Computers and Discretion: Evidence from Two Randomized Natural Experiments

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Abstract

Whereas the use of computers can increase productivity, it may also promote greater equality. We exploit two natural field experiments related to the renewal of national identification cards in Bolivia and show that applicants randomly assigned to a computer renewal process not only are more likely to successfully complete it, but they do it faster than when assigned to a manual process. We also show that the introduction of digital technologies substantially removed heterogeneity in the delivery of the public service, especially for individuals of less favored characteristics. Information technologies may help curb petty corruption by reducing discretion.

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1. Introduction

Many studies on the role of computers have focused on their potential to help increase productivity and growth. This is unsurprising given the type of efficiencies that they can bring to administrative processes and especially in the public sector, which tends to be highly bureaucratic[1]. Accessing, matching, verifying and keeping vital records among a host of other administrative processes in the public sector may be dramatically improved with the use of computers (World Bank, 2011). Furthermore, given the relatively low cost of adopting computer technologies, their potential positive returns may be particularly large for developing countries.

Interestingly, computer technologies also have some additional features that tend to be somewhat overlooked. In particular, they may help limit discretion from authorities and by doing so they may help promote transparency by facilitating interactions that are faceless, anonymous, and virtual, which when used properly may help promote greater equality. In this paper we take explicit consideration of these characteristics in the context of a modernization effort in the public sector of a developing country, Bolivia. We focus on a common, but crucial administrative document required in many countries, the national identification cards for adults. Typically, these cards must be shown to authorities in order to pursue the most common of endeavors, such as opening bank accounts, registering at schools, applying for social services, purchasing mobile phones, registering to vote, logging onto websites, and many others. Identification cards are essential documents in order to fully participate in the society[2]. Frequent times, the card issuing entity, typically a law-enforcement government agency, has monopoly power on the issuing and renewal of identity cards.

We take advantage of two randomized natural experiments within the national identification card renewal process in Bolivia, which is mandatory and is administrated by the National Police. The first natural experiment arises from the random assignment of both issuing police officers and applicants to a manual or digital identification card renewal process, which is identical in all aspects except that the latter makes use of computer technologies and reduces discretion by police officers. The second experiment arises from the potential occurrence of technical failures during the digital renewal process, which forces police officers to randomly change from a digital to a manual process during the day. While in the first case the causal effect is identified by comparing applicant-police officer pairs randomly assigned to each of these two renewal processes when controlling for day-of-renewal fixed effects, in the second case we apply a difference-in-difference strategy and compare applicant-police officer pairs that at the end of the day changed to a manual process due to a digital technical failure with respect to applicant-police officer pairs that stayed in a digital process throughout the day. The quality of public service is measured in

[1] While difficult to measure (Bresnahan and Gordon, 1997; Griliches, 1998) most of the current literature has looked at aggregate or firm-level data. Examples are Schreyer (2000); Colecchia and Schreyer (2001); Stiroh, (2001), Draca, et.al. (2006).
[2] In several countries, not carrying a national identification card at all times is even penalized with jail time. For a list of the specific countries that require compulsory national identification cards please see Privacy International (www.privacyinternational.org).

terms of success rates at completing the renewal process and time completion, conditional on being successful.

We find that applicants that are randomly assigned to a digital renewal process are, on average, 23 percentage points more likely to complete the renewal process as compared to those randomly assigned to the manual process. These results are similar for both natural experiments. More importantly, our findings are consistent with the existence of selective enforcement of rules as well as disparities in service quality by police officers based on the characteristics of the applicants as we find evidence that characteristics of applicants are significant predictors of completion success of the renewal process. It appears that applicants from rural areas, indigenous groups, lower levels of education, and lower socioeconomic status have relatively lower success rates. In order to provide further evidence regarding the use of discretion of police officers, we carried out a survey instrument in order to detect its existence and extent, if any. While merely exploratory, these survey findings are consistent with our conjecture that there exists differential service to certain groups of individuals that police officers deem easier to take advantage of, with the likely aim of extracting bribes. This explanation does not necessarily rule out other mechanisms in place.

We contribute to the literature by providing evidence that shows that computers may serve as effective tools to reduce discretion and promote equitable public service delivery. In addition, this research speaks to a broad literature exploring the benefits and risks of automation and information and communication technologies (ICT) by considering a context where digital technologies may foster productivity and also promote greater equality rather than generating more inequality. Consider Autor et al. (2003) who find that computers substitute workers in performing certain cognitive and manual tasks that can be easily performed by following explicit rules, but it complements workers in carrying out nonroutine problem-solving and communications tasks. Depending on the distribution of tasks, digital technologies are usually thought as inequality-increasing by affecting labor market conditions directly. In this research, the renewal of identification card entails certain communication tasks between police officers and applicants. In this sense, computers act as a complementary technology enhancing productivity of police officers. In our context, however, computers not only increase productivity as argued by Autor et al. (2003) but also promotes greater equality as police officers' communication tasks may be linked to discretionary power and computers implicitly allow for faceless meetings and add an accountability mechanism into the renewal process, limiting police officers' actions.

The introduction of digital technologies may not only increase efficiency through their complementarity with labor but may also promote equality as they may decrease discretion. Still, Busch, et al., (2018) argue that it may be true that decreasing discretion may also reduce efficiency in the delivery of a public good as discretion may be necessary to accomplish tasks of greater complexity. In this context, Autor and Scarborough, (2008) and Behaghel et al. (2015) show how changes in screening technologies may affect differences in hiring outcomes across majority and minority groups in the context of firm hiring depending on how they reduce information asymmetry. Computers may increase the informational signal for the disadvantaged group relative to the majority group. Moreover, if computers increase overall information available to risk-averse officers, then the average success rate of both groups may also increase. Our research directly relates to these issues and we believe that are of particular relevance, as the renewal of identification cards is an important public service and inequalities in their provision may disproportionally hinder certain groups.

Our research also contributes to the literature related to automating processes in the public sector, a topic that to the best of our knowledge has not been explored in economics. In the literature of public administration Wenger and Wilkins (2009) discuss the introduction of telephone claims in unemployment insurance and argue that the automation provided by the telephone claim filling restrains discretion of street-level bureaucrats and eliminates the bias that women face when entering an unemployment insurance office. As Buffat (2015) claims, ICTs may both increase and decrease discretion exerted by street-level bureaucrats, which depends on different features such as culture, type of tasks, and work organization. When matters are simple to solve, virtual interaction may be enough, whereas when matters require more elaborated discussions, virtual interaction may be perceived as irrelevant[3]. Moreover, Schuppan (2009) argues that transferring ICTs from developed countries to developing ones without additional efforts may cause unintended effects as different initial institutional, cultural and administrative contexts must also be considered. Our research contributes to this literature by providing cleanly identified estimates of the effect of digital technologies and their equality-enhancing impacts in the context of a developing country.

The rest of the paper is organized as follows. Section 2 describes the two natural experiments used in our research. Section 3 describes the data. Section 4 presents the empirical framework. Section 5 presents our findings. Section 6 presents the possible role of corruption. Section 7 summarizes and concludes.

2. Institutional Background

2.1. The national card renewal process

As described above, obtaining a national identification card is, perhaps, the single most important government-related administrative procedure that adults must pursue in order to function in everyday life. As in many countries, this involves complicated and bureaucratic steps. At the time of our research, the national identification card renewal process in our location of interest, La Paz, the capital city of Bolivia, was administered by the Police, and handled around 1200 requests per day.[4] In order to renew a national identification card, an individual had to bring proof of identity and pay an application fee of US 2.50 dollars in local currency. Upon presentation of a valid proof of identity, the applicant receives a token with a table number and gets her thumb

[3] A review of ICTs and street-level discretion is found in Busch and Henriksen (2018) and Bovens and Zouridis (2002).

[4] The organic law of the Bolivian Police of 1985 stipulates that the Police are the entity in charge of the provision of national identification cards to citizens (Article 27). Also, the population of La Paz was about 900,000 inhabitants in 2009 (UDAPE, 2009). At the time of our study (last quarter of 2009) there was also another administrative office located in the southern part of the city, but it only handled about five percent of the national identification cards requests.

marked with indelible ink[5]. In this location, there were 41 renewal tables at the time of this study, with one police officer permanently assigned to each. As soon as an applicant got assigned to a renewal table, the individual had to find the table number and then hand over her proof of identity along with the corresponding token to the police officer working in that renewal table. With this information, the police officer at the table went to the Vital Records Archive maintained by the Police at the basement of the building to locate the vital records of the applicant. The archive was accessible to police officers, only. Once the vital records of the applicant were physically retrieved, the applicant was called out in order to follow these additional steps: (i) pay a renewal fee in a separate collection office; (ii) have a photograph taken[6]; (iii) get fingerprinted and, if needed, (iv) update marital status, occupation, and address. Upon completion of all these steps, the identification card renewal process was considered complete and the filled-out card was sent to a different office for lamination. The individual could pick up the new identification card within 24 hours at the same location.

Applicants failed to renew their identification card for several reasons. The renewal process had been traditionally associated with red tape and lengthy delays.[7] Furthermore, vital records were frequently reported as missing because of the poor archiving system, which was based on the last name of the applicant only.[8] Furthermore, anecdotal evidence had long claimed a systematic pattern in reported records lost.[9] Since we focus on renewals only, any quality differential in paperwork did not appear to be a likely explanation for any observed variation in outcomes. By definition, individuals that applied for renewals had also applied and succeeded five years prior (the renewal timeframe) to the current application. Thus, the administrative office must have had all the corresponding paperwork required.[10] Also, in an environment with homogeneity in paperwork's quality, systemic correlation between observable characteristics of applicants and renewal outcomes is consistent with government officials trying to seize on the opportunities given by the discretion that the administrative process allows them. After all, given the highly asymmetric power position between applicant and government officials, the latter might have been able to complicate the process to create incentives for applicants to pay bribes in order to complete the process, such as

[5] The acceptable documents for identity proof are (i) expired national identification card; (ii) birth certificate; (iii) current (i.e. not expired) driving license, (iv) military identification card, (v) passport, (vi) university identification card; or (vii) electoral list fraud prevention card.

[6] Photographs were also taken in a different building and the corresponding pick-up at yet another one.

[7] In June 2011, a new law was passed by the Bolivian government transferring the responsibility of issuing identification cards to a new independent public agency, after many decades under the jurisdiction of the Police. This was done, in part, due to the inefficiency of the system, reflected in the overall high rejection rate (Please, see Table 1).

[8] Vital Records Archives held more than one million physical records in a small physical location.

[9] It was commonly believed that names of applicants were often called on a discretionary manner rather than following the first-come first-served established procedure (World Bank, 2000; Wanderley, 2007)

[10] If selection bias based on paperwork quality were to be an issue, one would observe that given that rural applicants face higher time and money costs as they have to pay for transportation and accommodation costs, they would have higher quality paperwork conditional on getting to the renewal process. This, however, is not consistent with our findings, as we will see below.

arbitrarily increasing wait times, claim loss of documents, increase the number of additional steps required to process paperwork, and many others. Using a qualitative approach Wanderley (2007) shows that the applicants at higher risk of being targeted were those who faced higher transaction costs, for example, those that came from places that were far away and thus needed to consider transportation and accommodation expenses and were from relatively disadvantaged backgrounds. This implies that they were less demanding and less likely to voice complaints. In addition, in Latin America it is very common to observe differential treatment based on specific characteristics. This suggests that a biased enforcement of rules might have been practiced among government officials. For instance, in Peru, it has been documented that 88 percent of individuals of a representative sample at the national level report having experienced at least one situation of discrimination. In Mexico, a nationally representative survey shows that nine out of every 10 individuals think discrimination exists in their country. In Ecuador, 62 percent of individuals agree that there is racial discrimination in their country, but only 10 percent of them admit to being openly racist (Chong and Ñopo, 2013). In Bolivia, according to a nationally representative survey, 80 percent of the population say that the clothing one wears influences how one is treated by police officers (Wanderley, 2007). Finally, the characteristics of government officials might have also mattered, including skills and experience.

Applicants who found that the bureaucratic delay was overwhelming might have decided to drop out at some point in the middle of the renewal process. One should note that the renewal processes could not be put on hold—if not completed by the end of the day, the applicant needed to start all over again. In our case, because of the nature of the data collection, dropouts were implicitly classified as unsuccessful in our sample. Yet, it is highly unlikely that these represented a large proportion of unsuccessful applicants. Applicants that decided to drop out without completing the process faced transportation expenses and substantial time costs. Because of the indelible ink used to mark thumbs, the applicants were not able to start a new renewal process right away but had to wait until the ink faded away. In addition, the number of dropouts was negligible, as confirmed by a subsequent survey instrument applied –please, see Section 6. It might have been the case that bureaucratic procedures affected applicants differently based on their intrinsic observable characteristics. As mentioned above, the process of renewing a national identification card in Bolivia was known to be chaotic and full of bureaucratic procedures and might have intimidated those from disadvantaged backgrounds and illiterate applicants might have found it harder to navigate. Endogenous red tape might have introduced an inequality dimension into the administrative process by requiring some skills from applicants, which might have translated into differential renewal outcomes based on characteristics. In this context, computer technologies might have acted as a brake to curb discretion, including petty corruption by reducing or even eliminating the possibility that government officials stall or introduce barriers. Furthermore, by allowing applicants to perform all the renewal steps within one physical location, computer technologies might have significantly facilitated the process and, thus, helped reduce gaps in renewal outcomes.

2.2. Two Natural Experiments

In 2006, the national police began a massive effort to digitize vital records of citizens across the country. This effort was aimed both at improving the efficiency in the provision of national identification cards to citizens and curbing electoral fraud. By the time our fieldwork took place, during the third quarter of 2009, vital records of all citizens in the city of La Paz had been digitized, and put into an electronic dataset, which called for a transformation of the renewal process. As such, the administrative office in charge of issuing national identification cards introduced a simplified digital process to police officers, which consisted in (i) accessing the vital records of the applicants online using a computer, (ii) filling the applicants' information online, (iii) getting the photograph taken using a digital camera connected to that computer, and (iv) printing the national identification card in an adjacent printer. Thus, unlike in the manual process, all of the renewal steps could be performed at the renewal table, except for the payment of the application fee.

As a result of budget constraints, and for a short period of time, the administrative office in charge of renewals employed both the manual and digital renewal processes in parallel. In order to avoid complaints about which process to get assigned to, the Police decided to randomly assign police officers and applicants to each of these two renewal processes. To do so, they used two different strategies. On the one hand, police officers were assigned to a renewal table using a lottery before the digital process was introduced. Each renewal table could follow a digital or manual process. At the time of this study, there were a total of 41 renewal tables in this Identification Unit, out of which 23 were digital. The lottery conducted by the Police was conducted in front of all public officials working in the Identification Renewal Unit and established the type of process assigned to each police officer during all time these two renewal processes coexisted in the Identification Unit. In practice, this was equivalent to being assigned to a desk with a pre-established type of renewal process. In addition, before the data collection for this study started, we compiled information on the baseline characteristics of police officers.

On the other hand, applicants were randomly assigned to a renewal table using a sequential rule that was very easy to implement in practice. Upon presentation of the valid document as proof of identity, each applicant was handed over a token with a table number from 1 to 41, which corresponded to the renewal table. The numerical organization of the tables was generated based on the availability of electric plugs to connect computers in the Identification Unit and did not correspond to any specific pre-established pattern. This meant one could have two manual tables next to each other, then a digital one, and then another manual one. Or one could have, for instance, three or four digital tables next to each other. Still, in order to avoid applicants to strategically change their assigned tables, their thumbs were marked with indelible ink after receiving a token with a renewal table. This simple device was strictly enforced by the Police and prevented applicants from starting a new renewal process within the same day. It is important to mention also that the line to get to the table where applicants could get a token to a randomization table took place completely outside the building and took applicants around 60-90 minutes and so they faced large opportunity costs if deciding to drop after starting the process. Indeed, the applicants' randomization table was located just right at the main entrance door so no applicant could access the building before getting a token assigned. Moreover, the Police never announced officially the coexistence of these two renewal processes to avoid complaints and most of the population was not aware of the possibility of being assigned to different renewal processes. In addition, even after being assigned to a renewal table, it was not evident that there were two different systems in place, as the Identification Unit was long known for being overcrowded, disorganized, and difficult to navigate.

Another unique feature of this study is the occurrence of so-called technical failures during the process, which affected tables that follow a digital process only. Technical failures refer to lack of printer consumables or temporarily out-of-order computers and may occur rather frequently. In fact, more than 20 percent of applicants assigned to a digital table, ended carrying out that process manually due to a technical failure during the four weeks of the data collection process. Given the administrative procedures followed by the Police, technical failures could not be addressed the same day of the occurrence of the event. For instance, if a computer or digital camera broke down it would be down for the rest of the day and the renewal table would switch to a manual renewal process. Similarly, if a printer ran out of toner, it would only be replaced at the end of the day. Thus, the data on technical failures is only available on a daily basis and it is not possible from our data to know how many people who passed through a digital table on a specific day were affected by a technical failure. We take advantage of this second natural experiment occurring within the administrative process since, in order to avoid delays and overcrowding of applicants, the Police established that digital tables should immediately switch to the old traditional manual process if a technical failure arose on a particular day.

While it may be argued that technical failures may not be random, consider that police officers assigned to a digital table faced high costs of switching to a manual process. They had to file a detailed report, which significantly delayed the time they could go home after ending a workday. Given the sequential rule used to allocate applicants across renewal tables, all police officers ended up serving a similar number of applicants by the end of the day. After the doors were closed to the public, officers still had to finish with all applicants already assigned, which required them to stay late if faced delays during the day. Moreover, the technician would have to report back on the issue resolved at the desk, so that it was not that easy for the officer to trick the system and in addition supervisors would perform random spot checks on their work.

3. Data

We collected data at the applicant level, at the table level (or equivalently, at the police officer level), and at the applicant-table level. The primary data at the applicant-table level were collected using a simple software platform specifically designed for this study[11]. These include whether the process of renewal was successful or not,

[11] The software platform was installed in three computers located next to the randomization table and at two computers located

starting and completion renewal times and table number. Characteristics at the applicant level include basic socioeconomic and demographic characteristics, such as gender, age, rural precedence, education, type of school, indigenous language spoken, and neighborhood of residence. In addition, we also have specific information on women's indigenous attire, which can be easily collected by direct observation, as they typically wear their hair in two long braids decorated with tassels, and dress in very distinctive skirts over puffy petticoats[12].

The administrative data at the table level include socioeconomic characteristics of police officers assigned to tables, information related to technical failures at renewal tables, and renewal table number. The socioeconomic characteristics of police officers were collected from administrative records provided by the central administrative office and include sex, age, rank, years of education, tenure at the main office, and tenure at the renewal table. The information on technical failures among the digital tables also comes from administrative records and it is collected on a daily basis. The subpopulation of analysis in this study is all individuals who officially applied for a national identification card renewal during the data collection time period and is representative of those individuals who decide to apply for a national identification card renewal. Our sample excludes applicants younger than 21 years of age. The data were collected between October and December of 2009.

Table 1 presents summary statistics. Panel A presents variables at the applicant-table level. 43 percent of applicants were matched to the digital process. Of those, 20.39 percent were matched to a table originally assigned to the digital process but due to technical failures ended as a manual process. In average, around 70 percent of applicants succeeded in the renewal process. Those that succeeded took 111 minutes in doing so. Panel B and D report the basic characteristics of both applicants and police officers, which are measured at the randomization table. The average age of the applicants is forty-one years old, with roughly 49 percent being women. In addition, about 58 percent completed high school, 16 percent are from rural areas, 14 percent attended a private school, 56 percent speak an indigenous language, and 31 percent of women wear indigenous attire.[13] Similarly, with respect to police officers, the average tenure at renewal table is one year, the average tenure at the administrative office is about three years, and the average age is 36 years old. In addition, about 53 percent are of low rank, and only 24 percent are women. Finally, Panel C summarizes technical failures measured at the renewal table level. Each of the eighteen digital tables suffered a technical failure 4.44 times. Some tables failed just once, while others could fail as much as

at the exit door and were operated by police officers from the administrative office. The head police officer instructed and monitored specific police officers to input the data required by the software platform. The latter were unrelated to the renewal process and had no knowledge on the objectives of our study and as such, had no interest or incentive in inputting potentially misleading data. Figure 1 shows a screenshot of the software interface used for the data collection.

[12] Most of the information was retrieved from the expired identification card. Data on indigenous language and private school status were self-reported.

[13] Census data for the city of La Paz reports the following average characteristics for the population: 51 percent women, 44 percent completed high school (average years of education is 9.4), 22 years old, 38 percent live in the rural areas, and 68 percent are indigenous.

8 times. Most of these failures were fixed at the end of the day as in average the number of contiguous days a computer was inoperative was 1.23. During the 28 days that the evaluation lasted, in average, each computer was inoperative a total of 5.44 days.

4. Identification Strategies

4.1. The randomization processes

As pointed above, people were randomly allocated to one of the 41 renewal tables, which were *ex ante* assigned to hold either the digital process or the manual process throughout the whole period of evaluation. We define this assignment as Z_{ij}. Notice that Z_{ij} takes the value of one if individual *i* is *ex ante* matched to a digital renewal table held by police officer *j*, and zero otherwise.[14] This randomization effectively produces two comparable groups. Columns 1, 2 and 3 in Table 2 show that the average of most observable variables are not statistically different across groups. This is true for the overall sample (Panel A), for the sample of males (Panel B) and for the sample of females (Panel C). There are some differences in the share of rural applicants for the overall sample and the sample of men, and in the share of applicants with complete high-school for the sample of females, albeit the differences tend to be small. This is reflected in the joint-test of significance.[15]

Due to technical failures, not all tables that were *ex-ante* assigned to hold a digital process in fact held one every day, as the Police established that digital tables suffering a technical failure should immediately switch to the old manual process until at least the end of the day. We call this failure variable as F_{ijt}. F_{ijt} takes the value of one at day *t* if individual *i* was assigned to a digital table held by police officer *j* (i.e. $Z_{ij} = 1$) but due a technical failure ended carrying out the renewal of her identification card using the manual process with the same police officer in the same table. It takes the value of zero otherwise.[16] We are interested in exploiting the variation in the treatment assignment within the same table (or police officer) to control for unobserved variables at the table level. To do so, technical failures need to occur independently of the applicants' characteristics. Columns 4, 5 and 6 of Table 2 show that this appears to be the case as, conditional on being *ex-ante* assigned to a digital table, applicants' characteristics are balanced across those that suffered a technical failure and those who did not for the overall sample, the sample of males and the sample of females. Performing a joint test on whether any of the variables is statistically different between the two groups gives the same result.[17]

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[14] This variable Z_{ij} corresponds to the variable reported in the first row of Panel A in Table 1: "Assigned to digital table (%)".

[15] Moreover, in columns 1 to 3 of Appendix 1, we show difference in means of police officers' characteristics across *ex-ante* digital and manual tables. P-values were calculated empirically using a randomization inference procedure. Differences are not statistically significant at conventional levels.

[16] F_{ijt} conditional on $Z_{ij} = 1$ would correspond to the variable reported in the second row of Panel A in Table 1: "Technical failures rate conditional on assignment to digital table (%)".

[17] In columns 4-6 in Appendix 1 we show differences in means between tables that were initially assigned to digital and ended using digital and those that ended using manual due to technical problems. Again, p-values were calculated using a randomization inference procedure. Differences are not statistically significant at conventional levels.

Using the *ex-ante* assignment variable, Z_{ij}, and the variable for technical failures, F_{ijt}, we define an *ex-post* assignment variable which we call $digital_{ijt}$. It indicates whether the applicant *i* in fact ended in a digital table held by police officer *j* at day *t*. In other words, $digital_{ijt}$ = Z_{ij} *x (1-*F_{ijt}*)*. We argue that both Z_{ij} and F_{ijt} are independent of applicants' and police officers' characteristics, hence $digital_{ijt}$ should also be independent. Columns 7 to 9 of Table 2 again show that this may be true in general, although as in the previous case there seems to be some small differences in the share of applicants with complete high-school education and in the share of rural applicants. This is also reflected in the joint test of significance. However, these differences are driven by heterogeneity in fixed table (or police) characteristics. Once we condition on table fixed effects, these differences disappear, and the joint test gives a p-value of 0.8726 for the overall sample, 0.4539 for the sample of males, and 0.2217 for the sample of females.[18]

4.2. Average effects

In order to identify the causal effect of computer processes over manual ones we exploit two sources of variation stemming from the random processes described above. First, we compare the success rate (or time) of the renewal process among those applicants that were *ex-post* assigned to digital tables against those that were *ex-post* assigned to manual tables. We can carry out this comparison as $digital_{ijt}$ is akin to a random and independent process. To estimate the causal effect of computer technologies we estimate the following regression for applicant *i* assigned to the renewal table of police officer *j* on day t:

$$y_{ijt} = \alpha + \beta digital_{ijt} + \pi X_{ij} + \omega_t + \varepsilon_{ijt} \qquad (1)$$

where the dependent variable *y* is measured in two ways, either as (i) an indicator of whether the renewal process was successfully completed; or (ii) the log of the time it takes to complete the renewal process conditional on successfully completing it; X is a vector of individual and table (or equivalently, police) characteristics*;* ω is a vector of renewal day fixed effects; and ε is a normally distributed error term independently and identically distributed over *i* and *t*, and clustered at the table level.[19] Second, we exploit the variation stemming from technical failures. The idea is to compare changes in the success rate between applicants assigned *ex-post* to digital tables with applicants that ended in manual tables due to technical failures *before and after* a technical failure. In other words, we use a differences-in-differences framework and estimate:

$$y_{ijt} = \gamma digital_{ijt} + \pi X_{ij} + \omega_t + \theta_j + \varepsilon_{ijt} \qquad (2)$$

where θ is a vector of table fixed effects (which in our context is equivalent to including police officer fixed effects).

There are some differences between specification (2) and specification (1) that are worth mentioning. First,

[18] In columns 7-9 of Appendix 1 we show the difference in means between tables that were initially assigned to digital and ended up using the digital process and those that ended using manual, without conditioning on *ex-ante* assignment. Again, p-values were calculated using a randomization inference procedure. Differences are not statistically significant.

[19] We also provide estimates of the intention-to-treat. We estimate (1) using Z_{ij} rather than $digital_{ijt}$ as independent variable.

as shown in Table 1, eighteen tables were assigned *ex-ante* to a digital process, whereas twenty-three were *ex-ante* assigned to a manual one. Thus, to identify β in specification (1) we compare, within each day, the success rates of *at most* eighteen tables to the success rates of *at least* twenty-three tables as some of the eighteen initially assigned to the digital process ended carrying out the manual process. In contrast, to identify γ we compare success rates within the eighteen *ex-ante* digital tables, across each day. As shown in Table 2 differences in observable characteristics within the eighteen *ex-ante* digital tables are neglible (see columns 4 to 6) and this appears to be a cleaner comparison. Second and related to the previous point, since in specification (2) we are exploiting within-table variation in treatment status, we can control for unobserved heterogeneity at the table level. Third, given the administrative procedures followed by the police, addressing any technical failures on the same day of occurrence of the event was not possible. As a consequence, it is difficult to account for the number of people who were assigned to a digital table on a specific day and were affected by a technical failure. We cannot rule out that some applicants that faced a digital technical failure may be recorded as following a manual process when in fact they may have followed a digital process. This contamination bias should reduce the measured impacts and may disproportionally affect specification (2) as it is well known that a differences-in-differences approach may tend to exacerbate any measurement error. For these reasons, we show estimates from equation (1) and equation (2).[20] Finally, a key identification assumption in our differences-in-differences strategy is that in the absence of the digital procedures both digital and manual tables (that were first assigned to be a digital process) evolved similarly. In order to check for parallel pre-trends we include leads of our treatment variable $digital_{ijt}$ in our specification in (2). We also include lags to analyze whether treatment effects change over time after the occurrence of a technical failure. In other words, we estimate the following equation:

$$y_{ijt} = \sum_{\tau=-3}^{-1} \phi_\tau digital_{ij\tau} + \sum_{\tau=0}^{3} \gamma_\tau digital_{ij\tau} + \pi X_{ij} + \omega_t + \theta_j + \varepsilon_{ijt} \qquad (3)$$

We expect ϕ_τ to be statistically indistinguishable from zero for every τ as we argue that technical failures happen randomly and are not anticipated. We also expect γ_τ to be indistinguishable from zero for every positive τ as most technical failures are fixed by the end of the day of occurrence.

4 3. Heterogeneous effects

In equations (1) to (3) we include a vector of applicants' and police officers' characteristics, *X*, as they may be important determinants of the renewal process. We do not expect the omission of these variables to bias our estimates of the causal effect of computer technologies. Rather, we are interested in measuring possible gaps in the

[20] As an alternative way to address the potential measurement bias, we use instrumental variables. In particular, we use Z_{ij} as instrumental variable for $digital_{ijt}$ in equation (1). Results are available in Appendix 2. The estimated effect for digital technologies using the IV strategy (see column 3) is almost identical to the one we find in our baseline with OLS (see column 1). Hence, measurement bias does not seem to be a big issue.

provision of this public service to least favored groups. For example, illiterate applicants may find it more difficult to navigate through the renewal process. Therefore, a question to ask is whether the adoption of digital technologies within the renewal process may help reduced some of these gaps in renewal success rates across the characteristics of the applicants bringing not only more efficiency in the provision of the public good but also more equality. In particular, digital technologies may limit discretion held by the police which is compounded by the fact that they allow for faceless, anonymous, and virtual interactions, and by doing so they may help promote transparency and greater equality. We use the following specifications:

$$y_{ijt} = \alpha + \beta digital_{ijt} + \pi X_{ij} + \psi\left(digital_{ijt} \times X_{ij}\right) + \omega_t + \varepsilon_{ijt} \qquad (4)$$

$$y_{ijt} = \gamma digital_{ijt} + \pi X_{ij} + \lambda\left(digital_{ijt} \times X_{ij}\right) + \omega_t + \theta_j + \varepsilon_{ijt} \qquad (5)$$

where X can be either a vector of applicants' characteristics $\boldsymbol{A}_i$ including age, education, gender, rural origin, type of school, language spoken, and indigenous attire; and a vector of table (or equivalently, police officer) characteristics $\boldsymbol{P}_j$ including tenure at the administrative office, tenure at the renewal table, rank, age, education, and gender. Failing to reject the null that a specific characteristic of an applicant and its interaction with the digital renewal process were statistically significant may show that disparities in renewal outcomes along that dimension may have been eliminated by the digital process. Notice that under the digital process no longer matters whether the individual is from a rural or urban area, whether he or she is from an indigenous background and so on.

5. Findings

Table 3 shows our findings. All the coefficients reported are marginal effects from probit regressions and are estimated separately for all applicants as well as for male and female applicants.[21] Columns 1, 3 and 5 show the impact of computer processes with respect to manual ones, after controlling for renewal day fixed effects, or β in Equation (1). Columns 2, 4, and 6 show the impact after controlling for table fixed effects and day fixed effects, which corresponds to γ in Equation (2). The adoption of computer technologies results in an overall improvement in the renewal process. Females randomly assigned to the digital process have a higher probability of completing the process of about 28.52 to 26.92 percentage points, compared to those randomly assigned to a manual process. These differences are statistically significant at one percent. For males, analogous improvements range from 17.51 to 18.89 percentage points. These differences are also statistically significant. For the overall sample, these estimates are around 22.91 and 22.81 percentage points.

Figure 2 presents the estimates of the anticipatory effects, or ϕ_t in (3), and the estimates of the post treatment effects, or γ_t. Panel A shows the results for the whole sample while Panel B shows the results for the sub-sample of males and females. The estimates for the anticipatory effects are particularly small and indistinguishable

[21] In the case of female applicants, we pay particular attention to women's indigenous attire, an objective and very clear indicator of women's background in the context of Bolivia.

from zero. This suggests that police officers were not able to predict timing of failures and act accordingly, which is reassuring of our identification strategy. Moreover, successful renewal rates sharply increased during the same day of the technical failure, but days after the effect is zero, which is consistent with the fact that most failures were repaired at the end of that same day. Notice that in this estimation we are controlling for applicants' characteristics whereas in columns 1 to 6 we did not control for them. In both cases the effect of digital technologies is fairly similar which suggests again that randomization was correctly performed.

Columns 7 to 12 in Table 3 show the results of estimating equation (4) and equation (5). We find that applicants' characteristics matter. Those from rural areas are around eleven percentage points less likely to complete the renewal process as compared to those from urban areas. Those who did not complete high school are between 4.66 and 6.87 percentage points less likely to complete the renewal process as compared to those who did complete high school. Those older than forty are around three percentage points less likely to complete the renewal process as compared to relatively younger applicants, although this is not true for the sample of females. Moreover, applicants who never attended private school and thus belong to a lower social status are roughly ten percentage points less likely to complete the renewal process as compared to those who attended a private school. Indigenous males, proxied by those who speak an indigenous language, are roughly seven percentage points less likely to complete the renewal process as compared to non-indigenous males. Furthermore, female applicants wearing indigenous attire are instead almost eleven percentage points less likely to complete the renewal process as compared to those female applicants who are not[22].

We ask whether the adoption of digital technologies helps reduce some of the observed gaps in renewal success rates. As shown in columns 7 to 12 we find that this is the case. For females, the coefficient for living in a rural area is smaller in magnitude and opposite in sign to that of the interaction between the dummy for rural areas and the variable for having the digital process. Thus, the digital process eliminated the gap associated with living in rural areas. For males, the digital process reduced inequalities from this variable but not completely. Furthermore, for females, if anything, the digital process reduced the gap associated with completed high school. For males, the magnitude of the effect of completed high school is similar in magnitude and opposite in sign to that of the effect of the interaction of completed high school and the variable for the digital process. The difference in success rates among older males and younger males is reduced by roughly four percentage points when randomly to renewal processes.[23] Success rates gap between indigenous and non-indigenous applicants is reduced by around six percentage points, as measured by the knowledge of an indigenous language for males. Finally, the difference in

[22] Speaking an indigenous language does not seem to be relevant to explain success rates among female applicants after the wearing of indigenous attire has been controlled for. This suggests that visual impression is a key aspect, one that is more immediately observable than knowledge of an indigenous language, as most indigenous people are bilingual and speak Spanish.
[23] Note that among all applicants, being old does not seem to interact with the digital process.

success rates between indigenous and non-indigenous females drops by around six percentage points, when measured with indigenous attire.

In Figure 3 we test whether the different characteristics of applicants and their interaction with a digital renewal process are jointly statistically significant. The idea is to explore whether gaps in renewal success rates are eliminated after the introduction of digital technologies. Under the digital process it would no longer matter whether the individual is from a rural or urban area, whether he or she is from an indigenous background or not, and so on and so forth. In particular, we can define "a" as a dummy that takes the value of one if the applicant belongs to a less favored group along a particular dimension and zero otherwise. For each "a", we test the null hypothesis that negative of the sum of the marginal effect of dimension "a" plus the marginal effect of the interaction term of "a" and $digital_{ijt}$ is equal to zero[24]. Failing to reject the null shows that disparities in renewal rates are eliminated by the digital process. In Panel A of Figure 3 we show the results using equation (1), whereas in Panel B we show the results based on equation (2). Notice that both models produce almost identical results. For the full sample most gaps disappear, although the gap for older applicants relative to younger applicants remains positive but small. Across genders not all gaps are totally eliminated, albeit they become considerable smaller. For males, we can still find gaps in terms of rurality, age and social status as measured by school of attendance. For females, most gaps are not statistically different from zero at the 5% level. The only exception is the gap related to rurality which is not only eliminated but reversed. After the introduction of digital technologies, rural female applicants are around 6 percentage points more likely to finish the process compared to their urban counterparts. In Appendix 3 we focus on the time taken to complete the renewal process instead of success rates. To do this, we employ the sample of applicants who were successful at completing the renewal process, only. Overall, we find very similar results. Applicants randomly assigned to the digital renewal process take on average around 38% to 42% less time than applicants in the manual process[25]. In terms of characteristics we also find an analogous pattern than in the case of success rates. This is shown in Figure C in Appendix 6, where as before, we explore whether gaps in the access to the public service shrinks measured by renewal times rather than success rates.[26]

[24] For the sake of clarity, $H_0\colon -\left[ME(a) + ME\left(a * digital_{ij}\right)\right] = 0$, where ME(x) is the marginal effect of x alone, that is, ignoring any interaction with other variables. We multiply the sum by minus one to interpret the result as the gap in the renewal success rates of applicants belonging to a less favored group with respect to applicants belonging to a more favored group (as measured by "a"). A positive result "x" means that success rates are x percentage points lower for applicants belonging to the less favored group. A negative result means that the gap was not only eliminated but was inverted after the introduction of digital technologies.

[25] Figure A (Appendix 6) shows that anticipatory effects are small and indistinguishable from zero, which is reassuring of our identification strategy. Renewal times decrease by almost 40%, during the same day of the technical failure. However, successful applicants took 4% more time finishing their renewal process the day after. Given that this effect is ten times smaller than the effect of same day failure, we interpret it as of second order. Also, Figure B (Appendix 6) shows probability density functions using an Epanechnikov kernels. Unsurprisingly, it takes less time to complete a digital process along all of the percentiles in the distribution. The two-sample Kolmogorov-Smirnov statistic testing is 0.582 with a p-value of 0.0.

[26] In Appendix 4 we show that overall success rates and renewal times are not correlated to police officer characteristics, which

The existing heterogeneity in the renewal process of identification cards was substantially removed by the introduction of digital technologies. In absence of further evidence, it is difficult to interpret these results directly, although we may provide some insights. There are multiple reasons why applicants fail to renew their identification cards although heterogeneity in the quality of the paperwork required to finish the process is an unlikely explanation. Notice that we focus on renewals only. Thus, the bureaucracy must have had full records from the last application, which by definition, had to be complete since the individual was successful in obtaining an identification card the previous time. In addition, given that individuals at higher risk of being targeted faced higher transaction costs, they had an incentive to stay quiet and comply. This is consistent with the idea that discretion was used to improve the screening of applications.

In-depth interviews pursued by us suggest that because of the asymmetric power position between applicant and official, the latter had incentives to complicate the process, perhaps, with the aim of extracting bribes. This included arbitrarily increasing wait times, claim loss of documents, increase the number of steps required to process paperwork, and others[27]. This is also supported by previous qualitative work as well as by our own survey (see next section). Finally, as mentioned above, in Latin America it is very common to observe differential treatment based on specific characteristics. In fact, in Bolivia, according to a nationally representative survey, 80 percent of the population say that the clothing one wears influences how one is treated by police officers (Wanderley, 2007).

Computer technologies may serve as effective tools at promoting equitable public service delivery since discretion of agents may be drastically reduced, as they implicitly add an accountability mechanism into the renewal process, which may be successfully operating in our setting and helping reduce barriers by altering the probability of detecting malpractice by police officers. These technologies may also facilitate the process for the applicant and, thus, help reduce gaps in renewal outcomes. Whereas we still find some prevailing gaps in a few categories, this is consistent with the fact that our natural experiments do not fully eliminate discretion by government officials, as they still have control of the initial exchange with the applicant. In order to provide further evidence supporting that discretion of police officers may be exploited as a way for extracting bribes or even discriminate, we carried out a survey instrument. We present our results in the following section.

6. Exploring Corruption

Police officers may be applying discretion in the identification card renewal process based on specific observable characteristics. It is unclear whether they are behaving selectively in order to maximize extracting bribes or are using characteristics as signals to improve screening (Autor and Scarborough, 2008). We try to shed light

is consistent with our findings in Table 3 (Van Reenen and Chennells, 2002). In addition, in Figure D (Appendix 6) we show that for the most part police characteristics do not seem to greatly interact with applicants' characteristics. Finally, in Appendix 5 we show intention-to-treat estimates of the effect of ex-ante assignment to the digital process.

[27] In-depth interviews are available upon request.

on the underlying mechanism behind the equality-enhancing effect of digital technologies by carrying out a survey instrument asking about direct and indirect bribes requests from police officers. In 2011, we applied this survey to a representative sample of about 780 individuals that had gone through the renewal process at the national identification card administrative office in La Paz. Our aim is to explore the possible relationship between applicants' characteristics and bribe requests from police officers. Previous evidence about the bureaucratic services provided by the Bolivian Police show that only 28 percent of citizens agreed that it was possible to successfully complete a bureaucratic process involving this institution without having to incur an extra-legal payment. Furthermore, nearly 47 percent of citizens admitted having paid at least an extra-legal payment in the previous year in order to facilitate the completion of a bureaucratic process, and 30 percent of citizens reported explicitly being asked for a bribe by a police officer in order to complete a process. It has been estimated that extra-legal payments are usually in the order of two to ten US dollars per identification card. This is a significant amount in Bolivia considering that the minimum monthly wage is around 92 US dollars, and that the median monthly wage is around 363 dollars (UDAPE, 2009).

In Table 4 we show basic summary statistics of the variables collected in our survey, including responses related to direct or indirect requests for bribes by police officers. In particular, we asked the following questions: (i) Have you ever been required to make an extra payment during the process without receiving a receipt? (ii) Have you ever been asked to make an extra payment during the process? (iii) Have police officers ever offered to help you to speed up the process if you 'acknowledge' their time? Using these three variables we compute a dummy variable that takes the value of one whether (i), (ii) or (iii) is equal to 1, and 0 otherwise. For convenience, we also report the summary statistics from Panel B in Table 1. Two stylized facts standout. First, both the survey findings and the data from Table 1 are very similar in terms of characteristics. Second, corruption is pervasive. At least 62 percent of our sample have answered positively to either (i), (ii) or (iii). We investigate whether differential treatment by testing:

$$Bribe_i = \alpha + \beta A_i + \varepsilon_i \qquad (6)$$

where *"Bribe"* is a dummy variable that captures whether or not the individual was asked or suggested to pay a bribe to the police officer and is based on the questions described above. In particular, we use the three different questions described above, which intend to capture petty corruption. The exact wording of each question is also presented in Table 5[28]. The vector *"A_i"* contains a set of explanatory variables that reflect basic characteristics of the applicants and are chosen to match the key characteristics of our field experiment.

Table 5 presents our results. We already showed that gaps in success rates were larger for disadvantaged groups. Regardless of the corruption-related variable that we employ, we find that observable characteristics generally linked with being more disadvantaged are correlated to increased probability of corruption too. This relationship is particularly strong for applicants that attended a public school and for applicants that did not finish

[28] The original questions were written and asked in Spanish; the translation is ours.

high school. In the case of rural applicants, for the first two corruption outcomes we do not find a statistically significant relationship. However, regarding the third corruption variable, rural applicants were offered "help" by police officers. We were not able to estimate the coefficient associated with rurality from the probit specification because all rural applicants reported a 1 on the variable "were offered help by police officers".[29] This difference is not surprising as typically bribes are not requested directly, but almost always indirectly, as a "suggestion" to make things easier. In this context "helping" the applicant perfectly fits the bill. Moreover, speaking an indigenous language or using indigenous attire in the case of females is also strongly related with corruption, especially for the third corruption variable, suggesting "help". Interestingly, applicants' age does not correlate with corruption, which goes in line with our previous findings as gaps in the delivery of the public service were small for older applicants. While exploratory, the findings are consistent with differential service to certain groups of individuals. This is consistent with the literature on corruption as well as with surveys in Bolivia and other developing countries (Olken and Barron, 2009; United Nations Development Program, 2009).[30]

7. Conclusions

Taking advantage of two randomized natural experiments occurring in the context of the renewal of national identification cards in Bolivia, we provide evidence that computer technologies can be a very useful tool to significantly reduce heterogeneity in the delivery of this public service. These results are impressive given the significant differential service provision to individuals in our experiment. Whereas it is true that there is room for different explanations, we believe that our results are consistent with computers being able to curb petty corruption. Computer technologies might also significantly facilitate the process for the applicant and, thus, help reduce gaps in renewal outcomes. Computers and related technologies may have the potential to transform the way in which governments interact with citizens as well as on the way services are delivered to the public. In general, they may be of important help in countless situations where the power and discretion of economic agents is unbalanced. As these technologies continue to evolve, policy makers and regulators may increasingly adopt them not only as a tool to enhance government efficiency and transparency, but also as a tool to achieve more equitable societal outcomes.

[29] According to an OLS estimation, using (iii) as dependent variable, this marginal effect would be around 0.60 and significant at conventional levels. Using the corruption dummy as dependent variable, this marginal effect would be around 0.30.

[30] When asked about whether (i) the individual understands all the instructions given or (ii) delays were his or her fault, we do not find any statistically significant differences on overall renewal success and characteristics of the individuals, including education, age, gender, language, socio-economic status, and rural origin. This is consistent with our claim that there is no heterogeneous paperwork quality among applicants.

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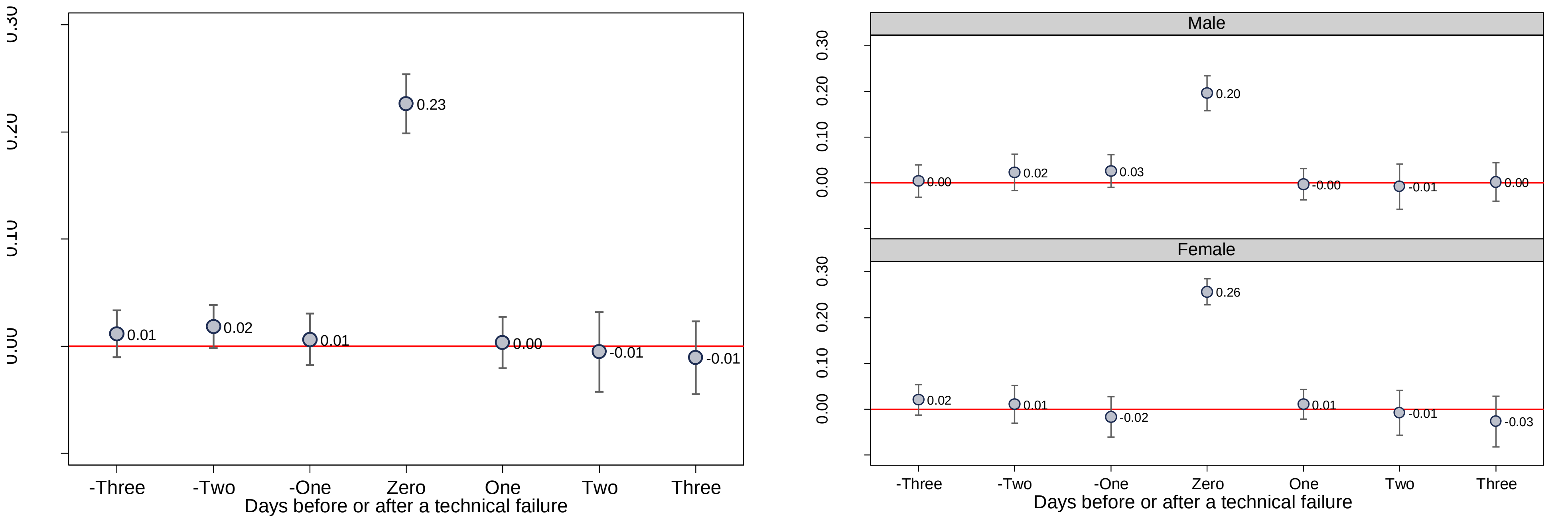
Figure 1
Software Platform for Primary Data Collection

Figure 2
Time-Event Study of the Effect of Digital Technologies on Success Rates

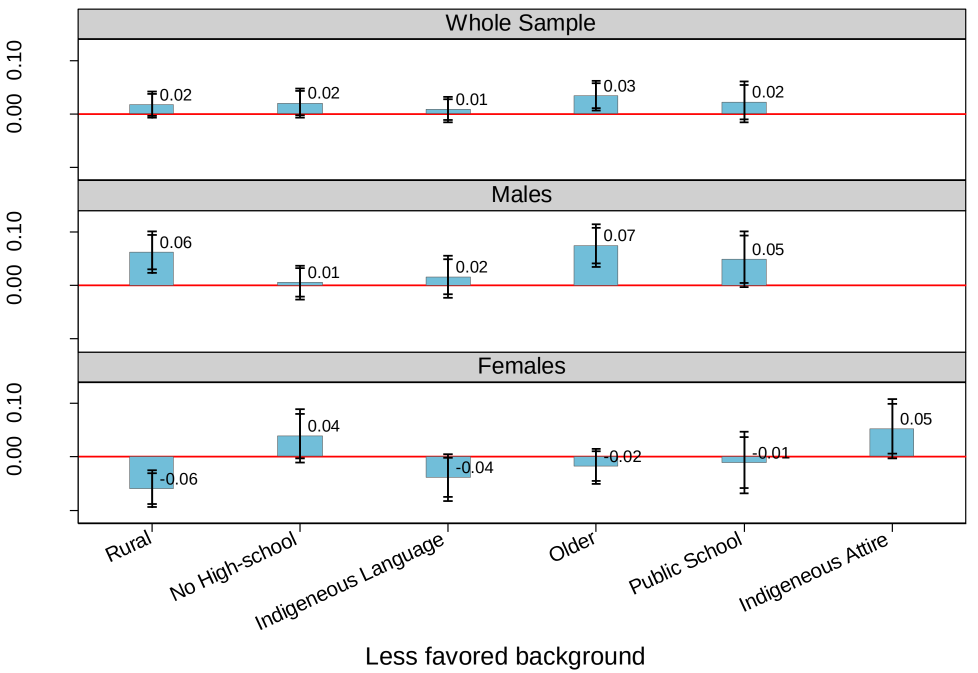
Panel A: All applicants	Panel B: By sex



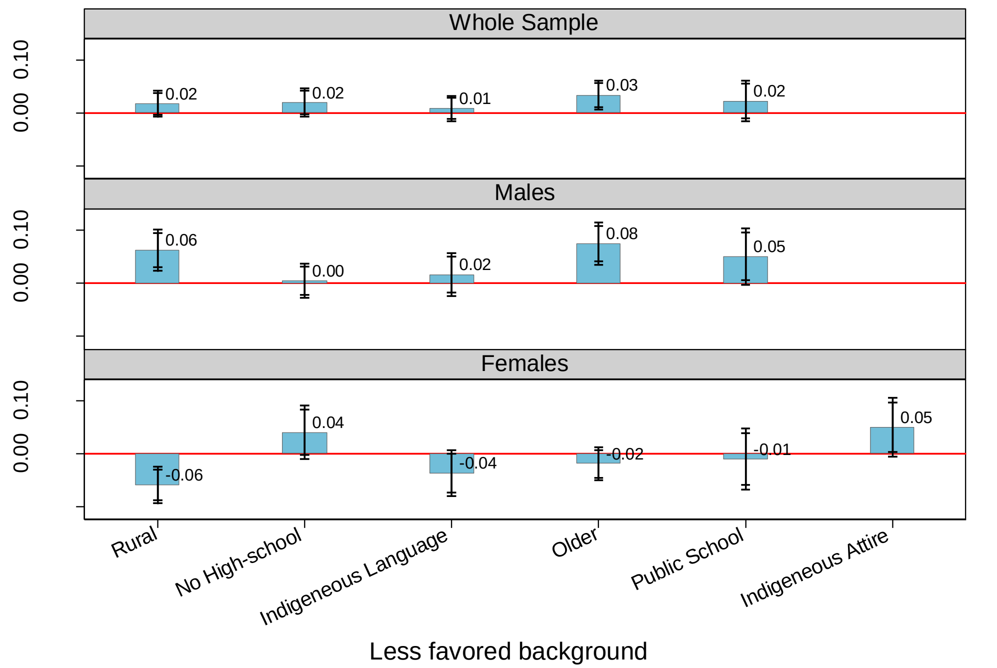
Estimates of the coefficients associated to leads, lags and current values of $digital_{ijt}$ in equation (3). Estimates reported are marginal effects from probit regressions. The vector of applicant characteristics include: whether the applicant is from rural areas, whether applicant did not finish high school, whether applicant speaks an indigenous language, whetter the age of applicant is 40 or older, whether applicant attended public school. For the sample of females, we also include a variable indicating whether the applicant wears an indigenous attire. 95% level confidence intervals reported.

Figure 3
Gaps in Renewal Success Rates of Less Favored Groups After the Introduction of Digital Technologies

Panel A: Day fixed effects



Panel B: Differences-in-differences



All statistics are computed based on estimates reported in columns (7) to (12) of Table 3. Panel A is based on estimates from equation (1), whereas Panel B is based on estimates from equation (2). For the marginal effect of characteristic "a" in the x-axis, we test the null hypothesis "$(a + digital \times a) \times (-1) = 0$", where "$digital \times a$" is the marginal effect of the interaction between the characteristic "a" and the dummy "digital". We have multiplied the whole sum $(a + digital \times a)$ by minus one to interpret the result as a gap in the renewal success rate of a less favored group with respect to a more favored group. A positive result of for example 0.05 means that success rates are 5 percentages points lower for applicants belonging to the less favored group. 90% and 95% level confidence intervals reported.

Table 1: Summary Statistics

Panel A: Applicant-table pair	
Assigned to digital table (%)	43.00
	(49.51)
Technical failures rate conditional on assignment to digital table (%)	20.39
	(40.29)
Success rate (%)	70.20
	(45.74)
Renewal time in minutes conditional on success	111.14
	(39.57)
Observations	19,542

Panel B: Applicant characteristics	
Age of applicant	40.75
	(14.43)
Finished high school (%)	62.73
	(48.35)
Female (%)	48.68
	(49.98)
Rural area (%)	16.15
	(36.80)
Attended private school (%)	14.44
	(35.15)
Speaks indigenous language (%)	56.06
	(49.63)
Female applicant wears indigenous attire (%)	30.58
	(46.08)
Observations	19,542

Panel C: Digital table characteristics	
Total number of days machine was inoperative	5.44
	(2.09)
	[2.00; 9.00]
Number of times machine was inoperative	4.44
	(1.89)
	[1.00; 8.00]
Number of contiguous days machine was inoperative	1.23
	(0.45)
	[1.00; 3.00]
Observations	18

Panel D: Table (i.e. Police Officer) characteristics	
Tenure at renewal table (in years)	1.05
	(1.44)
Tenure at administrative office (in years)	3.12
	(2.16)
Police officer is low rank (%)	53.66
	(50.49)
Age of police officer	36.17
	(9.04)
Years of education	13.07
	(2.25)
Police officer is female (%)	24.39
	(43.48)
Observations	41

Standard deviations reported within parenthesis. Panel A shows summary statistics for applicant-table pairs. Panel B exhibit summary statistics for applicants. Panel C shows summary statistics specific to digital tables only. Minimum and maximum are reported within brackets. Panel D shows summary statistics for police officers, or tables, which are equivalent in our context as each table was assigned to only one police officer. For reference, the evaluation period lasted 28 days.

Table 2: Balance Across Groups for Applicants' Characteristics

	Ex-ante assignment (Zij)			Technical failure conditional on *ex-ante* digital table (Fijt | Zij =1)			*Ex-post* assignment ($digital_{ijt}$)		
	Digital	Manual	Difference (1) – (2)	Failure	No failure	Difference (4) – (5)	Digital	Manual	Difference (7) – (8)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Panel A: All applicants									
Age of applicant	40.38	41.03	-0.65	40.82	40.26	0.56	40.26	41.00	-0.74
	(14.08)	(14.68)	(0.52)	(14.06)	(14.08)	(0.37)	(14.08)	(14.60)	(0.49)
Finished high school (%)	63.73	61.98	1.75	62.81	63.96	-1.15	63.96	62.09	1.87*
	(48.08)	(48.55)	(1.06)	(48.34)	(48.01)	(1.68)	(48.01)	(48.52)	(1.10)
Female (%)	48.02	49.18	-1.16	47.75	48.09	-0.33	48.09	48.99	-0.90
	(49.96)	(50.00)	(1.04)	(49.96)	(49.97)	(1.47)	(49.97)	(49.99)	(0.98)
Rural area (%)	15.27	16.82	-1.56*	16.00	15.08	0.91	15.08	16.71	-1.63**
	(35.97)	(37.41)	(0.71)	(36.67)	(35.79)	(1.15)	(35.79)	(37.31)	(0.73)
Attended private school (%)	14.84	14.13	0.71	14.59	14.90	-0.31	14.90	14.19	0.71
	(35.55)	(34.84)	(0.54)	(35.32)	(35.61)	(1.15)	(35.61)	(34.90)	(0.67)
Speaks indigenous language (%)	55.40	56.56	-1.16	54.93	55.52	-0.58	55.52	56.34	-0.83
	(49.71)	(49.57)	(1.01)	(49.77)	(49.70)	(1.20)	(49.70)	(49.60)	(0.90)
Joint-test of significance (p-value)			0.0034			0.8991			0.0023
Observations	8,403	11,139		1,713	6,690		6,690	12,852	
Panel B: Male applicants									
Age of applicant	39.96	40.69	-0.72	40.19	39.90	0.28	39.90	40.62	-0.71
	(14.24)	(14.91)	(0.56)	(14.31)	(14.23)	(0.57)	(14.23)	(14.83)	(0.53)
Finished high school (%)	66.55	66.54	0.01	67.49	66.31	1.17	66.31	66.67	-0.36
	(47.19)	(47.19)	(1.04)	(46.87)	(47.27)	(1.71)	(47.27)	(47.14)	(1.06)
Rural area (%)	15.66	17.13	-1.48**	17.54	15.17	2.37	15.17	17.19	-2.02**
	(36.35)	(37.68)	(0.72)	(38.05)	(35.88)	(1.67)	(35.88)	(37.73)	(0.75)
Attended private school (%)	14.15	14.10	0.05	14.08	14.17	-0.09	14.17	14.09	0.07
	(34.86)	(34.80)	(0.65)	(34.79)	(34.88)	(1.09)	(34.88)	(34.80)	(0.74)
Speaks indigenous language (%)	59.80	60.11	-0.31	59.55	59.86	-0.31	59.86	60.04	-0.17
	(49.04)	(48.97)	(1.16)	(49.11)	(49.02)	(2.13)	(49.02)	(48.99)	(0.99)
Joint-test of significance (p-value)			0.0574			0.8487			0.0102
Observations	4,368	5,661		895	3,473		3,473	6,556	
Panel C: Female applicants									
Age of applicant	40.82	41.38	-0.55	41.51	40.64	0.86	40.64	41.39	-0.75
	(13.88)	(14.43)	(0.59)	(13.76)	(13.91)	(0.58)	(13.91)	(14.34)	(0.58)
Finished high school (%)	60.67	57.27	3.40**	57.70	61.42	-3.72	61.42	57.32	4.10**
	(48.85)	(49.47)	(1.62)	(49.94)	(48.68)	(2.27)	(48.68)	(0.49)	(1.61)
Rural area (%)	14.85	16.50	-1.66*	14.30	14.98	-0.68	14.98	16.22	-1.23
	(35.56)	(37.12)	(0.96)	(35.03)	(35.70)	(1.49)	(35.70)	(36.86)	(1.03)
Attended private school (%)	15.59	14.17	1.42	15.16	15.70	-0.54	15.70	14.29	1.40
	(36.28)	(34.87)	(0.89)	(35.88)	(36.38)	(1.49)	(36.38)	(35.00)	(1.02)
Speaks indigenous language (%)	50.63	52.88	-2.25	49.88	50.82	-0.95	50.82	52.49	-1.67
	(50.00)	(49.92)	(1.63)	(50.03)	(50.00)	(1.09)	(50.00)	(49.94)	(1.46)
Female applicant wears indigenous attire (%)	30.09	30.94	-0.86	32.03	29.59	2.44	29.59	31.08	-1.49
	(45.87)	(46.23)	(1.55)	(46.69)	(45.65)	(1.43)	(45.65)	(46.29)	(1.38)
Joint-test of significance (p-value)			0.0054			0.1245			0.0046
Observations	4,035	5,478		818	3,217		3,217	6,296	

Columns (1), (2), (4), (5), (7), and (8) present the average value of the variables in the left and standard deviations within parenthesis for each sub-sample as indicated by the first row. Columns (3), (6), and (9) present the difference between the two previous columns, respectively. Differences in means were computed from a regression of each of the variables at the left on a dummy variable indicating treatment status (i.e. Zij, Fijt | Zij =1, or digitalijt). Standard errors in parentheses are robust to arbitrary heteroskedasticity in the variance-covariance matrix and clustered at the table level. *** Significant at 1 percent;** Significant at 5 percent; * Significant at 10 percent.

Table 3: Probability of Successfully Completing ID Renewal

Dependent variable	*Completed process*											
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	All applicants		Male applicants		Female applicants		All applicants		Male applicants		Female applicants	
ID Digital renewal process	0.2289***	0.2278***	0.1751***	0.1889***	0.2852***	0.2692***	0.1078***	0.1099***	0.0813**	0.1006***	0.1164***	0.0998***
	(0.0059)	(0.0112)	(0.0085)	(0.0142)	(0.0090)	(0.0134)	(0.0215)	(0.0229)	(0.0317)	(0.0331)	(0.0311)	(0.0331)
Applicant is from rural areas							-0.1177***	-0.1185***	-0.1130***	-0.1133***	-0.1004***	-0.1003***
							(0.0115)	(0.0116)	(0.0183)	(0.0184)	(0.0168)	(0.0172)
Applicant did not finish high school							-0.0824***	-0.0820***	-0.0470***	-0.0466***	-0.0687***	-0.0676***
							(0.0071)	(0.0072)	(0.0114)	(0.0112)	(0.0139)	(0.0142)
Applicant speaks indigenous language							-0.0467***	-0.0463***	-0.0712***	-0.0705***	0.0013	0.0022
							(0.0070)	(0.0071)	(0.0127)	(0.0125)	(0.0104)	(0.0106)
Age of applicant is 40 or older							-0.0152**	-0.0145**	-0.0302***	-0.0311***	0.0091	0.0101
							(0.0072)	(0.0073)	(0.0112)	(0.0113)	(0.0108)	(0.0110)
Applicant attended public school							-0.0961***	-0.0962***	-0.1103***	-0.1095***	-0.0909***	-0.0918***
							(0.0108)	(0.0108)	(0.0179)	(0.0179)	(0.0146)	(0.0147)
Female applicant wears indigenous attire											-0.1080***	-0.1086***
											(0.0150)	(0.0153)
Digital*(Applicant is from rural areas)							0.1092***	0.1101***	0.0530*	0.0527*	0.1834***	0.1828***
							(0.0183)	(0.0185)	(0.0279)	(0.0282)	(0.0291)	(0.0293)
Digital*(Applicant did not finish high school)							0.0644***	0.0644***	0.0428**	0.0430**	0.0300	0.0278
							(0.0167)	(0.0166)	(0.0199)	(0.0198)	(0.0296)	(0.0301)
Digital*(Applicant speaks indigenous language)							0.0391***	0.0384***	0.0565**	0.0555**	0.0377	0.0350
							(0.0131)	(0.0134)	(0.0253)	(0.0256)	(0.0247)	(0.0246)
Digital*(Applicant is 40 or older)							-0.0185	-0.0189	-0.0434**	-0.0431**	0.0085	0.0093
							(0.0161)	(0.0159)	(0.0218)	(0.0218)	(0.0213)	(0.0206)
Digital*(Applicant attended public school)							0.0747***	0.0744***	0.0621*	0.0596	0.1026***	0.1034***
							(0.0231)	(0.0233)	(0.0359)	(0.0362)	(0.0329)	(0.0333)
Digital*(Female applicant wears indigenous attire)											0.0558*	0.0590*
											(0.0312)	(0.0311)
Mean of dep. var. given digitalijt = 0	0.6235		0.6563		0.5893		0.6235		0.6563		0.5893	
Mean of dep. var. given digitalijt = 0 and Zij=1		0.6235		0.6346		0.6112		0.6235		0.6346		0.6112
Renewal day fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Renewal table fixed effects	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes
Observations	19,542	19,542	10,029	10,029	9,513	9,513	19,542	19,542	10,029	10,029	9,513	9,513

Estimates reported are marginal effects from probit regressions. The digital renewal process indicator is estimated using the observed renewal process after incorporating technical failures. Standard errors in parentheses are robust against arbitrary heteroskedasticity in the variance-covariance matrix and clustered at the table level across all specifications. *** Significant at 1 percent. ** Significant at 5 percent. * Significant at 10 percent.

Table 4: Summary Statistics for Post-Natural Experiment Survey

	Post Natural Experiment Survey			Panel B Table 1	
	Observations	Mean	Std. Dev	Mean	Std.Dev
Age	784	40.29	14.11	40.75	14.43
Finished high school (%)	784	56.63	49.59	62.73	48.35
Female (%)	784	48.85	50.02	48.68	49.98
Rural (%)	784	14.92	35.65	16.15	49.98
Attended private school (%)	784	10.71	30.95	14.44	35.15
Speaks indigenous language (%)	784	56.63	49.59	56.06	49.63
Female applicant wears indigenous attire (%)	383	26.11	43.98	30.58	46.08
Made Payment	762	31.76	46.58	.	.
Payment was asked	769	30.17	45.93	.	.
Police help	768	43.09	49.53	.	.
Corruption Dummy	766	62.27	49.53	.	.

Dependent variables: (i) “Made payment” = Have you ever been required to make an extra payment during the process without receiving a receipt? (ii) “Payment was asked” =Have you ever been asked to make an extra payment during the process? (iii) “Police help” = Have police officers ever offered to help you to speed up the process if you ‘acknowledge’ their time? (iv) “Corruption dummy”: dummy variable that takes the value of one whether (i), (ii) or (iii) variables are equal to one, and zero otherwise.

Table 5: Observable Characteristics and Corruption

	Made Payment			Payment was asked			Police help			Corruption dummy		
	Whole Sample	Male	Female	Whole Sample	Male	Female	Whole Sample	Male	Female	Whole Sample	Male	Female
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Applicant is from rural area	-0.0184	-0.0630	0.0255	-0.0131	-0.0234	-0.0085	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
	(0.0472)	(0.0601)	(0.0746)	(0.0479)	(0.0661)	(0.0721)	.	.	.	.	.	.
Applicant did not finish high school	0.2127***	0.2308***	0.1796***	0.1572***	0.1647***	0.1344**	0.1072***	0.1341**	0.0181	0.2166***	0.2470***	0.1110**
	(0.0384)	(0.0547)	(0.0584)	(0.0381)	(0.0562)	(0.0567)	(0.0384)	(0.0547)	(0.0578)	(0.0375)	(0.0522)	(0.0563)
Applicant speaks an indigenous language	0.0366	-0.0054	0.0838	0.0487	0.0366	0.0577	0.1647***	0.1742***	0.0910	0.1247***	0.0601	0.1372**
	(0.0366)	(0.0504)	(0.0580)	(0.0362)	(0.0508)	(0.0563)	(0.0374)	(0.0533)	(0.0574)	(0.0371)	(0.0526)	(0.0541)
Age of applicant is a 40 or older	-0.0044	0.0111	-0.0318	-0.0153	0.0318	-0.0668	0.0193	-0.0358	0.0653	0.0095	0.0145	-0.0065
	(0.0344)	(0.0486)	(0.0497)	(0.0344)	(0.0503)	(0.0487)	(0.0366)	(0.0526)	(0.0509)	(0.0351)	(0.0515)	(0.0481)
Applicant attended a public school	0.1568***	0.1447**	0.1787***	0.0903*	0.0592	0.1232*	0.1132**	0.0712	0.1619**	0.1879***	0.1402*	0.2565***
	(0.0474)	(0.0669)	(0.0668)	(0.0499)	(0.0747)	(0.0667)	(0.0567)	(0.0840)	(0.0736)	(0.0580)	(0.0845)	(0.0786)
Female applicant wearing indigenous attire			0.0219			0.0275			0.2048***			0.1885***
			(0.0713)			(0.0711)			(0.0748)			(0.0653)
Observations	769	391	378	762	392	370	768	393	375	766	391	375

Estimates reported are marginal effects computed from probit regressions. Standard errors in parentheses robust against arbitrary heteroskedasticity in the variance-covariance matrix. Dependent variables: (i) "Made payment" = Have you ever been required to make an extra payment during the process without receiving a receipt? (ii) "Payment was asked" =Have you ever been asked to make an extra payment during the process? (iii) "Police help" = Have police officers ever offered to help you to speed up the process if you 'acknowledge' their time? (iv) "Corruption dummy"= Answered yes to (i), (ii), or (iii). **N.A.:** For the dependent variable "Police Help", it was not possible to estimate a coefficient for the dummy variable indicating whether the applicant is from the rural area because **all** rural applicants were offered "help" by police officers. According to an OLS estimation, this marginal effect would be around 0.60 for "Police Help" and around 0.30 for "Corruption dummy". *** Significant at 1 percent. ** Significant at 5 percent. * Significant at 10 percent.

Appendices

Appendix 1: Balance Across Groups for Police Officers' Characteristics

	Ex-ante assignment (Zij)			Technical failure conditional on *ex-ante* digital table (Fijt | Zij =1)			*Ex-post* assignment ($digital_{ijt}$)		
	Digital	Manual	Difference (1) – (2)	Failure	No failure	Difference (4) – (5)	Digital	Manual	Difference (7) – (8)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Tenure at renewal table (in years)	1.18	0.96	0.21	1.31	1.14	0.17	1.14	1.00	0.14
	(1.47)	(1.45)	[0.63]	(1.57)	(1.39)	[0.29]	(1.39)	(1.44)	[0.77]
Tenure at administrative office (in years)	2.972	3.04	-0.07	3.13	2.93	0.20	2.93	3.06	-0.12
	(2.28)	(2.12)	[0.93]	(2.43)	(2.16)	[0.44]	(2.16)	(2.12)	[0.85]
Police officer is low rank (%)	0.61	0.48	0.13	0.65	0.60	0.05	0.60	0.50	0.10
	(0.50)	(0.51)	[0.53]	(0.48)	(0.49)	[0.37]	(0.49)	(0.50)	[0.50]
Age of police officer	33.94	37.91	-3.96	34.81	33.74	1.07	33.74	37.50	-3.77
	(8.95)	(8.92)	[0.17]	(9.39)	(8.53)	[0.29]	(8.53)	(8.87)	[0.16]
Years of education	13.44	12.78	0.66	13.44	13.44	0.01	13.44	12.87	0.57
	(2.75)	(1.78)	[0.34]	(2.79)	(2.64)	[1.00]	(2.64)	(1.93)	[0.36]
Police officer is female (%)	0.22	0.26	-0.04	0.26	0.21	0.04	0.21	0.26	-0.05
	(0.43)	(0.45)	[1.00]	(0.44)	(0.41)	[0.42]	(0.41)	(0.44)	[0.74]
Level of observations	Table-level			Table-day level			Table-day level		
Observations	18	23		98	406		406	742	

Columns (1), (2), (4), (5), (7), and (8) present the average value of the variables at the left and standard deviations within parenthesis for each sub-sample as indicated by the first row. Columns (3), (6), and (9) present the difference between the two previous columns and the p-value testing statistically significance in brackets, respectively. The differences in means were computed from a regression of each of the variables at the left on a dummy variable indicating treatment status (i.e. Zij, Fijt | Zij =1, or digitalijt). P-values in parenthesis were computed using a randomization inference procedure with 2000 repetitions. In Column (9) permutations treated each cluster at the table level as units of assignment.

Appendix 2: TOT estimates

Dependent Variable:	OLS: Success Rates	1st stage: $digital_{ijt}$	2nd stage: Success Rates
	(1)	(2)	(3)
Digital	0.2287 (0.0059)***		0.2291 (0.0065)***
Zij		0.7961 (0.1732)***	
Cragg-Donald Wald F statistic		44356.20	
Kleibergen-Paap Wald rk F statistic		2113.76	
Renewal day fixed effects	Yes	Yes	Yes
Table fixed effects	No	No	No
Observations	19,542	19,542	19,542

Standard errors in parentheses are robust against arbitrary heteroskedasticity in the variance-covariance matrix and clustered at the table level across all specifications. Column (1) shows the result of an OLS regression between success rates and a dummy for digital table incorporating technical failures. Column (2) shows the first stage of an IV regression using table assignment as instrument for the dummy for digital table incorporating technical failures. Column (3) shows the second stage of the aforementioned IV regression. *** Significant at 1 percent. ** Significant at 5 percent. * Significant at 10 percent.

Appendix 3: Time to Complete ID Renewal

Dependent variable	*Ln(Renewal time)*											
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	All applicants		Male applicants		Female applicants		All applicants		Male applicants		Female applicants	
ID Digital renewal process	0.4226***	-0.3815***	-0.4241***	-0.3850***	-0.4212***	-0.3774***	-0.3543***	-0.3129***	-0.3595***	-0.3197***	-0.3476***	-0.3021***
	(0.0103)	(0.0117)	(0.0115)	(0.0177)	(0.0114)	(0.0120)	(0.0170)	(0.0158)	(0.0178)	(0.0209)	(0.0222)	(0.0220)
Applicant is from the rural area							0.1122***	0.1126***	0.1096***	0.1092***	0.1086***	0.1107***
							(0.0097)	(0.0096)	(0.0133)	(0.0134)	(0.0141)	(0.0144)
Applicant did not finish high school							0.0767***	0.0768***	0.0825***	0.0821***	0.0647***	0.0644***
							(0.0107)	(0.0108)	(0.0125)	(0.0128)	(0.0137)	(0.0134)
Applicant speaks an indigenous language							0.0124*	0.0120*	0.0197**	0.0197**	-0.0033	-0.0039
							(0.0069)	(0.0071)	(0.0086)	(0.0088)	(0.0105)	(0.0106)
Age of applicant is a 40 or older							0.0208***	0.0216***	0.0149*	0.0142*	0.0249***	0.0253***
							(0.0061)	(0.0061)	(0.0075)	(0.0079)	(0.0088)	(0.0089)
Applicant attended a public school							0.0459***	0.0462***	0.0389***	0.0390***	0.0549***	0.0559***
							(0.0065)	(0.0064)	(0.0097)	(0.0097)	(0.0100)	(0.0100)
Female applicant wearing indigenous attire											0.0284	0.0280*
											(0.0161)	(0.0157)
Digital*(Applicant lives in rural area)							-0.0774***	-0.0784***	-0.0687***	-0.0696***	-0.0893***	-0.0905***
							(0.0152)	(0.0156)	(0.0199)	(0.0202)	(0.0244)	(0.0252)
Digital*(Applicant did not finish high school)							-0.0714***	-0.0720***	-0.0911***	-0.0896***	-0.0556***	-0.0557***
							(0.0133)	(0.0134)	(0.0161)	(0.0165)	(0.0195)	(0.0195)
Digital*(Applicant speaks indigenous language)							-0.0085	-0.0097	-0.0058	-0.0077	-0.0155	-0.0136
							(0.0127)	(0.0126)	(0.0163)	(0.0165)	(0.0178)	(0.0173)
Digital*(Applicant is 40 or older)							-0.0176	-0.0204*	-0.0138	-0.0155	-0.0238	-0.0251
							(0.0114)	(0.0115)	(0.0167)	(0.0170)	(0.0163)	(0.0160)
Digital*(Applicant attended public school)							-0.0319***	-0.0321***	-0.0263**	-0.0286**	-0.0386**	-0.0404**
							(0.0105)	(0.0106)	(0.0126)	(0.0129)	(0.0153)	(0.0152)
Digital*(Female applicant wearing indigenous attire)											0.0103	0.0067
											(0.0227)	(0.0229)
Mean of dep. var. given digitalijt = 0	128.99		128.55		129.45		128.99		128.55		129.45	
Mean of dep. var. given digitalijt = 0 and Zij=1		125.42		125.65		125.20		125.42		125.65		125.20
Renewal day fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Renewal table fixed effects	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes
R-squared	0.367	0.374	0.374	0.382	0.361	0.371	0.392	0.399	0.400	0.409	0.386	0.396
Observations	13,497	13,497	7,196	7,196	6,301	6,301	13,497	13,497	7,196	7,196	6,301	6,301

Estimates reported are ordinary least squares coefficients. Dependent variable is log of renewal times conditional on having completed the renewal process. The digital renewal process indicator is estimated using the observed renewal process after incorporating technical failures. Standard errors in parentheses are robust against arbitrary heteroskedasticity in the variance-covariance matrix and clustered at the table level across all specifications. *** Significant at 1 percent. ** Significant at 5 percent. * Significant at 10 percent.

Appendix 4: Computers, Renewal Outcomes, and Police Officers Characteristics

Dependent variable	Success Rates						Log renewal times					
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	All applicants		Male applicants		Female applicants		All applicants		Male applicants		Female applicants	
Digital	0.1222***	0.1418***	0.1020***	0.1436***	0.1174***	0.1046**	-0.3820***	-0.3484***	-0.4016***	-0.3833***	-0.3598***	-0.3081***
	(0.0263)	(0.0425)	(0.0355)	(0.0546)	(0.0431)	(0.0471)	(0.0299)	(0.0213)	(0.0314)	(0.0365)	(0.0355)	(0.0297)
Police officer characteristics												
Police officer has low tenure at renewal table	-0.0022		-0.0177		0.0118		0.0089		0.0080		0.0104	
	(0.0102)		(0.0154)		(0.0156)		(0.0104)		(0.0115)		(0.0161)	
Police officer has low tenure at office	-0.0049		-0.0097		-0.0002		0.0125		0.0063		0.0202	
	(0.0090)		(0.0145)		(0.0101)		(0.0090)		(0.0088)		(0.0126)	
Police officer is low rank	-0.0000		0.0032		-0.0034		-0.0052		-0.0016		-0.0099	
	(0.0083)		(0.0133)		(0.0115)		(0.0097)		(0.0100)		(0.0139)	
Police officer is a senior (>40 years old)	-0.0097		-0.0008		-0.0156		0.0080		0.0056		0.0110	
	(0.0090)		(0.0117)		(0.0121)		(0.0086)		(0.0097)		(0.0130)	
Police officer did not go to college	0.0086		0.0082		0.0097		0.0114		0.0108		0.0114	
	(0.0071)		(0.0136)		(0.0141)		(0.0116)		(0.0127)		(0.0120)	
Police officer is female	-0.0003		0.0034		-0.0067		-0.0108		-0.0185*		-0.0012	
	(0.0078)		(0.0123)		(0.0099)		(0.0103)		(0.0101)		(0.0184)	
Digital*(Police officer has low tenure at renewal table)	-0.0251	0.0046	-0.0326	-0.0201	-0.0045	0.0446	-0.0469*	-0.0827*	-0.0148	-0.0575	-0.0867***	-0.1103*
	(0.0195)	(0.0514)	(0.0201)	(0.0643)	(0.0315)	(0.0468)	(0.0237)	(0.0460)	(0.0297)	(0.0470)	(0.0228)	(0.0589)
Digital*(Police officer has low tenure at office)	0.0071	-0.0484	0.0090	-0.0394	0.0134	-0.0406	0.0293	0.0568	0.0200	0.0710	0.0422*	0.0381
	(0.0195)	(0.0456)	(0.0199)	(0.0481)	(0.0297)	(0.0491)	(0.0259)	(0.0355)	(0.0294)	(0.0448)	(0.0250)	(0.0439)
Digital*(Police officer is low rank)	-0.0035	-0.0008	-0.0347*	-0.0506	0.0371**	0.0585**	0.0007	0.0055	0.0122	0.0502	-0.0097	-0.0386
	(0.0132)	(0.0239)	(0.0205)	(0.0327)	(0.0179)	(0.0261)	(0.0212)	(0.0235)	(0.0245)	(0.0340)	(0.0212)	(0.0251)
Digital*(Police officer is a senior)	-0.0113	-0.0426*	-0.0158	-0.0452	-0.0044	-0.0295	0.0267	0.0190	0.0302	0.0116	0.0231	0.0245
	(0.0138)	(0.0252)	(0.0188)	(0.0352)	(0.0175)	(0.0287)	(0.0206)	(0.0256)	(0.0242)	(0.0388)	(0.0221)	(0.0263)
Digital*(Police officer did not go to college)	-0.0130	-0.0067	0.0050	0.0116	-0.0305	-0.0205	0.0173	0.0170	0.0253	0.0233	0.0086	0.0075
	(0.0149)	(0.0311)	(0.0225)	(0.0431)	(0.0259)	(0.0312)	(0.0226)	(0.0234)	(0.0254)	(0.0308)	(0.0224)	(0.0299)
Digital*(Police officer is female)	-0.0045	-0.0092	0.0200	0.0287	-0.0339	-0.0501	0.0487**	0.0241	0.0412	-0.0139	0.0555*	0.0662*
	(0.0210)	(0.0421)	(0.0213)	(0.0496)	(0.0371)	(0.0480)	(0.0240)	(0.0315)	(0.0260)	(0.0351)	(0.0289)	(0.0354)
Applicant characteristics												
Applicant is from rural areas	-0.1178***	-0.1182***	-0.1134***	-0.1132***	-0.1002***	-0.0999***	0.1128***	0.1120***	0.1101***	0.1078***	0.1086***	0.1101***
	(0.0116)	(0.0116)	(0.0183)	(0.0183)	(0.0170)	(0.0172)	(0.0098)	(0.0096)	(0.0134)	(0.0135)	(0.0144)	(0.0145)
Applicant did not finish high school	-0.0821***	-0.0821***	-0.0471***	-0.0467***	-0.0683***	-0.0681***	0.0764***	0.0766***	0.0820***	0.0818***	0.0648***	0.0648***
	(0.0071)	(0.0072)	(0.0114)	(0.0112)	(0.0141)	(0.0143)	(0.0107)	(0.0108)	(0.0126)	(0.0128)	(0.0137)	(0.0149)
Applicant speaks indigenous language	-0.0466***	-0.0462***	-0.0713***	-0.0700***	0.0013	0.0022	0.0125*	0.0121*	0.0198**	0.0197**	-0.0036	-0.0037
	(0.0070)	(0.0071)	(0.0125)	(0.0126)	(0.0105)	(0.0107)	(0.0069)	(0.0071)	(0.0086)	(0.0087)	(0.0105)	(0.0106)
Age of applicant is 40 or older	-0.0152**	-0.0146**	-0.0310***	-0.0308***	0.0095	0.0101	0.0207***	0.0215***	0.0151*	0.0139*	0.0239**	0.0251***
	(0.0072)	(0.0072)	(0.0112)	(0.0113)	(0.0109)	(0.0111)	(0.0061)	(0.0061)	(0.0076)	(0.0080)	(0.0090)	(0.0089)
Applicant attended public school	-0.0962***	-0.0962***	-0.1099***	-0.1095***	-0.0911***	-0.0915***	0.0463***	0.0463***	0.0392***	0.0393***	0.0558***	0.0558***
	(0.0108)	(0.0108)	(0.0178)	(0.0179)	(0.0147)	(0.0147)	(0.0064)	(0.0064)	(0.0098)	(0.0097)	(0.0100)	(0.0100)
Female applicant wears indigenous attire					-0.1077***	-0.1084***					0.0287*	0.0280*
					(0.0151)	(0.0153)					(0.0160)	(0.0157)
Digital *(Applicant is from rural areas)	0.1006***	0.1008***	0.0518**	0.0504*	0.1600***	0.1593***	-0.0771***	-0.0775***	-0.0701***	-0.0683***	-0.0877***	-0.0899***
	(0.0155)	(0.0155)	(0.0258)	(0.0257)	(0.0216)	(0.0217)	(0.0152)	(0.0156)	(0.0197)	(0.0204)	(0.0246)	(0.0252)
Digital *(Applicant did not finish high school)	0.0625***	0.0624***	0.0421**	0.0421**	0.0293	0.0278	-0.0718***	-0.0718***	-0.0907***	-0.0891***	-0.0567***	-0.0561***
	(0.0153)	(0.0153)	(0.0187)	(0.0187)	(0.0292)	(0.0295)	(0.0132)	(0.0135)	(0.0161)	(0.0165)	(0.0191)	(0.0194)
Digital *(Applicant speaks indigenous language)	0.0384***	0.0376***	0.0545**	0.0532**	0.0361	0.0338	0.0338	-0.0089	-0.0097	-0.0057	-0.0076	-0.0134
	(0.0130)	(0.0131)	(0.0243)	(0.0243)	(0.0242)	(0.0241)	0.0125)	(0.0126)	(0.0163)	(0.0164)	(0.0174)	(0.0175)
Digital *(Applicant is 40 or older)	-0.0184	-0.0190	-0.0439*	-0.0446**	0.0098	0.0098	-0.0179	-0.0203*	-0.0145	-0.0147	-0.0232	-0.0252
	(0.0160)	(0.0160)	(0.0225)	(0.0227)	(0.0201)	(0.0200)	(0.0112)	(0.0114)	(0.0169)	(0.0168)	(0.0161)	(0.0161)
Digital *(Applicant attended public school)	0.0738***	0.0736***	0.0579*	0.0579	0.1028***	0.1020***	-0.0318***	-0.0320***	-0.0281**	-0.0286**	-0.0380**	-0.0404**
	0.0227)	(0.0228)	(0.0351)	(0.0353)	(0.0320)	(0.0323)	(0.0104)	(0.0105)	(0.0123)	(0.0128)	(0.0157)	(0.0153)
Digital *(Female applicant wears indigenous attire)					0.0574*	0.0597*					0.0073	0.0062
					(0.0313)	(0.0312)					(0.0230)	(0.0230)
Renewal day fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Renewal table fixed effects	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes
Observations	19,542	19,542	10,029	10,029	9,513	9,513	13,497	13,497	7,196	7,196	6,301	6,301

From columns 1 to 6, estimates reported are marginal effects from probit regressions using success rates as dependent variable. From 7 to 12, estimates reported are marginal effects from OLS using log of renewal times as dependent variable. The digital renewal process indicator is estimated using the observed renewal process after incorporating technical failures. Standard errors in parentheses are robust against arbitrary heteroskedasticity in the variance-covariance matrix and clustered at the table level across all specifications. *** Significant at 1 percent. ** Significant at 5 percent. * Significant at 10 percent.

Appendix 5: Intention-To-Treat Estimates

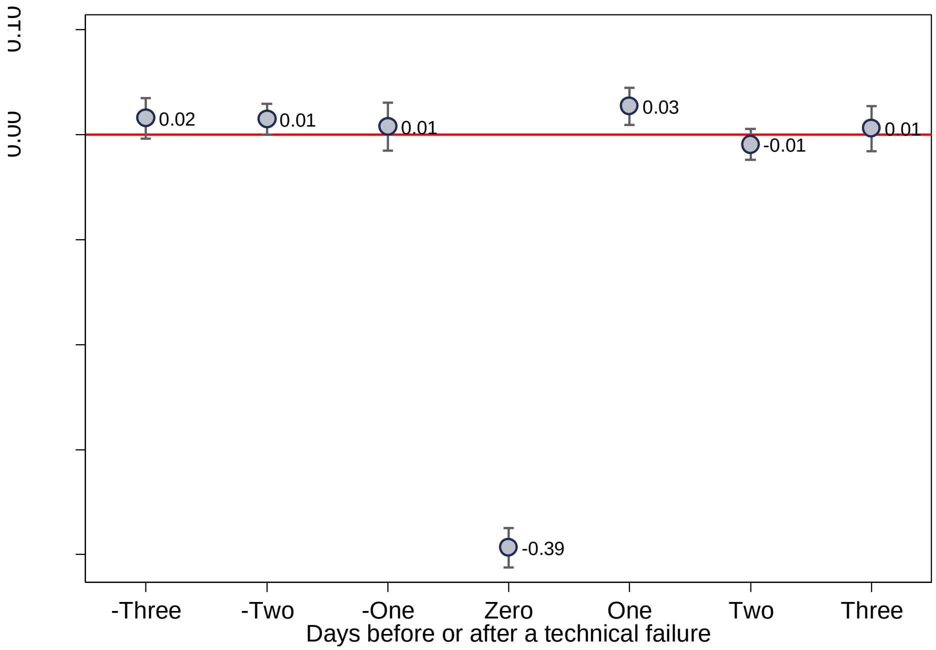
Dependent variable	Success Rates						Log renewal times					
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	All applicants		Male applicants		Female applicants		All applicants		Male applicants		Female applicants	
Zij	0.1827***	0.1033***	0.1322***	0.0843***	0.2352***	0.1084***	-0.3637***	-0.3009***	-0.3630***	-0.3011***	-0.3650***	-0.3004***
	(0.0066)	(0.0209)	(0.0088)	(0.0280)	(0.0099)	(0.0349)	(0.0130)	(0.0201)	(0.0148)	(0.0234)	(0.0130)	(0.0224)
Applicant is from rural areas		-0.1219***		-0.1209***		-0.0992***		0.1108***		0.1073***		0.1099***
		(0.0125)		(0.0200)		(0.0185)		(0.0100)		(0.0138)		(0.0148)
Applicant did not finish high school		-0.0837***		-0.0427***		-0.0708***		0.0766***		0.0819***		0.0648***
		(0.0077)		(0.0127)		(0.0155)		(0.0117)		(0.0136)		(0.0149)
Applicant speaks indigenous language		-0.0445***		-0.0699***		0.0044		0.0097		0.0156*		-0.0021
		(0.0076)		(0.0143)		(0.0110)		(0.0073)		(0.0090)		(0.0110)
Age of applicant is 40 or older		-0.0173**		-0.0323***		0.0075		0.0146**		0.0064		0.0209**
		(0.0080)		(0.0121)		(0.0122)		(0.0059)		(0.0075)		(0.0093)
Applicant attended public school		-0.0919***		-0.1025***		-0.0908***		0.0463***		0.0410***		0.0526***
		(0.0125)		(0.0209)		(0.0160)		(0.0074)		(0.0107)		(0.0109)
Female applicant wears indigenous attire						-0.1109***						0.0253
						(0.0149)						(0.0169)
Zij *(Applicant is from rural areas)		0.0768***		0.0456*		0.1115***		-0.0757***		-0.0470**		-0.1104***
		(0.0156)		(0.0236)		(0.0201)		(0.0154)		(0.0198)		(0.0210)
Zij *(Applicant did not finish high school)		0.0450***		0.0238		0.0173		-0.0655***		-0.0899***		-0.0440**
		(0.0108)		(0.0174)		(0.0248)		(0.0132)		(0.0170)		(0.0188)
Zij *(Applicant speaks indigenous language)		0.0236		0.0365*		0.0240		-0.0109		-0.0031		-0.0289
		(0.0144)		(0.0201)		(0.0237)		(0.0124)		(0.0177)		(0.0182)
Zij *(Applicant is 40 or older)		-0.0112		-0.0274		0.0029		0.0024		0.0055		-0.0038
		(0.0127)		(0.0217)		(0.0159)		(0.0108)		(0.0146)		(0.0163)
Zij *(Applicant attended public school)		0.0383*		0.0193		0.0705**		-0.0366***		-0.0382**		-0.0344**
		(0.0228)		(0.0323)		(0.0343)		(0.0120)		(0.0144)		(0.0163)
Zij *(Female applicant wears indigenous attire)						0.0517*						0.0170
						(0.0283)						(0.0243)
Mean of dep. var. given Zij=0		0.6235		0.6346		0.6112		0.6235		0.6346		0.6112
Renewal day fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Renewal table fixed effects	No	No	No	No	No	No	No	No	No	No	No	No
Observations	19,542	19,542	10,029	10,029	9,513	9,513	13,497	13,497	7,196	7,196	6,301	6,301

From columns 1 to 6, estimates reported are marginal effects from probit regressions using success rates as dependent variable. From 7 to 12, estimates reported are marginal effects from OLS using log of renewal times as dependent variable. The digital renewal process indicator is estimated using the observed renewal process after incorporating technical failures. Standard errors in parentheses are robust against arbitrary heteroskedasticity in the variance-covariance matrix and clustered at the table level across all specifications. *** Significant at 1 percent. ** Significant at 5 percent. * Significant at 10 percent.

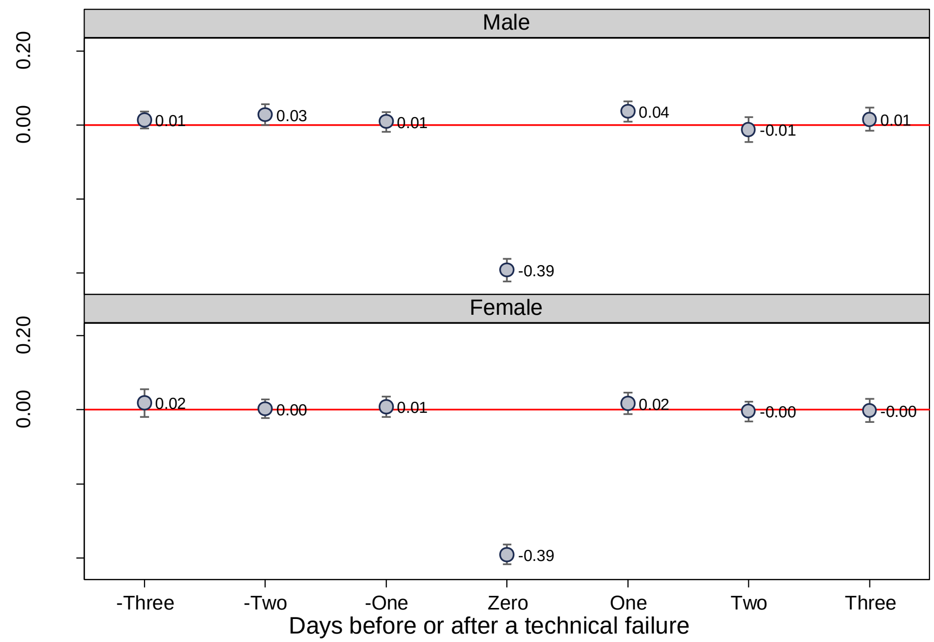
Appendix 6: Figures

Figure A
Time-Event Study of the Effect of Digital Technologies on Renewal Times

Panel A: All applicants

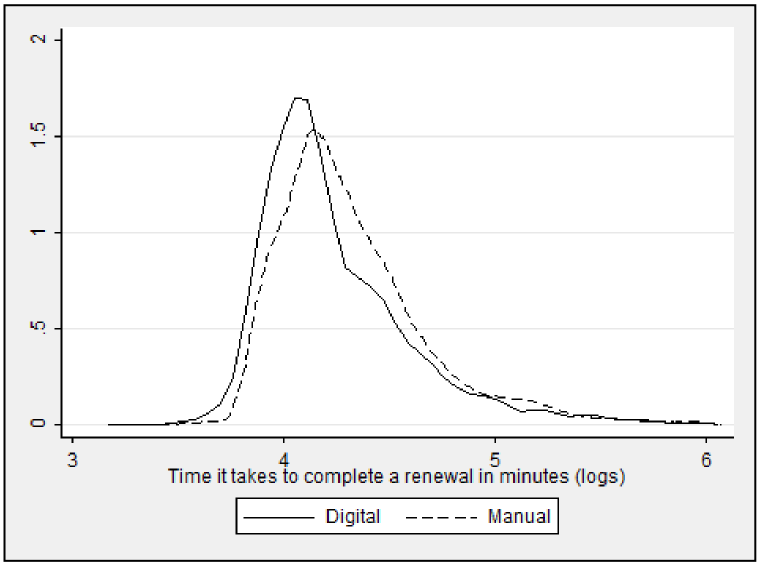


Panel B: By sex



Estimates of the coefficients associated to leads, lags and current values of $digital_{ijt}$ in equation (3). Estimates reported are marginal effects from OLS regressions. The vector of applicant characteristics include: whether the applicant is from rural areas, whether applicant did not finish high school, whether applicant speaks an indigenous language, whetter the age of applicant is 40 or older, whether applicant attended public school. For the sample of females, we also include a variable indicating whether the applicant wears an indigenous attire. 95% level confidence intervals reported.

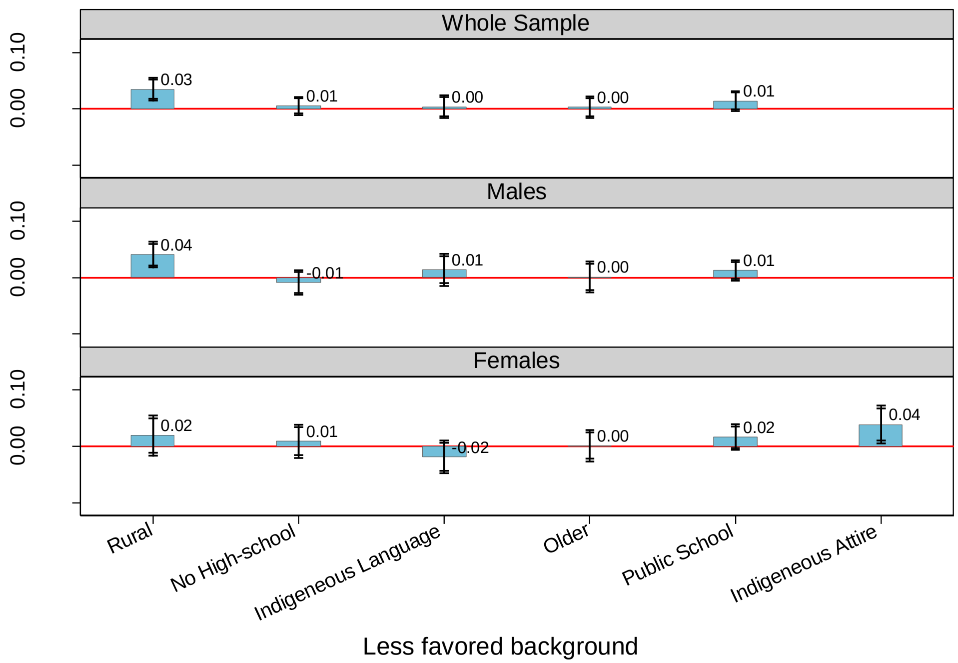
Figure B
Distribution of Time to Complete Renewal of ID Cards



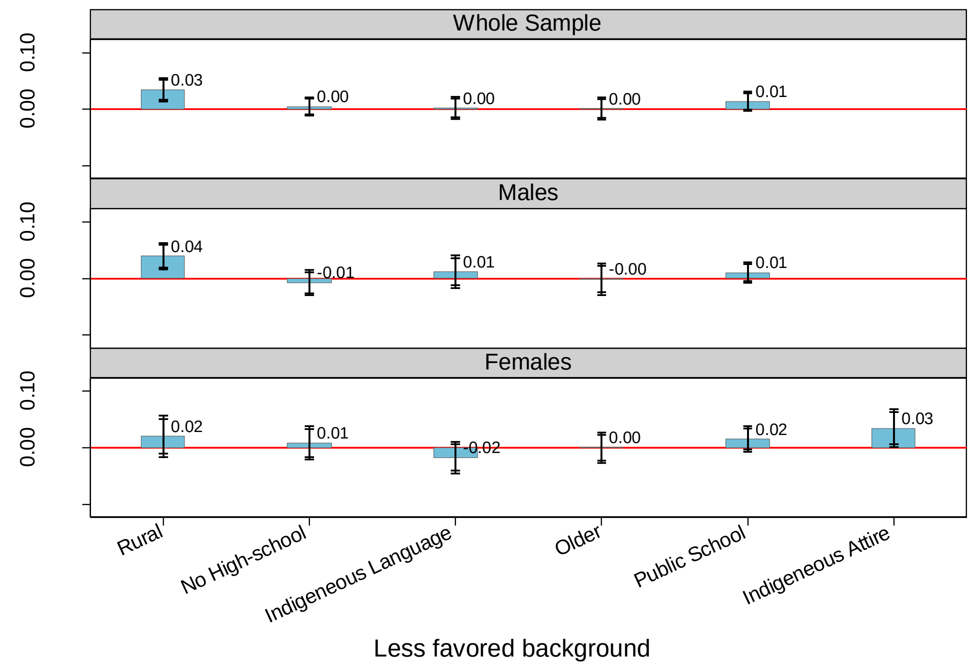
The probability distribution function is estimated using a Epanechnikov kernel, BW = 5. The two-sample Kolmogorov-Smirnov test for equality of distribution functions yields 0.582 (p-value = 0.00)

Figure C
Gaps in Renewal (Log) Times of Less Favored Groups After the Introduction of Digital Technologies

Panel A: Day fixed effects

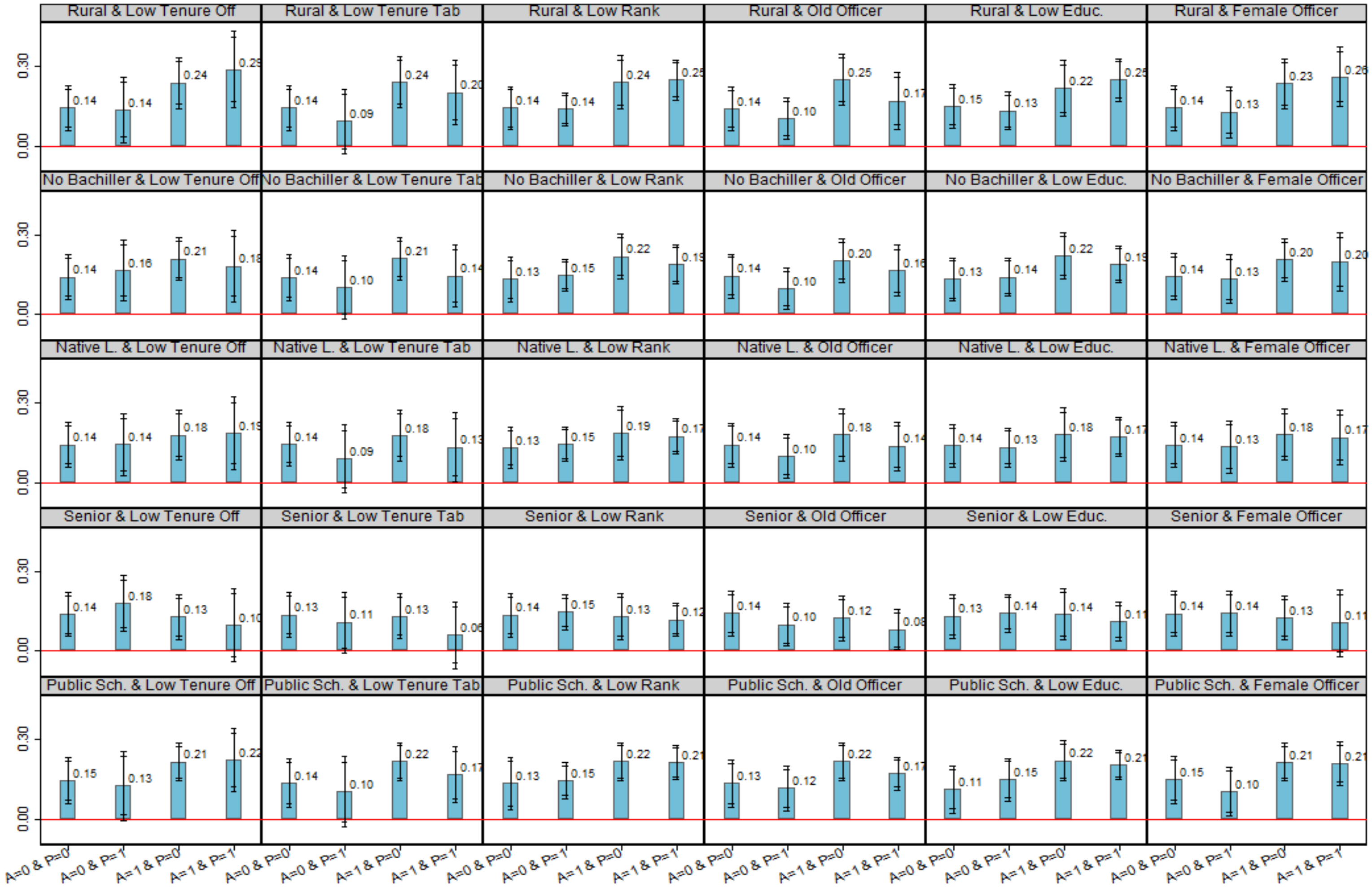


Panel B: Differences-in-differences



All statistics are computed based on estimates reported in columns (7) to (12) of Appendix 3. Panel A is based on estimates from equation (1), whereas Panel B is based on estimates from equation (2). For the marginal effect of characteristic "a" in the x-axis, we test the null hypothesis "$(a + digital \times a) \times = 0$", where "$digital \times a$" is the marginal effect of the interaction between the characteristic "a" and the dummy "digital". Results are interpreted as a gap in the renewal times of a less favored group with respect to a more favored group. A positive result of for example 0.05 means that renewal times are 5 percent higher for applicants belonging to the less favored group. 90% and 95% level confidence intervals reported.

Figure D
Heterogeneous Effects on Success Rates – Interaction Between Applicants' and Police Officers' Characteristics



Each square shows the result of estimating equation (5) including additional interaction terms, namely, the interaction between one of the applicant's characteristics and one of the police officer's characteristics. Each bar within each square is the estimated marginal effect for a particular group. For example, focusing on the first square in the upper left part of the figure, the first bar reports the marginal effect of digital technologies on urban applicants (A=0) matched with an officer that has high tenure in the administrative office (P=0). The second bar reports the marginal effect on urban applicants (A=0) matched with an officer that has low tenure in the administrative officer (P=1). Third bar reports the marginal effect on rural applicants (A=1) matched with an officer that has high tenure in the administrative officer (P=0), and so on. 90% and 95% confidence intervals reported.