Computers, Discretion and Discrimination:

Evidence from Two Natural Field Experiments

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Abstract

Whereas computer technologies increase productivity, they also diminish discrimination by reducing discretion in situations of monopoly power in the public sector. We exploit two natural field experiments related to the renewal of identification cards in Bolivia to show that, as expected, applicants randomly assigned to a computer process are more likely to complete renewal faster as compared to those assigned to a manual one. More interestingly, we also find that computers help reduce discrimination based on observable characteristics, such as age, gender, and rural-urban background. Finally, we find that corruption may be reduced too, as it typically goes hand in hand with discrimination issues.

Key Words: Automation, Bribes, Public Service, Corruption, Productivity, Latin America

JEL Classifications: H40, J71, O38, O10

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1. Introduction

Most studies on the role of computers and related technologies on the economy have focused on their potential to achieve increased productivity and growth. This is unsurprising given the type of efficiencies that computers can bring to productive and administrative processes and it is particularly true in the context of the deeply ingrained highly bureaucratic procedures typical of the public sector[1]. For instance, accessing, matching, and verifying vital records of applicants, slow and deficient record keeping, data input mistakes, and a broad host of common administrative shortcomings may by dramatically facilitated with the use of computers which may affect governance and public service delivery outcomes through different channels, including efficiency, effectiveness, and increased access (World Bank, 2011). Furthermore, given the significant low quality of public service delivery in and the relatively low cost of adopting computer technologies, their potential positive returns can be even larger for developing countries. In fact, these technologies possess some additional characteristics that have been somewhat overlooked from the perspective of their potential economic repercussions, thus underestimating their benefits. In particular, they can help limit discretion from authorities and by doing so they may help promote transparency, which is compounded by the fact that they allow for faceless, anonymous, and virtual interactions, which when used properly may help promote greater equality.

In this paper we take explicit consideration of these particular characteristics of computer technologies in the context of a modernization effort in the public sector of a developing country. We focus on a common, but crucial administrative procedure required in many countries, which is the issuance and renewal of national identification cards for adults. These cards, which are currently in more than one hundred countries around the world, must be shown on demand on everyday circumstances and as such, are the most important piece of information required in many of these countries in order to pursue everyday endeavors, including most of administrative tasks related with both the public and the private sectors, such as opening bank accounts, registering at schools, applying for social services, purchasing mobile phones, registering to vote, and even

[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).

logging on to websites many others. In short, in these countries identification cards are an essential document to fully participate in society[2]. It is very clear that the issuing entity, typically a law-enforcement government agency, and in particular, its issuing agents, will have monopoly power on the issuing of identity cards. Computer technologies may significantly reduce affect the way in which citizens and governments interact, and whether they may help improve interactions and improve the delivery of services as well as enhance government efficiency and transparency.

We take advantage of two randomized natural experiments occurring within the national identification card renewal process in Bolivia, which is a compulsory process for adults and 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, which 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 working 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 exploit the occurrence of technical failures by comparing applicant-police officer pairs randomly assigned to the digital or manual process after controlling for police officer fixed effects and day fixed effects. Put it differently, we exploit a difference-in-difference strategy and compare applicant-police officer pairs that ended in a manual process due to a technical failure to applicant-police officer pairs that ended in a digital process before and after the occurrence of the failure. The quality of public service delivery within this bureaucratic process is measured in 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, around 23 percentage points more likely to complete the renewal process as compared to those randomly assigned to the manual process. Furthermore, applicants who are able to complete the renewal process and who are randomly assigned to the digital process, take on

[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).

average 39 percent less time to complete the renewal process as compared to the average time taken by 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 very strong evidence that characteristics of applicants are significant predictors of completion success and completion time of the renewal process. Applicants from rural areas, indigenous groups, lower levels of education, and lower socioeconomic groups all have relatively lower success rates, which is not fully consistent with a simple story of efficiencies only, but brings about issues related to preference-based discrimination. In fact, we find that the differences in preferential treatment are likely due to corruption. In this context we contribute to the literature on economics of discrimination by providing very robust evidence that computers serve as effective tools to reduce discretion and promote equitable public service delivery in the form of issuing of identification cards, which appears to be particularly useful in contexts where both preference-based discrimination is pervasive and widespread, such as when it cuts along social and economic characteristics, not only including treats such as race and gender, but also poverty, schooling, and others. [3]

In addition, this research speaks to a broad literature that explores the benefits and risks of automation and information and communication technologies (ICT). Acemoglu and Restrepo (2019) argue that automation enables capital to replace labor, but at the same time allows the creation of new tasks in which labor has comparative advantage. In this regard, Autor et al. (2003) find that computer capital substitutes workers in performing certain cognitive and manual tasks that can be easily performed by following explicit rules. However, it may complement workers in carrying out nonroutine problem-solving and communications tasks. In this research, we are studying the introduction of a technology that is complementary to labor. This is because the renewal of identification cards entails certain communication tasks between police officers and applicants that are not easily automated, which results in high discretionary power from police officers.

In this context, the introduction of digital technologies may not only increase efficiency through their complementarity with labor, but may also promote equality as they may decrease the discretion exerted by police officers. This is particularly relevant as the renewal of

[3] For a review on field experiments related to discrimination, refer to Bertrand and Duflo (2016).

identification cards is an important public service and inequalities in its provision may disproportionally hinder certain disfavored groups. However, decreasing discretion of officers can also reduce efficiency in the delivery of the public good as discretion may be necessary to accomplish tasks of greater complexity (Busch et al., 2018). This is related to Autor and Scarborough (2008) and Behaghel et al. (2015) in the context of firm hiring. They show how changes in screening technologies affect differences in hiring outcomes across "majority" and "minority" groups. We ask the same type of questions in the context of public service delivery.

Finally, this research also contributes to a literature in public administration about automating processes in the public sector, a topic that has not been explored extensively in economics to the best of our knowledge. Street-level bureaucrats are public service workers who interact directly with the public, such as the police officers in our context, and it is commonly believed they exert significant discretion when interacting with the public (Lipsky, 2010).[4] In this context, Wenger and Wilkins (2009) discusses the introduction of telephone claims in US state Unemployment Insurance offices. They find that telephone claim filling increases the number of women receiving UI benefits but does not affect the number of men receiving these benefits. They argue that the automation provided by the telephone claim filling restrained discretion of street-level bureaucrats and eliminated the bias that women faced when entering an UI office. Moreover, Schuppan (2009) argue that transferring ICT technologies from developed to developing countries without additional efforts may cause unintended effects as different initial institutional, cultural and administrative contexts must be taken into account. Hence, we contribute 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 remainder of this paper is organized as follows. Section 2 describes the two natural experiments exploited in our research. Section 3 describes the data. Section 4 presents the empirical framework. Section 5 presents our main findings. Section 6 presents the possible role

[4] Previous research in this literature has concluded that ICTs can both increase and decrease discretion exerted by street-level bureaucrats, and this depends on different features as culture, type of tasks and work organization as the technology (Buffat, 2015). For example, digital technologies can prevent bureaucrats from manipulating information streams between institutions and the public and in general challenge their ability of making decisions. However, they can also increase discretion as digital technologies can coexist with face-to-face interactions. For example, 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 (Buffat, 2015). A review of ICTs and street-level discretion is found in Busch and Henriksen (2018) and Bovens and Zouridis (2002).

of corruption in discrimination outcomes. Section 7 summarizes and concludes.

2. Institutional Background

2.1. The 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. In many countries, this involves a complicated process, which is usually associated with excessive bureaucracy, discrimination, and corruption.

The national identification card renewal process in La Paz, the capital city of Bolivia, is administrated by the Police[5]. For this study, we focus on the main administrative office located in the capital city of La Paz, which handles the vast majority of applications, approximately 1200 requests per day.[6] In order to renew a national identification card, an individual must bring a proof of identity to the administrative office and pay an application fee of US 2.50 dollars in local currency[7]. Upon presentation of a valid proof of identity, the applicant receives a token with a table number and gets her thumb marked with indelible ink. 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, she 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. An important thing to mention here is that the Vital Records Archive was not publicly available and only accessible to police officers. Once the vital records of the applicant were physically retrieved, the last name of the applicant was called in order to go through a series of additional steps to complete the renewal process, including (i) paying a renewal fee in a separate collection office; (ii) having a photograph taken[8]; (iii) fingerprinting; and, if needed, (iv) updating

[5] 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).

[6] 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.

[7] 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.

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

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.

Failing to renew the identification card could be due to several reasons. First, applicants who find bureaucratic delay overwhelming may decide to drop out at some point in the middle of the renewal process and come back later. It should be mentioned that the renewal processes cannot be put on hold — if they are not completed by the end of the day, the applicant needs to start a whole new renewal process. In our case, because of the nature of the data collection, dropouts are implicitly classified as unsuccessful applicants in our sample. Yet, it is highly unlikely that these represent a large proportion of unsuccessful applicants. Applicants that decide to dropout in the middle of the process faced transportation expenses and substantial time costs. Because of the indelible ink used to mark thumbs, the applicants cannot 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.

Second, the process of renewing a national identification card in Bolivia was traditionally associated with red tape and lengthy delays.[9] Administrative shortcomings were pervasive within this process. Vital records were frequently reported as missing because of the poor archiving system, which was based on the last name of the applicant only. While this is not unsurprising, given that the Vital records archives held more than one million physical records in a small physical location, anecdotal evidence had long claimed that there was a systematic pattern in the reported records lost (e.g. World Bank, 2000; Wanderley, 2007). Furthermore, 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. The extent to which this systematic pattern actually existed or not and if so, whether this might be resulting from discrimination, corruption, or simply systematic shortcomings on part of the applicants' paperwork is unclear. However, since we focus on identification card renewals only, any differential paperwork quality among applicants required to complete the process is a highly unlikely explanation for any

one.

[9] 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.

variation in renewal outcomes. Individuals applying for renewals must be applicants who five years ago, the renewal timeframe, were able to successfully obtain a national identification card. This means that, in theory, the administrative office must have all the paperwork required to complete the renewal process for each of those applicants.[10]

Finally, given the homogeneity in the quality of paperwork needed to apply for the renewal of an identification card, observable characteristics of applicants should in principle not be a determinant of the probability of being successful at obtaining an identification card. However, as we will see later, we do observe a systemic correlation between success rates and applicants' characteristics. There is qualitative and descriptive evidence suggesting that government officials in charge of this process might be practicing a selective enforcement of rules. Hence, it is unlikely that the discretion given to police officers in this context allows them to improve the screening of bad applications. We review this evidence below.

First, this systemic correlation is consistent with government officials trying to seize on the opportunities given by the discretion that the administrative process allows them. After all, because of the highly asymmetric power position between applicant and government officials, the latter might be able to complicate the process to create incentives for applicants to pay bribes in order to complete the process, such as arbitrarily increasing wait times, claim loss of documents, increase the number of additional steps required to process paperwork, and many others[11]. This is supported by in-depth interviews carried out to users of this public service (Wanderley, 2007). Moreover, these interviews suggest that the applicants at higher risk of being targeted are those who face higher transaction costs, for example, those that come from faraway places, which have to pay for transportation and accommodation expenses and are from relatively disadvantaged backgrounds, which implies that they tend to be less demanding and less likely to voice complaints. This is consistent with the survey instrument we designed asking about direct and indirect requests for bribes by police officers, which we applied to a sample of 780 individuals

[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.

[11] This is consistent with Autor and Scarborough (2008) who argue that the effect of a new screening technology on discrimination will depend on how they reduce information asymmetry. If computers increase the informational signal for the disadvantaged group relative to the majority group, then they reduce discrimination. Moreover, if computers increase overall information available to risk-averse officers, then the average success rate of both groups would also increase.

that had gone through a renewal process at the national identification card administrative office in la Paz. We review these results in Section 6.

Second, in Latin America it is very common to observe differential treatment based on specific characteristics. This suggests that a selective enforcement of rules might be practiced among government officials because they might be biased and exhibit strong preference-based discrimination. 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, 2011). Inclusively, 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). In this context, computer technologies may act as a brake to curb petty corruption in administrative processes in the public sector, reducing or even eliminating the possibility that government officials may stall or introduce barriers in procedures, by reducing discretion and introducing implicit accountability to the process.

Third, it may also be possible that bureaucratic procedures affect applicants differently based on their intrinsic observable characteristics. As mentioned above, the process of renewing a national identification card in Bolivia is known to be chaotic and full of bureaucratic procedures. In this context, illiterate applicants may find it harder to navigate the administrative steps established by public officials because they are not being able to read signs. Administrative procedures may intimidate people, particularly those among groups from disadvantaged backgrounds. Endogenous red tape may be introducing an inequality dimension into the administrative process by requiring some skills from applicants, which may in turn translate into differential renewal outcomes based on their characteristics. By allowing applicants to perform all the renewal steps within one physical location, computer technologies might be significantly facilitating the process for the applicant and, thus, reducing observed gaps in renewal outcomes based on the characteristics of applicants. Finally, the characteristics of government officials may also matter, including skills and experience.

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 analogue 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 complied 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 you could have two manual tables next to each other, then a digital one, and then another manual one. Or you 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 table initially assigned to the digital process, 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.[12]

[12] While it may be claimed that technical failures may not be random, police officers assigned to a digital table faced high costs of switching to a manual process. In particular, they had to file a detailed report, which significantly delayed the time they could go home after ending a working day. That is,

3. Data

We collected data at the applicant level, at the police level, and at the applicant-police level. The primary data at the applicant-police level were collected using a simple software platform specifically designed for this study[13]. These include: whether the process of renewal was successful or not, 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[14].

The administrative data at the police officer level include basic socioeconomic characteristics, the information related to technical failures at renewal tables, and the renewal table number. The basic socioeconomic characteristics of police officers were collected from administrative records provided by the central administrative office. These data include sex, age, rank, years of education, tenure at the administrative officer, 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 old. All these data were

given the sequential rule used to allocate applicants across renewal tables, all police officers working in the Identification Unit ended up serving to a similar number of applicants by the end of the day. After the doors to the public were closed, police officers had to finish to help all applicants assigned to their tables, which required them to stay late if they had faced delays during the day. Moreover, the technician would have to report back on the issue resolved at the table so it was not that simple for the police officer to trick the system.

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

[14] Most of the information was retrieved from the expired identification card. If another document was provided as proof of identity the missing information was collected directly from the applicant. The data on indigenous language and private school status was self-reported.

collected between October and December of 2009.

We also applied an additional survey to individuals who had undergone renewal processes in order to explore possible key covariates of differential treatment based on observables. In particular, we focus on corruption outcomes. The survey instrument and corresponding findings are presented in detail in Section 6.

Table 1 presents summary statistics for variables at each of the levels described above. Panel A presents variables at the applicant-police officer 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.[15] 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 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 all the evaluation period, 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. To fix ideas, we can call this assignment variable as Z_{ij}. Z_{ij} takes the

[15] 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.

value of one if individual *i* is *ex ante* matched to a digital renewal table held by police officer *j*, and zero otherwise.[16] One may wonder whether this randomization effectively produced two comparable groups. Columns 1, 2 and 3 of Table 2 shows that this may be in fact the case as 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 they seem to be small.[17]

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. It takes the value of zero otherwise.[18] As we will explain with detail below, we are interested in exploiting variation in the treatment assignment within the same police officer to control for unobserved variables at the police officer level. To do so, technical failures need to arise independently of applicants' characteristics. Columns 4, 5 and 6 of Table 2 shows that this seems to be true 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.[19]

Using the *ex-ante* assignment variable, Z_{ij}, and the variable indicating technical failures, F_{ijt}, we can define an *ex-post* assignment variable which we call $digital_{ijt}$. It indicates whether

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

[17] Moreover, in columns 1 to 3 of Table A1, 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.

[18] 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 (%)".

[19] In columns 4-6 of Table A1 we show the difference in means between tables that were initially assigned to be digital and ended using the digital process, against those that ended using the manual process due to technical problems. Again, p-values were calculated empirically using a randomization inference procedure. Differences are not statistically significant at conventional levels.

the applicant *i* in fact ended in a digital table held by police officer *j* at day *t*. In other words, $digital_{ijt} = Z_{ij} \times (1-F_{ijt})$. We argued 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 8 of Table 2 again shows that this may be true in general, although again there seems to be some small differences in the share of applicants with complete high-school education and in the share of rural applicants.[20]

4.2. Average effects

To identify the causal effect of computer technologies over traditional technologies on the provision of national identification cards for citizens 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 *ex-post* were assigned to digital tables against those that *ex-post* were assigned to manual tables. We can carry out this comparison as we argue that $digital_{ijt}$ is 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:

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

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 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 police officer level.[21]

Second, we exploit the variation stemming from technical failures. The basic idea is to

[20] In columns 7-9 of Table A1 we show the difference in means between tables that were initially assigned to be digital and ended using the digital process against those that ended using the manual process, without conditioning on *ex-ante* assignment. Again, p-values were calculated empirically using a randomization inference procedure. Differences are not statistically significant at conventional levels.

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

compare changes in the success rate (or renewal times) 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 the following regression model:

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

where and θ is a vector of police officer fixed effects.

There are some differences between specification (2) and specification (1) that are worth highlighting. First, note that according to 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, within each day. Given that according to Table 2 differences in observable characteristics within the eighteen *ex-ante* digital tables are neglible (see columns 4 to 6), this may 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 police officer level, whereas this is not possible under specification (1).

Third, given the administrative procedures followed by the Police, technical failures could not be addressed the same day of the occurrence of the event 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. Hence, some applicants received during a day in which a failure occurred are recorded as following a manual process when in fact they followed a digital process. This contamination bias should reduce the measured impacts and may disproportionally affect specification (2) as it is well known that the differences-in-differences method tends to exacerbate any measurement error. For these reasons, throughout this research we present estimates from equation (1) and equation (2). Finally, a key identification assumption in our differences-in-differences strategy is that in absence of the digital procedures both digital and manual tables (that were first assigned to be a digital proccess) would have evolved similarly. Even though this assumption is untestable, we can check for parallel pre-trends by including leads of our treatment

variable $digital_{ijt}$ in our specification in (2). We can also include lags to analyze whether treatment effects change over time after the occurrence of a technical failure. In other words, we can estimate the following equation:

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

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

4 3. Heterogeneous effects

Through equations (1) to (3) we have included a vector of applicants' and police officers' characteristics, *X*, as they may be important determinants of the renewal process. However, 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 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 natural 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. In order to explore these hypotheses, we use the following empirical specifications:

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

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

Where X can be either a vector of applicants' characteristics ***Ai*** including age, education, gender, rural origin, type of school, language spoken, and indigenous attire; and a vector of police officer characteristics ***Pj*** 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. 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.

5. Findings

Table 3 presents the effects of computer technologies on the probability of successfully completing a renewal process. All the coefficients reported are marginal effects from probit regressions, and are separately estimated for all applicants and for male and female applicants to focus in our women's indigenous attire variable, an objective and very clear indicator of women's background in the context of Bolivia. The effect of computer technologies over traditional technologies after controlling for renewal day fixed effects, or coefficient β in (1) in the previous section, is presented in columns 1, 3 and 5 for all applicants and for male and female applicants, respectively. Columns 2, 4, and 6 show instead the effect of computer technologies over traditional technologies after controlling for police officer fixed effects and day fixed effect, or coefficient of γ in (2). As Table 3 shows, the adoption of computer technologies results in an overall improvement in the renewal process. Males randomly assigned to the digital process have a higher probability of completing the process of about 17.51 to 18.89 percentage points, compared to those randomly assigned to a manual process, which are statistically significant at one percent. For the case of females, the analogous improvement ranges from 28.52 to 26.92 percentage points, which is 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 from zero. This suggests that police officers were not able to predict when a failure was going to happen and act accordingly, which is reassuring of our identification strategy. Moreover, successful renewal rates sharply increased

during the same day the technical failure occurred, 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.

Going back to Table 3, columns 7 to 12 show the results of estimating (4) and (5), which control for the characteristics of the applicants and allow for technologies to interact with these characteristics. Columns 7 and 8 show the estimates for the whole sample, columns 9 and 10 for males, and columns 11 and 12 report our findings for females. These alternative specifications allow assessing the extent to which applicants' characteristics might be important determinants of success rates across type of renewal process. We also explore whether characteristics of the applicants may determine renewal success rates and find very strong evidence on renewal success rates. We show this in columns 7 to 12 too. Applicants from rural areas are around eleven percentage points less likely to complete the renewal process as compared to those from urban areas. Applicants 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. Finally, 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].

A natural question to ask is whether the adoption of digital technologies within the renewal process may help reduced some of these observed gaps in renewal success rates across the characteristics of the applicants. As shown in columns 7 to 12 we do find that, in fact, this is

[22] Interestingly, 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 inspection might be a more important aspect of being indigenous for citizens' lives as opposed to speaking an indigenous language.

the case. The effect of coming from the rural area is smaller in magnitude and opposite in sign to the magnitude of the effect of the interaction of coming from the rural area with being assigned to a digital process in the case of females. For males, the digital process reduced inequalities from this variable but did not reduce it completely. Similarly, the magnitude of the effect of having completed high school is similar in magnitude and opposite in sign to the magnitude of the effect of the interaction of having completed high school with being assigned to a digital process in the case of males. For females, if anything, the digital process reduced the gap observed.[23] Furthermore, the difference in success rates among male older and younger applicants is reduced by roughly four percentage points when randomly to renewal processes. Interestingly, success rates gap between indigenous and non-indigenous applicants is reduced by around six percentage points, as measured by knowledge of an indigenous language. Finally, the difference in 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 statistical 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. For the sake of clarity, this is: $H_0: -\left[ME(a) + ME\left(a * digital_{ij}\right)\right] = 0$, where ME(x) is the marginal effect of x. We have multiplied the whole 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 of for example 0.05 means that success rates are 5 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. Failing to reject the null for a particular dimension a may show that disparities in

[23] Note that among all applicants, being old does not seem to interact with the digital process. However, for older males, gaps in the delivery of the public service may increase compared with younger males after the introduction of digital technologies.

renewal rates along that dimension may have been eliminated by the digital process.

In Panel A of Figure 3 we show the exercise described above using equation (1), whereas in Panel B we show the results based on equation (2). First, this figure shows that both models produce almost identical results in terms of resulting gaps after the introduction of digital technologies. Moreover, we can see that in the whole sample of applicants most gaps disappear, although the gap for older applicants relative to younger applicants remains positive and small. In addition, when we divide the sample between males and females, we can see that not all gaps are totally eliminated, albeit they become considerable smaller. For males, we can still find gaps in terms of rural applicants, older applicants and applicants from public schools. For females, most gaps are not statistically different from zero at the 5% level. The only exception is the gap related to rural applicants 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.

Table 4 focuses on the time taken to complete the renewal process. To do this, we employ the sample of applicants who were successful at completing the renewal process, only. As before, all the coefficients are estimated for the whole sample and also separately for males and females. Focusing first in columns 1 to 6, applicants randomly assigned to the digital renewal process take on average around 38% to 42% less time than applicants in the manual process. We find similar numbers for males and females. Moreover, just as before, we estimate equation (3) to see if there are any anticipatory effects, ϕ_t, and post-treatment effects, γ_t. Results are shown in Figure 4. Panel A shows the results for the whole sample while Panel B shows the results for the sub sample of males and females. Again, the estimates for the anticipatory effects are particularly small and indistinguishable from zero, which is reassuring of our identification strategy. Moreover, renewal times sharply decreased, by almost 40%, during the same day of the technical failure. However, we find that the day after, successful applicants took 4% more time finishing their renewal process. Given that this effect is ten times smaller than the effect on the same day of the failure, it is of second order. Finally, Figure 5 shows the estimated probability density functions for each type of renewal process[24]. Unsurprisingly, we find that it takes less time to complete a digital process along all of the percentiles in the distribution. The two-sample Kolmogorov-Smirnov statistic testing for equality of both density functions is 0.582 with a p-value of 0.0.

[24] We estimate density functions using an Epanechnikov kernel.

Now we focus our attention to columns 7 to 12 of Table 4. The characteristics of applicants produce a similar pattern to that reported for the probability of completing the renewal process. Applicants from relatively disadvantaged backgrounds take longer to complete the renewal process when randomly assigned to the digital renewal process as compared to the manual one. In particular, applicants from rural areas take on average 10-11 percent more time to complete the renewal process as compared to those from the urban area. Applicants who did not complete high school take on average 6-8 percent more time to complete the renewal process as compared to those who did complete high school. Older people take on average 1-3 percent more time to complete the renewal process as compared to younger applicants. Moreover, applicants who attended a public school take approximately 4-5 percent more time. In addition, indigenous males, as measured by the ability to speak an indigenous language, take on average 4 percent more time to complete the renewal process as compared to those of non- indigenous descent. Finally, females wearing indigenous attire take on average 3 percent more time to complete the renewal process as compared to female applicants not wearing indigenous attire. Note that females speaking an indigenous language also take on average around 5 percent more time in finishing the renewal process[25]. Table 4 also reports the interactions between digital renewal and characteristics of the applicants. We find similar results as before as the use of digital technologies produce more equal results among less favored groups.

In Figure 6 we test whether the different characteristics of applicants and their interaction with a digital renewal process are jointly statistical significant, now using the log of renewal times as dependent variable. The idea is the same as before, that is, explore whether gaps in the access to the public service provided, in this case the identification card renewal process, remain after the introduction of digital technologies. In particular, we test the following hypothesis, which can be easily expressed using coefficients from equation (1), $H_0: \pi + \psi = 0$, or from equation (2), $H_0: \pi + \lambda = 0$. A positive result of for example 0.05 means that applicants from a particular less favored group takes 5 percent more time than applicants from a more favored group in finishing their renewal process. A negative result means that the gap was not only eliminated but was upturned after the introduction of digital technologies. Failing to reject the null for a particular show that disparities in renewal rates along certain dimension may have been eliminated by the

[25] In contrast with previous findings, wearing an indigenous attire is not as relevant to explain renewal times for females once the ability to speak an indigenous language is controlled for.

digital process. Results are similar when testing renewal times instead of renewal completion rates. For the whole sample, gaps are almost eliminated except for the case of rural applicants. For males, results are similar as for the whole sample. For females, the only gap that remains positive is that for female applicants wearing an indigenous attire.

We also explore whether the characteristics of police officers affect success rates as it is plausible that the application of technology is complementary to skills (Van Reenen and Chennells, 2002). In columns 1 to 6 of Table A2 we estimate equations (4) and (5) for success rates considering both, applicants' and police officers' characteristics and we show that given the nature of the police officers' randomization process, their background characteristics are, in general, not significantly correlated with success rates. Moreover, the interactions between technologies and police officers' characteristics are small in magnitude, does not show any clear pattern, and are not significant at conventional levels.[26] This suggests that the variation in success rates observed in the data is not the result of observed differences in police officer characteristics, which is confirmed when we compare the marginal effects of introducing digital technologies obtained from this table with those of Table 3. Similar conclusions are reached when we focus on renewal times, in columns 7 to 12.[27] [28]

To interpret our results, we must first recall the reasons why applicants' characteristics were systematically correlated with success rates and renewal times. In the first place, it could be

[26] Interestingly, the increase in success rates thanks to the introduction of digital technologies seem to be larger for females matched with low ranked police officers.

[27] Applicants' and officers' characteristic may interact as matching a particular type of applicants with a particular type of officers may determine the efficiency of the digital process. Figure A1 shows the effect of estimating equation (5) including additional interaction terms. In particular, each square reports the results of estimating equation (5) including the interaction between a particular applicant's characteristic and a police officer's characteristic. In general, officers' characteristics do not seem to greatly interact with applicants' characteristics. Perhaps the most noticeable effect is that old officers tend to produce worse results, especially for rural applicants and applicants from public schools (see the fourth column). Also, officers with low tenure at the renewal table seem to produce worse results especially for applicants with low education and senior applicants (see second column). Interestingly, officers with low tenure at the administrative office tend to produce better results for rural applicants than for urban applicants (the effect goes from 0.24 to 0.29 in the case of rural applicants, whereas for urban applicants it remains at 0.14). Another interesting pattern is in the case of senior applicants and low tenure officers (first column, fourth row). We can see the effect is larger for younger applicants matched to officers with low tenure, whereas senior applicants matched to high tenure officers tend to produce worse results.

[28] Table A3 shows the intention-to-treat estimates of the effect of *ex-ante* assignment to the digital process. These estimates may be informative from a policy implementation perspective, as technical failures were quite common and represent part of the costs of introducing digital technologies.

that the quality of the paperwork required to finish the process is heterogeneous and depends on applicants' characteristics. However, we argue this is unlikely as we focus on identification card renewals only. Individuals applying for renewals must be applicants who five years ago, the renewal timeframe, were able to successfully obtain a national identification card. This means that, in theory, the administrative office must have all the paperwork required to complete the renewal process for each of those applicants. Any improvements in the efficiency of compiling information thanks to the digital process should be uniform across different groups of applicants.

Second, it is true that depending on the context, giving more discretion to police officers may allow improve the screening of bad applications, however, again, paperwork quality was highly homogeneous across applicants, and given previous descriptive and qualitative evidence we argue this is unlikely. In fact, in-depth interviews suggest that because of the highly asymmetric power position between applicant and government officials, the latter might be able to complicate the process to create incentives for applicants to pay bribes in order to complete the process, such as arbitrarily increasing wait times, claim loss of documents, increase the number of additional steps required to process paperwork, and many others (Wanderley, 2007). Furthermore, 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).

We argue instead that discrimination is the more plausible explanation for our findings. Our results above appear to show that computers significantly lower structural barriers to individuals who otherwise may be discriminated against by reason of some specific observable characteristics, which is reflected in the dramatic improvements in terms of both completion success rates and time reduction when tracking their corresponding their national identification card renewal processes. Computer technologies may serve as effective tools at promoting equitable public service delivery due to the fact that discretion of agents with monopoly power may be drastically reduced. For instance, by drastically reducing the possibility that police officers may lie about not finding the vital records of an applicant, computer technologies implicitly add an accountability mechanism into the renewal process, which may be successfully operating in this setting to reduce barriers in access to identification card renewal by explicitly altering the probability of detecting malpractices among police officers. 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.

To give further evidence supporting that the discretion given to police officers may be exploited as a way for extracting bribes, we carried out a survey instrument asking about direct and indirect request for bribes by police officers. We present our results regarding this survey in the following section.

6. Exploring Discrimination and Corruption

As seen above, police officers may be applying discretion in the identification card renewal process based on specific observable characteristics. It is unclear whether government officials are behaving selectively in order to maximize the probability of extracting bribes or are using applicants' characteristics as signals for a better screening (Autor and Scarborough, 2008). Furthermore, applicants of certain characteristics may find it more difficult to navigate through the manual process, and thus introducing digital technologies has the effect of reducing gaps in the delivery of the public service.

In this section we try to shed light 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 with this survey 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 to have 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).

Table 5 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 facts standout. First, we can see that both the post-natural experiments survey and the data from Table 1 are very similar in terms of applicants' characteristics. Second, corruption is pervasive. At least 62 percent of our sample have answered positively to either (i), (ii) or (iii).

In this section we investigate whether the differential treatment observed in our natural field experiment in characteristics of the individuals helps determine corruption by testing the following reduced form:

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

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 6[29]. 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 6 presents our results. In Section 5 we show that gaps in success rates were larger for almost all disadvantaged group we considered. 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 high-school as our four outcomes in general are strongly correlated. 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, in our data all rural applicants were offered

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

"help" by police officers. Hence, we cannot estimate the marginal effect of living in a rural area.[30] Moreover, speaking an indigenous language or using an indigenous attire in the case of females is also strongly related with corruption, especially for the third corruption variable and hence for the aggregate dummy. Interestingly, applicants' age does not correlate with corruption, which goes in line with our findings from Section 5 as gaps in the delivery of the public service were small for older applicants.

These results are remarkably similar to the ones we find in our natural experiments.[31] While merely exploratory, these findings are at least consistent with our conjecture that differential service to certain groups of individuals that police officers deem easier to take advantage of, with the aim of extracting bribes and not simply because of any preference-based discrimination, only. The finding is also consistent with the existing literature on corruption as well as with surveys in Bolivia and other developing countries (Olken and Barron, 2009; Wanderley 2007; United Nations Development Program, 2009).[32]

7. Conclusions

Taking advantage of two randomized natural field 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 discrimination by reducing discretion and by increasing implicit accountability. In fact, computers and related technologies may have the potential to transform the way in which governments interact with citizens as well as on the manner in which 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. Whereas we show that the introduction of computer technologies leads to impressive improvements in efficiency and productivity, we find evidence consistent with the idea that the introduction of these tools may lead to a reduction in gaps associated to the delivery of the public

[30] 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.

[31] When asking questions related to customer satisfaction we also find results consistent with these findings. These additional results are available upon request.

[32] Interestingly, 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.

service, which we interpret as a reduction in discrimination lead by a decrease in police officers' discretion. These results are impressive given the significant differential service provision to individuals in our experiment. Our findings are also consistent with the idea that computers may lead to a reduction of corruption in the public sector. 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.

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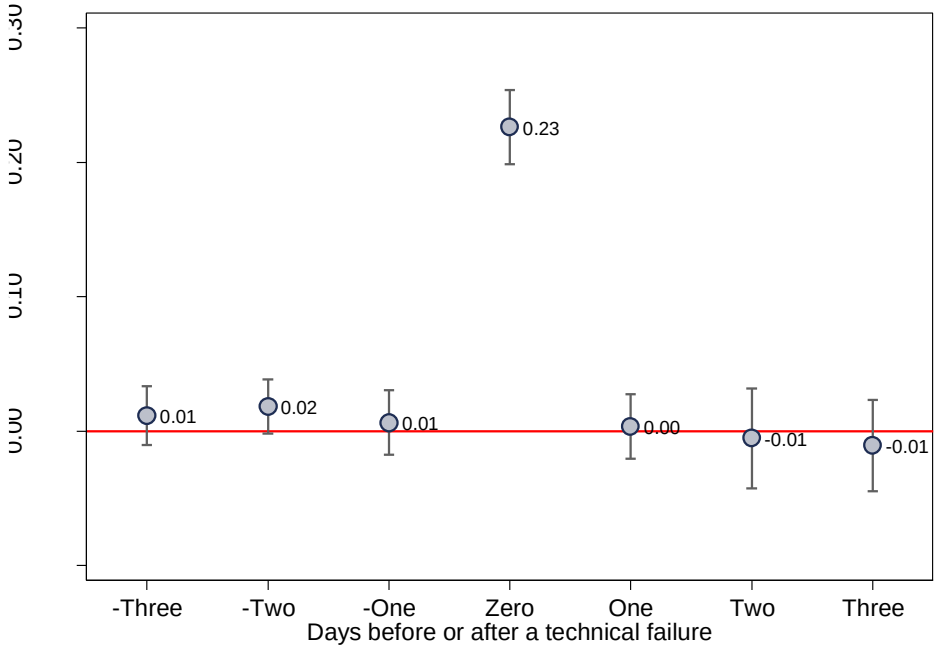
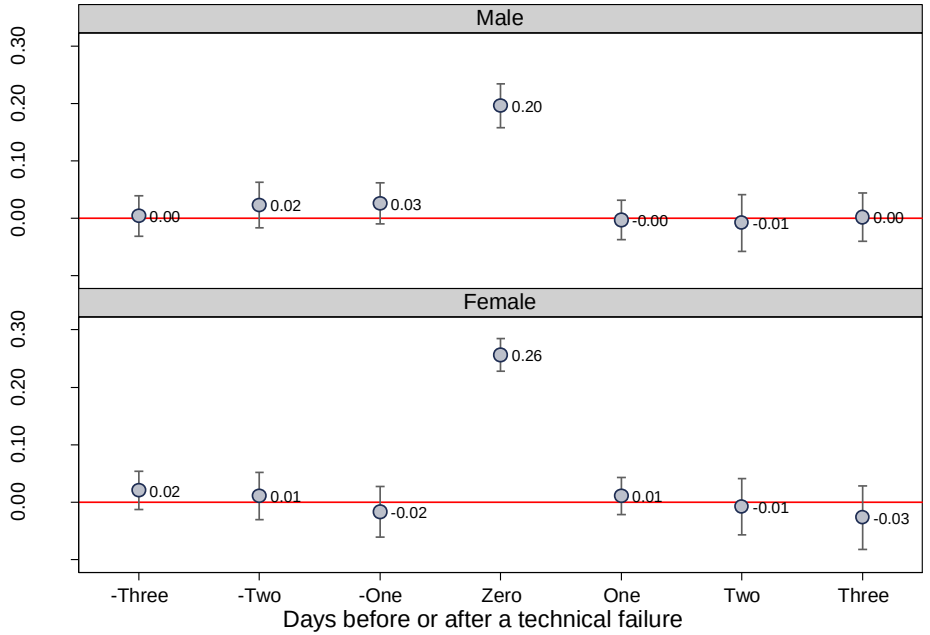
Figure 1
Software Platform for Primary Data Collection

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

Panel A: All applicants



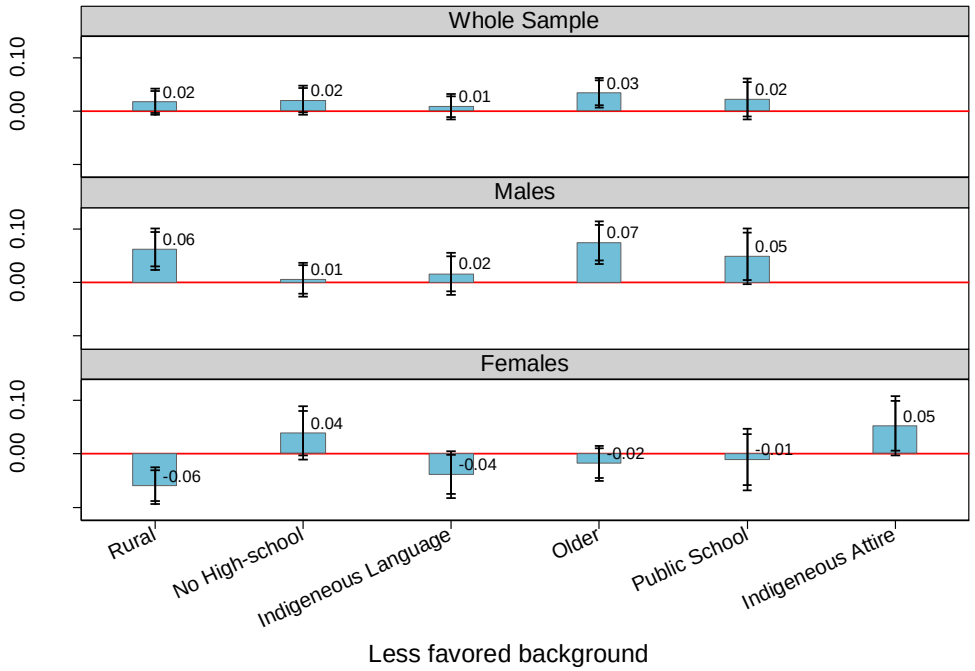
Panel B: By sex



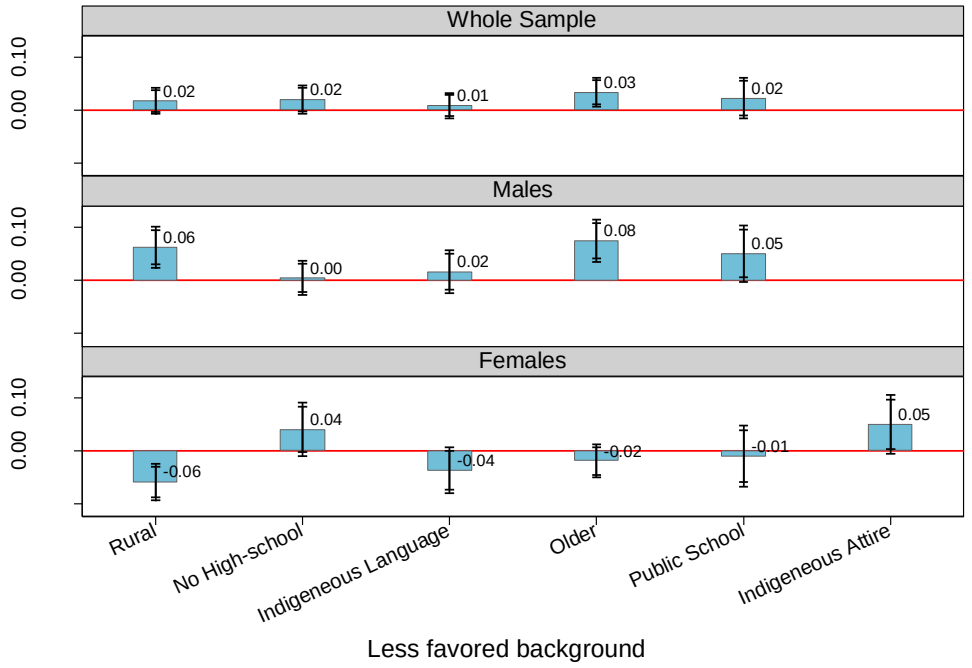
Estimates of the coefficients associated to $digital_{ijt}$ in equation (3). Estimates reported are marginal effects from probit regressions. The vector of applicant characteristics include: whether the applicant is from rural areas, whether applicant did not finish high school, whether applicant speaks 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



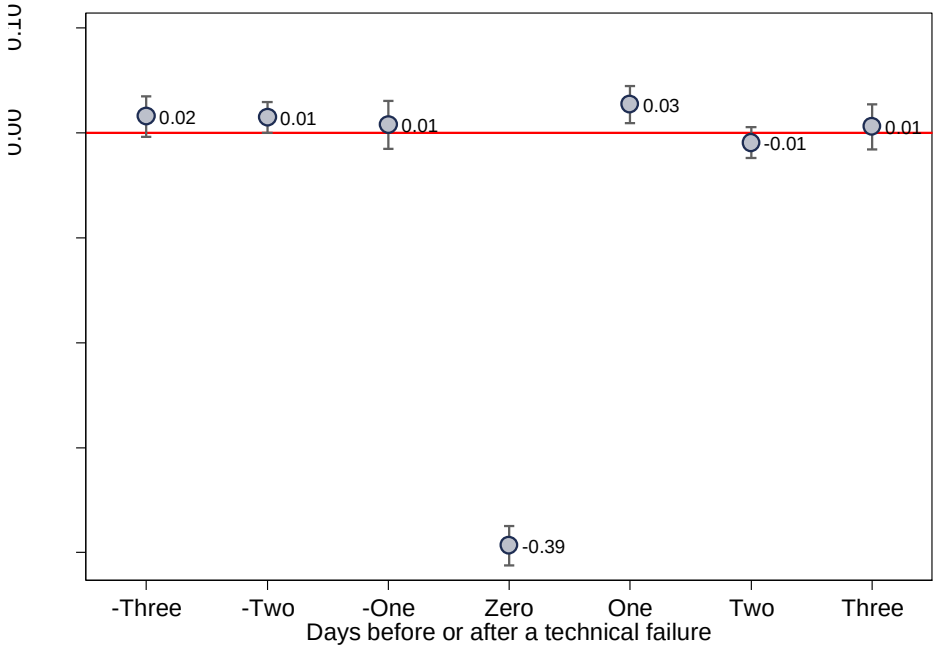
Panel B: Differences-in-differences



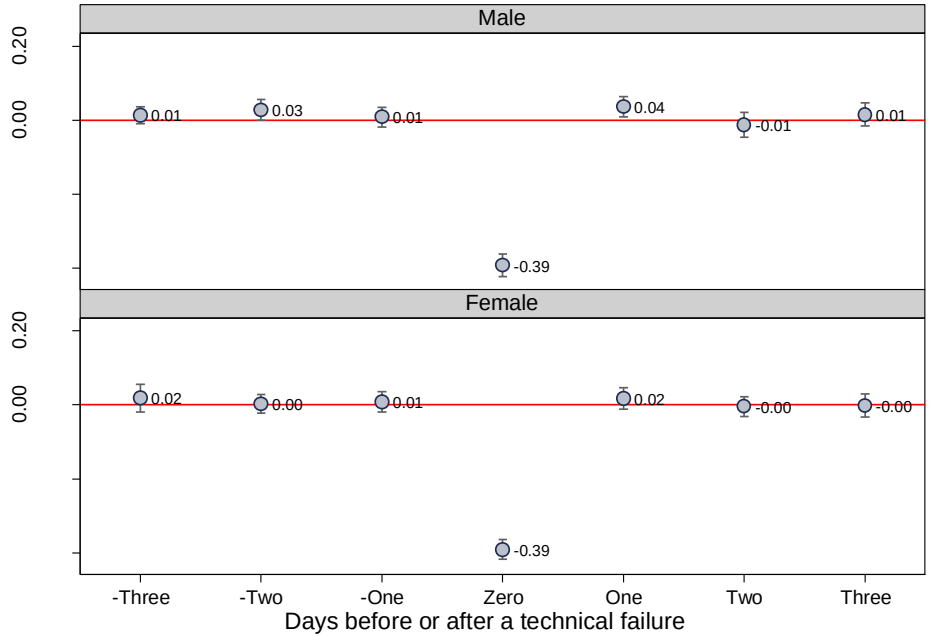
All statistics are computed based on estimates reported in columns (7) to (12) of Table 3. Panel A is based on estimates from equation (1), whereas Panel B is based on estimates from equation (2). For the marginal effect of characteristic "a" in the x-axis, we test the null hypothesis "$(a + digital \times a) \times (-1) = 0$", 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.

Figure 4
Time-Event Study of the Effect of Digital Technologies on Renewal Times

Panel A: All applicants

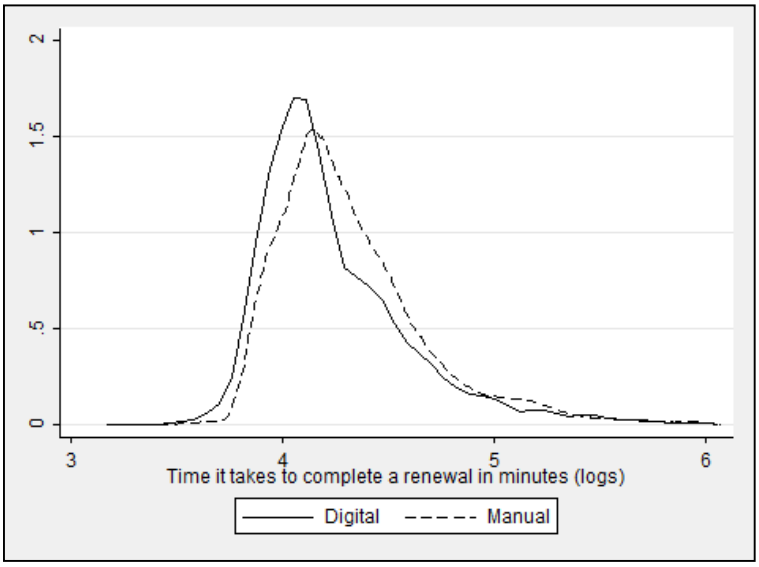


Panel B: By sex



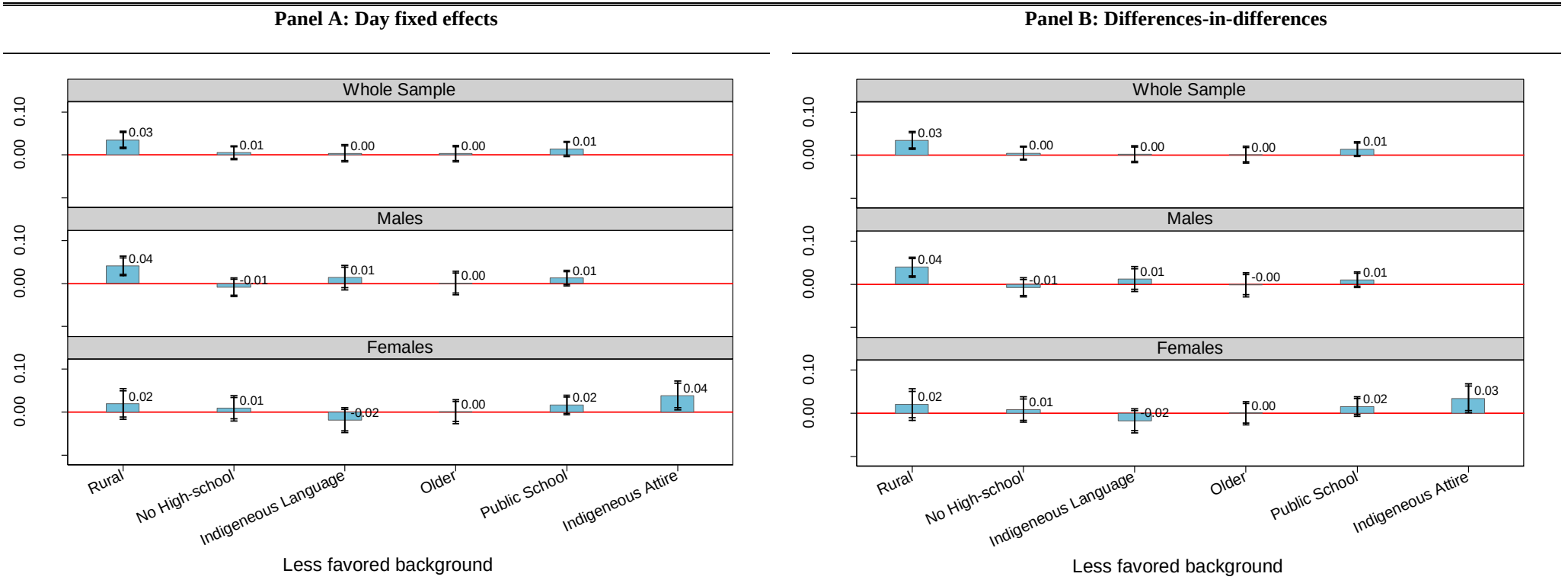
Estimates of the coefficients associated to $digital_{ijt}$ in equation (3). The vector of applicant characteristics include: whether the applicant is from rural areas, whether applicant did not finish high school, whether applicant speaks an indigenous language, whether the age of applicant is 40 or 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 shown.

Figure 5
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 6
Gaps in Renewal (Log) Times of Less Favored Groups After the Introduction of Digital Technologies



All statistics are computed based on estimates reported in columns (7) to (12) of Table 4. 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.

Table 1: Summary Statistics

Panel A: Applicant-police officer 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: 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. In Panel C, minimum and maximum reported within brackets.

Table 2: Balance Across Groups for Applicants' Characteristics

	Ex-ante assignment (Z_{ij})			Technical failure conditional on *ex-ante* digital table ($F_{ijt} \mid Z_{ij}=1$)			*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)	(0.54)	(49.77)	(49.70)	(1.20)	(49.70)	(49.60)	(0.90)
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)
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)
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. The differences in means were computed from a regression of each of the variables in the left on a dummy variable (i.e. Z_{ij}, $F_{ijt} \mid Z_{ij}=1$, or $digital_{ijt}$). 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 $digital_{ijt} = 0$	0.6235		0.6563		0.5893		0.6235		0.6563		0.5893	
Mean of dep. var. given $digital_{ijt} = 0$ and $Z_{ij}=1$		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: 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 $digital_{ijt} = 0$	128.99		128.55		129.45		128.99		128.55		129.45	
Mean of dep. var. given $digital_{ijt} = 0$ and $Z_{ij}=1$		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. Standard errors in parentheses robust against arbitrary heteroskedasticity in the variance-covariance matrix, and clustered at the table level across all specifications. Mean of dependent variable given in minutes. *** Significant at 1 percent. ** Significant at 5 percent. * Significant at 10 percent.

Table 5: 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 6: 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 the 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 ordinary least squares coefficients. 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? **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. *** Significant at 1 percent. ** Significant at 5 percent. * Significant at 10 percent.

Table A1: Balance Across Groups for Police Officers' Characteristics

	Ex-ante assignment (Z_{ij})			Technical failure conditional on *ex-ante* digital table ($F_{ijt} \mid Z_{ij}=1$)			*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 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 and the p-value of in brackets, respectively. The differences in means were computed from a regression of each of the variables in the left on a dummy variable (i.e. Z_{ij}, $F_{ijt} \mid Z_{ij}=1$, or $digital_{ijt}$). 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.

Table A2: 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

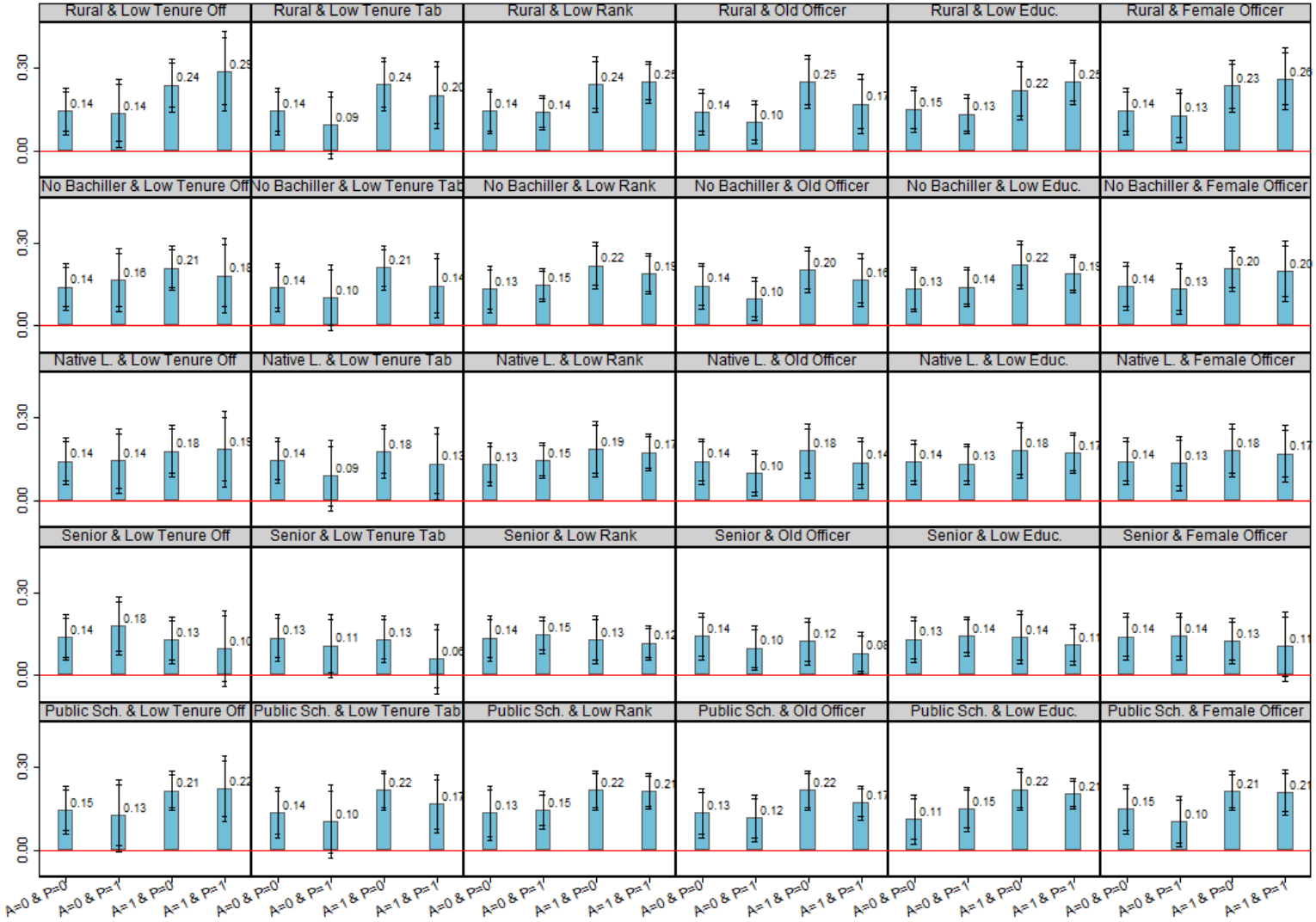
From columns 1 to 6, estimates reported are marginal effects from probit regressions. From 7 to 12, estimates reported are marginal effects from OLS. The digital renewal process indicator is estimated using the observed renewal process after incorporating technical failures. Standard errors in parentheses 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 A3: 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	
Z_{ij}	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)
Z_{ij} *(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)
Z_{ij} *(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)
Z_{ij} *(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)
Z_{ij} *(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)
Z_{ij} *(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)
Z_{ij} *(Female applicant wears indigenous attire)						0.0517*						0.0170
						(0.0283)						(0.0243)
Mean of dep. var. given Z_{ij}=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. From 7 to 12, estimates reported are marginal effects from OLS. 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.

Figure A1: 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.