introduction of cash) and columns (3) and (6) changes in the extensive margin (trips and fares in census blocks that became active after the introduction of cash). Column (7) reports the results using the change in the total number of trips paid by card, column (8) reports the results using the percent change in total fares paid with cards as the dependent variable. Column (9) reports changes in prices calculated using the ratio of total fares to the total driving distance of each trip. ***, **, and *, represent statistical significance at 1%, 5%, and 10% levels.

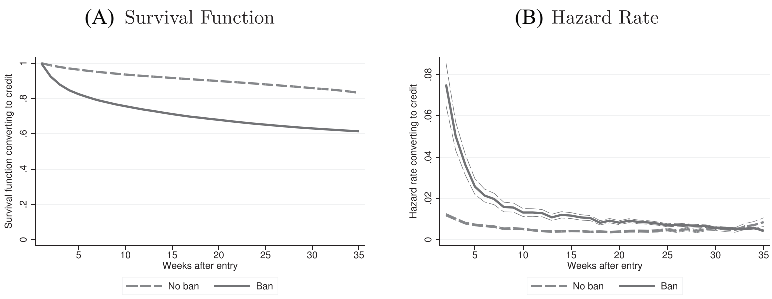

FIGURE IX

Puebla: Survival Function and Hazard Rate before and after the Ban

The graph shows the survival function and hazard rate of users using card payments for the first time. Panel A shows the survival function and Panel B the hazard rate. The data are taken from Puebla and considers users that first used the application in the week of March 6, 2016, when cash payments were introduced. The last cohort of users considered are those that entered in the week of the ban on cash, which took place on December 8, 2017. We consider 39 cohorts of users before the ban on cash and 39 cohorts after. The dashed lines in Panel B show 99% confidence intervals.

propensity of cash users to start using a card for Uber rides after the ban on cash payments, we estimate survival functions of different cohorts of users. We use data starting on the week of March 6, 2016, when cash was introduced. The last cohort of users we consider entered in the week of the ban on cash, which took place on December 8, 2017. We consider 39 cohorts of users before the ban on cash and 39 cohorts after.

Figure IX shows the survival function for pure-cash users and the hazard rate of pure-cash users taking a trip and paying with a card for the first time, as a function of the number of weeks since the user first joined Uber. Panel A shows the survival function and Panel B shows the hazard rate. The graphs show that new pure-cash users are more likely to adopt card payments but the hazard of card payment adoption remains mostly constant afterward. Moreover, the cohort of users that entered before the ban on cash payments are much more likely to adopt card payments, particularly in the first few weeks after they first use the application. Overall, we find that after 35 weeks, 22% of all pure-cash users ended up adopting credit, in excess of the percentage that would have normally done so. The majority of these users adopted card payments in the weeks immediately after the ban.

This trend suggests that these users already had a credit card available yet had chosen not to register it with Uber.

VI.D. Intensive Margin: Mixed Users

The decrease in the number of trips after the ban is accounted for by both pure-cash and mixed users. Almost half of Puebla's users paid both in cash and with a card before the ban. We show that even users who had adopted credit before the ban took fewer trips after the ban on cash was in place. The ban's effect on the number of trips is larger for those users who paid for more trips in cash before the ban.[37] We show this effect by estimating the following specification:

$$\Delta Y_j = \alpha + \sum_k \beta_k \text{ Share Cash Before}_{jk} + \lambda X_j + \epsilon_j, \tag{4}$$

where ΔY_j is the change in the average number of trips per week before and after the ban. The unit of observation j is a specific rider in the city of Puebla. Share Cash Before$_{jk}$ is an indicator that the share of cash fares before the ban for rider j are in the k bin, and X_j is a vector of observables that includes the cohort of the user (week the rider took her first trip in Uber) and the average weekly fares before the ban.

Figure X shows the estimates of β_k over 100 bins of the share of cash fares before the ban. The figure shows that the average weekly trips of mixed riders was significantly reduced 10 months after the ban. This reduction in the number of trips varies depending on how cash intensive the users were before the ban. Not surprisingly, the users that were more cash intensive before the ban decrease their trips more drastically. Online Appendix Figure D3 shows that if we consider the change in the average weekly trips 2 months after the ban, instead of 10 months after the ban, the decrease in demand for trips is more drastic, indicating that the medium-run elasticity of substitution between cash and credit is lower.

This result indicates that cash and credit are far from perfect substitutes. If they were perfect substitutes, the change in total trips should be unrelated to the cash share before the ban and should be represented by a horizontal line at zero. In other words,

37. The distribution of users over the share of cash fares is nearly uniform. We provide more details about the shape of this distribution in the next section.

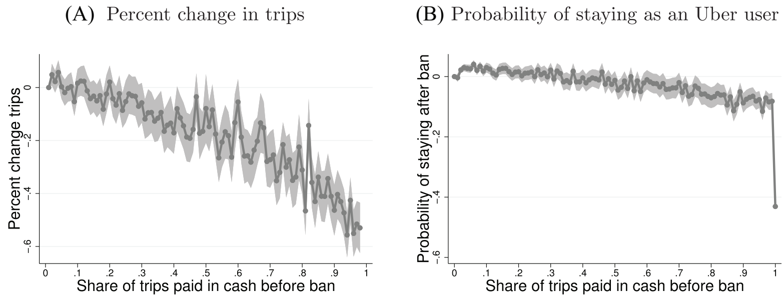

FIGURE X

Puebla: Intensive- and Extensive-Margin Adjustment to the Ban given Past Cash Intensity

Panel A shows the change in the average weekly trips of mixed users after the ban on cash as a function of the share of cash fares of different users before the ban. Mixed users are defined as those whose share of cash fares before the ban was between 1% and 99%. The panel plots the coefficient of β_k estimated using equation (4) for different shares of cash payments (indexed by k). Panel B shows the probability of staying as an Uber user after the ban on cash payments as a function of the share of cash fares of different users before the ban. The sample of users plotted in Panel B include pure-card users, pure-cash users, and mixed users. In both graphs the users considered are those that were active in 2017, the year before the ban on cash, and that had at least 10 trips that year.

there should be no monotonic pattern in the coefficients of β_k. If cash and credit were perfect complements, all mixed users should have left Uber at the time of the ban on cash. We interpret the relationship in Figure X as evidence of imperfect substitutability across means of payments.

To read an elasticity of substitution from the figure, we require more structure for the demand for rides.[38] For instance, assume that Uber rides paid with cash and Uber rides paid with credit are combined into a good called composite Uber rides denoted by X. In particular, suppose they are aggregated in a CES function where η is the elasticity of substitution and α is the share parameter for trips paid with cards. Last, composite Uber rides have a downward-sloping demand with a finite choke price. For instance, let the demand be equal to $X(P) = -k \log P + k \log \bar{P}$, where k is the constant semielasticity, $\bar{P}$ is the price at which the demand is zero, and $\epsilon = \frac{k}{X}$ is the elasticity of demand. From

38. We thank Gabriel Chodorow-Reich for suggesting an extension along this line.

the CES assumption, the price for composite rides is equal to $P(p_c, p_a; \eta) = [\alpha p_c^{1-\eta} + (1-\alpha) p_a^{1-\eta}]^{\frac{1}{1-\eta}}$, where p_c is the price of rides paid with cards and p_a is the price of rides paid with cash. We normalize the units of a trip so that before the ban, $p_a = p_c = P(p_a, p_c; \eta) = 1$. Note that when both means of payment are available, composite rides equal total rides. After the ban on cash, total rides are equal to total rides paid with cards. Thus, the percent change in total trips before and after the ban on cash can be written as:[39]

$$\%\Delta T = \alpha^{\frac{1}{1-\eta}} \left(1 - \frac{\epsilon}{1-\eta} \ln \alpha\right) - 1. \tag{5}$$

Note that equation (5) indicates that the change in demand is more drastic for cash-intensive users, those with lower α. Note also that for a finite elasticity of demand ϵ, if cash and credit are perfect substitutes (i.e., $\eta \to \infty$), there is no change in demand after a ban on cash.

We use the data from Puebla and the estimates of the demand elasticity for Uber rides in Alvarez and Argente (2020) ($\epsilon = 1.1$), to obtain an estimate of the elasticity of substitution η. Online Appendix Figure H1 compares the data to the predictions of the model for different values of η. The changes in trips after the ban on cash in Puebla imply an elasticity of substitution between 3 and 5 given that the long-run elasticity is higher than the medium-run elasticity of substitution.[40] In Online Appendix H.4.1 we apply equation (5) to the introduction of cash in Mexico City, where the cash share was measured postintroduction of cash to provide an independent estimate of η. There are several reasons to expect a different elasticity of substitution in these two cases. For instance, they could differ due to the irreversibility of fixed costs paid to register a card in the case of the ban on cash. Furthermore, the simple model we outline in this section allows for heterogeneity in the intensive margin (given by α), but not in the extensive margin. For this reason, to make the introduction of cash comparable to the ban on cash, we focus on a balanced sample of users, those

39. We provide more details of the model and the derivation of this equation in Online Appendix H. A more detailed discussion of the functional-form assumptions as well as estimates of the relevant elasticities obtained using experimental data can be found in Alvarez and Argente (2020).

40. Alvarez and Argente (2020) estimate a short-run elasticity of substitution of 3 using field experiments that lasted only one week.

active in the application before and after each of the events. We show that values of η close to 8 are consistent with both the ban and entry of cash.[41] The evidence shows in both cases that cash and credit are far from perfect substitutes even for mixed riders.

Panel B shows the results when we estimate equation (4) using an indicator variable that equals 1 if the rider used the application after the ban as an outcome variable. This specification allows us to estimate the propensity of users to use the application after the ban on cash payments. The graphs show that cash-intensive users were also less likely to return to Uber, even if they had enabled credit as a payment method before the ban.[42] Pure-cash users are the most affected, since they must adopt card payments to return to the application. The probability that these users return to Uber after the ban is 30%–35% lower than that for users who were almost as cash-intensive but had adopted card payments before the ban.

The evidence presented here shows imperfect substitutability at the extensive margin (Section VI.C) in that pure-cash users did not return to the application after the ban, and at the intensive margin (Section VI.D), in that mixed users took fewer trips after the ban. These results also suggest that when evaluating the effects of restrictions on the use of cash in terms of output and public welfare, researchers must consider a policy's effect on consumers who use a mixture of cash and card payments, instead of focusing exclusively on consumers who use only cash.

VI.E. Panama: Effect on Prices

Last, to complement our analysis of the effect of the availability of payment methods on the prices for Uber rides and close substitutes, we use data from Google Maps to study the changes in prices that took place before, during, and after the ban on cash that took place in Panama City between September 30, 2019, and February 6, 2020. During this period, we collected prices and ETAs from Uber along with those of public transport and other ride-hailing services for several origin addresses evenly distributed across Panama City.

41. We thank an anonymous referee for suggesting this extension.

42. Online Appendix Figure D4 shows the correlation between the probability of users returning to the application and several variables. Users in high-income municipalities and in municipalities with wider availability of banking services are more likely to remain in the application after the ban.

Figure XI, Panel A shows the patterns of prices for Uber and Cabify before and after the ban on cash payments after controlling for origin-address fixed effects. The prices for Uber or Cabify did not change around the implementation of the ban.[43] Panels C and E show that neither the ETA of ride-hailing companies nor the estimated time to location show differences before and after the ban on cash payments.

Figure XI, Panel B shows that the prices of ride-hailing companies remained constant when cash was reintroduced a few months later. This is also the case for the ETA of ride-hailing companies and for all estimated times to location.[44] Despite the large demand changes in the number of trips and fares observed when cash payments are introduced or banned, we do not observe changes in the prices of Uber or its close substitutes, whether or not those costs were pecuniary. These results imply a very elastic supply of trips and are consistent with little effects on producer surplus and on riders who pay for their trips exclusively with cards if restrictions on cash payments are implemented.

VII. Mixed Users: Portability and Welfare Implications

Here we argue that the mechanism explaining the presence of mixed users and their imperfect substitutability across payment methods is a portable feature across goods and countries. In particular, we discuss a theoretical mechanism that gives rise to the simultaneous use of cash and cards, review evidence consistent with this mechanism across several countries, and offer new direct evidence of the mechanism using rider-level data for Uber. Last, we use the elasticity of substitution η to estimate the welfare implications of a ban on cash on all goods for mixed users.

First, mixed users are ubiquitous. They can be found in both developed and developing countries. Table VIII, based on payment

43. Interestingly, in October 24, a student protest that blocked the main avenues in Panama City caused the prices of both Uber and Cabify to spike. The sudden increase in prices kept the ETA practically constant, as shown in Panel C. Panel E shows that the protest increased the estimated time to location of both ride-hailing companies and public transport.

44. On January 26, 2020, Uber drivers protested, demanding that the government further regulate the firm. Since the prices of Uber remained constant that day, the ETA for Uber rides increased on this day as shown in Panel D. There were no changes in the prices of Cabify or in the estimated time to location of ride-hailing companies or public transport on this day.

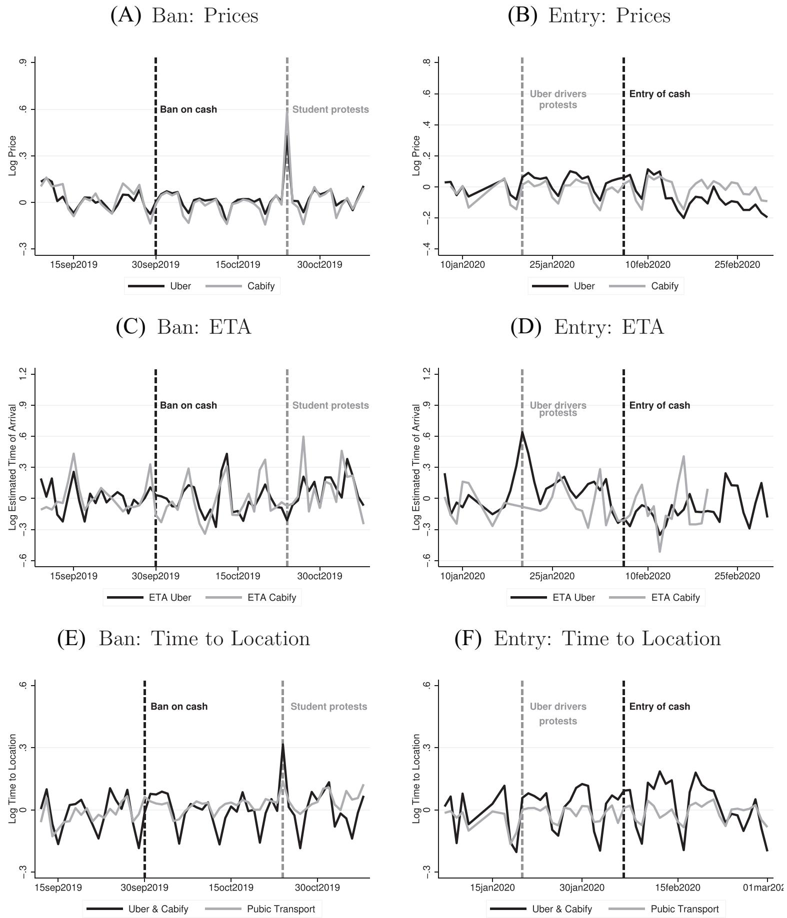

FIGURE XI

Ban on Cash Payments in Panama: Prices, ETA, and Time to Location

The figure shows the prices, ETA, and time to location of ride-hailing companies (Uber and Cabify) as well as public transport in Panama City before, during, and after the ban on cash payments for Uber rides. We specified 20 different origin addresses in the Google Maps application across Panama City (depicted in Online Appendix Figure F2) and Plaza de la Independencia, one of the main squares of the city, as the destination address. The data used in the figure are what is displayed by Google Maps in its public transit option. Panels A, C, and E show the prices, ETA, and time to location before and after the ban on cash. Panels B, D, and F show the same variables before and after the reentry of cash. The data cover from September 2019 to March 2020 and are displayed after controlling for origin-address fixed effects.

TABLE VIII
CONSUMER PAYMENTS BY COUNTRY

	AU (1)	AT (2)	CA (3)	FR (4)	DE (5)	NL (6)	US (7)	MX (8)
Share of payment by value with cards	0.68	0.35	0.77	0.85	0.47	0.66	0.77	0.10
Share of respondents with cards	0.95	0.86	0.99	0.92	0.94	1.00	0.88	0.45
Share of payment by value with cards, mixed (α)	0.72	0.41	0.78	0.92	0.50	0.66	0.88	0.22
Welfare costs, mixed ($\eta = 5$)	0.08	0.22	0.06	0.02	0.17	0.10	0.03	0.38
Welfare costs, mixed ($\eta = 8$)	0.05	0.13	0.04	0.01	0.10	0.06	0.02	0.22

Notes. The data in columns (1)–(6) and the first two rows come from payment diary surveys from seven countries harmonized by Bagnall et al. (2014). The seven diary surveys were conducted in 2009 (Canada), 2010 (Australia), 2011 (Austria, France, Germany, and the Netherlands), and 2012 (the United States). The data in column (6) and the first two rows are calculated by Alvarez et al. (2022) and come from the National Survey of Household Income and Expenditure (ENIGH), which was conducted August 21 to November 28, 2018. The information is based on a diary of daily expenditures collected along with the survey. Households are asked to report the payment method they use for each good and the total amount spent on each. The share of payment by value with cards is calculated as one minus the share of payment by value in cash. The share of payment by value with cards for mixed users (α) is calculated as the ratio of the share of payment by value with cards and the share of respondents with cards. Welfare costs are reported in log points.

diaries for seven developed countries, indicates that approximately 90% of people have access to cards and cash and actively use both payment methods. Because households using only cash are so rare in developed countries, the lessons that are more portable for developed countries are those that apply to mixed users.

Second, recent evidence shows that cash inventory management is relevant for payment instrument choice and, thus, to determine the degree of substitutability across payment methods. There are several models that have a nontrivial cash-management problem and payment instrument choices (e.g., Barro 1970; Prescott 1987; Stokey and Lucas 1989). We concentrate on a particular class of these models where micro data can help us identify the mechanism behind the presence of mixed users. In these models, the preferred payment instrument depends on the stock of cash holdings at the time of the purchase. Households behave as if "cash burns" in their hands: everything else the same, for the same good, households pay with cash if they have it available and otherwise use other methods. The subtlety of these models is to construct a coherent set-up where cash burns in the households' hands and yet households use it repeatedly. Going over the details of such models is beyond the scope of this article, but some of the ideas can be found in Deviatov and Wallace (2014), and a paper fully dedicated to this idea is Alvarez and Lippi (2017).

Recent empirical work has found support for the idea that “cash burns,” that is, it has shown that other payment instruments are more likely to be used when agents are short of cash. This is documented for several developed countries using data from payment diaries in Arango, Huynh, and Sabetti (2011), Bouhdaoui and Bounie (2012), Eschelbach and Schmidt (2013), and Bagnall et al. (2014). In particular, Briglevics and Schuh (2020) show, using the Diary of Consumer Payment Choice, that in the United States the probability of cash use for mixed users is roughly constant (around 50%) when consumers have sufficient cash in their wallets.

Furthermore, Wang and Wolman (2016) use data from a discount retailer with multiple stores across the United States to show that the share of transactions paid with cash declines steadily, from the first day until the fifteenth day of the month. They interpret this pattern as consistent with households having more cash at the beginning of the month, due to a pay-day effect. While their data do not contain information of whether a household has access to payment methods other than cash, this behavior is consistent with cash burns. In fact, we use our rider-level data to show a similar pattern for mixed users. To show that this mechanism is also present in Uber, we explore whether mixed users are more likely to use cash whenever they have it available. We take advantage of the facts that (i) in Mexico the majority of workers get paid every other week on Friday (this day is known in Mexico as Viernes de Quincena) and (ii) approximately 35% of mixed users get paid in cash, according to the ENIF. We then estimate the following specification:

$$\begin{aligned} Cash_{it\tau} &= \alpha + \sum_{k=2}^{7} \gamma_k DOW_k + \sum_{k=1}^{7} \beta_k DOW_k \times Quincena_s \\ &\quad + \zeta X_{i\tau} + \lambda_i + \theta_\tau + \epsilon_{it\tau}, \end{aligned} \tag{6}$$

where i denotes a mixed rider, t a trip, and τ is the day of the trip. $Cash_{it\tau}$ is an indicator if the trip taken was paid in cash. DOW_k are day of the week fixed effects, $Quincena_s$ is an indicator that equals 1 if the day of the week falls in a quincena (week when workers get paid), $X_{i\tau}$ is a control for the fares paid for the trip, λ_i are individual fixed effects, which control for unobserved

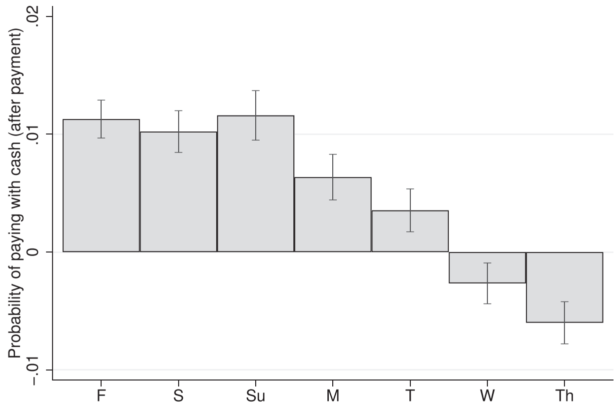

FIGURE XII

Probability of Using Cash during Payment Days (Quincena)

The graph shows the probability of paying with cash for an Uber ride in the days after getting paid. Payments usually take place every other week on Fridays. The figures plot the coefficients of β_k after estimating equation (6). The lines depict the 95% confidence interval computed after clustering the standard errors at the rider level.

heterogeneity across riders, and θ_τ are time effects. The specification is a linear probability model. In essence, we compare the fraction of trips paid in cash in the same day across two weeks: the week immediately after workers get paid and the following week. This effect is measured in the interaction coefficient β_k.

Figure XII plots the coefficients of the interaction of days of the week and quincena, β_k. The figure shows that the probability mixed users pay for their rides with cash is higher the days after they get paid and slowly declines over the course of the week. Consistent with the evidence of micro studies of other countries, mixed users behave as if "cash burns" in their hands. This is, mixed users are more likely to pay with cash if they have it available. The fact that the behavior of mixed users in Mexico is similar to the one found in developed countries leads us to believe that the elasticity of substitution that we estimate can be informative for developed countries as well.

Last, we use a stylized model to estimate the consumer surplus lost for mixed users in the event of a complete ban on cash across all goods. To do so, we assume the same CES aggregator used in Section VI.D for all expenditures, not just Uber rides. Recall that we chose units such that the baseline level of welfare is

$P(1, 1; \eta) = 1$. In this case, we assume that either all goods have the same card share or that the substitution elasticity across varieties equals the substitution elasticity across means of payments. Since the welfare costs are decreasing in the elasticity of substitution across goods, and we expect this parameter to be lower than the elasticity of substitution across payment methods, this specification gives a lower bound for the cost. Under these assumptions, the private welfare cost of a ban on cash (expressed in log points) can be written as:

(7)

$$-\log W(\infty; \eta) = \log P(1, \infty; \eta) \equiv \lim_{p_a \to \infty} \log P(1, p_a; \eta) = -\frac{1}{\eta - 1} \log \alpha.$$

Note that in this specification, we do not need to estimate an elasticity of demand to calculate the welfare implications of a ban on cash, as in the case of Uber rides. Rather, all that is required is the card share, α, which can be obtained from micro data, and the elasticity of substitution across payment methods, η.[45] The welfare costs are decreasing in both of these parameters; α summarizes the prevalence of payment methods other than cash in a country, and η controls how easily households can substitute across payment methods if the relative prices change.

To estimate the welfare costs of a ban on cash, we approximate the share of payment by value with cards for mixed users, α, taking the ratio of the share of payment by value with cards and the share of respondents with cards. Both values, which are presented in Table VIII, were obtained from payment diaries or consumer expenditure surveys for seven developed countries and Mexico. Given the portability of η, we use the same long-run elasticity of substitution ($\eta = 5$) for all countries. Then we use equation (7) to calculate the welfare costs of a ban on cash. The last two rows of Table VIII report our results. They show substantial heterogeneity across countries. For the United States, we estimate a consumer surplus loss of about 3% of GDP. If we use a higher elasticity of

45. This specification also gives a lower bound of the cost in the presence of pure-cash and mixed users. Alvarez et al. (2022) show that if pure-cash households face the minimum fixed cost that will make them indifferent between using both means of payments or just cash at baseline prices, for any increase in the price of cash goods, they will choose to pay the cost. Then, assuming that the share of card purchases is the same for mixed and pure-cash users substantially reduces the cost of a ban on cash and yields the same expression as equation (7).

substitution ($\eta = 8$), the loss is approximately 2% of GDP. For Mexico, a country where almost 90% of payments are conducted using cash, estimated losses are an order of magnitude higher.

VIII. Conclusion

We use three quasi-natural experiments in Mexico and one in Panama to estimate how the availability of cash payments affects the consumption of Uber rides. We find that cash is used heavily when it is available as a payment option and changes in its availability lead to large changes in measures of the quantity of Uber rides taken, mainly among low-income households. Although many users without access to a card joined the application after the introduction of cash, mixed users account for a significant share of the increases in the number of trips and fares collected. We do not find that the availability of cash as a payment option has a statistically significant effect on prices. This finding about prices imply that prohibitions on cash payments have little effect on riders who pay for their trips exclusively with cards. Our evidence suggests that Uber customers do not treat cash and cards as perfect substitutes. At the extensive margin, only about a third of pure-cash users returned to the application after the ban. At the intensive margin, users that paid for more trips with cash before the ban took fewer Uber trips after the ban, despite having access to card payments.

Our results can serve as a stepping stone toward accurate measurements of the wider implications of policies that try to discourage the use of cash. The present findings imply that studies seeking to evaluate the effect of such policies must distinguish between effects on those that use both payment methods and effects on those that do not own any payment cards, particularly given the low degree of substitutability between cash and card payments. We believe that the elasticity of substitution across payment methods is a portable parameter.

Consumer surplus evaluation that incorporates mixed users and pure-cash users for which intensive and extensive margins are important requires more information than was gathered in the quasi-natural experiments we use herein. In a separate project, we use field experiments to generate this variation and develop a structural model more suitable for the evaluation of the different margins.

Our study is limited by our inability to measure the costs of using cash, like potential effects on crime and encouraging informal transactions, given the data we used.[46] Accurate measurement of these costs is also relevant to the analysis of policies that restrict the use of cash. In Alvarez et al. (2022), we aim to quantify the social benefits of a ban on cash due to reductions on crime and tax evasion.

University of Chicago, United States
Pennsylvania State University, United States

Supplementary Material

An Online Appendix for this article can be found at *The Quarterly Journal of Economics* online.

Data Availability

Code replicating the tables and figures in this article can be found in Alvarez and Argente (2022) in the Harvard Dataverse, https://doi.org/10.7910/DVN/TSRQOE.

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46. Unfortunately, we do not have access to data of crimes committed by riders or drivers and cannot quantify the social benefits of such policy. We do not find evidence that the introduction of cash by Uber affected city-level crime statistics. These results can be found in Online Appendix I.1.

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