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Abstract

This paper proposes three indicators constructed from the surnames of the current population to analyze the effect of *mita*, a forced mining labor system in Peru and Bolivia during 1573 and 1812, on historical migration. The underlying assumption is that surnames within a community might be the same over time unless migration or mortality displacement takes place. The *mita* case is particularly appealing for applying our indicators because the use of surnames was introduced in the study region only since the Spanish conquest in 1532. We estimate the effect of *mita* by using a regression discontinuity design similar to the one conducted by Dell (2010), which exploits the exogenous variation in its geographic assignment. Our results show that *mita* districts currently have 47% fewer surnames than *non-mita* districts, 65% fewer surnames that are present in only one district and 93% fewer surnames that are solely present in one area (*mita* or *non-mita*). Our results, robust to different specifications of the RD polynomial and other specification tests, are associated with large population movements. Hence, migration constitutes an important channel of institutional persistence.

JEL codes: J47, O15, N36.
Keywords: Forced labor, migration, surnames.

1 Introduction

The idea that historical institutions have influenced economic development has become an important issue of debate in recent years. A number of important studies find quantitative evidence for an impact of these institutions on current economic outcomes. Most of these exploit cross country institutional variation and propose various strategies to avoid identification problems caused by unobservable country-specific factors (Acemoglu et al. (2001), Hall & Jones

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(1999), Nunn (2008)). However, the literature has not placed the same emphasis on channels of persistence, that is, how institutions have managed to continue to influence economic development to this day.

A recently expanding literature focuses on these intermediate factors by exploiting institutional variation within countries (Banerjee & Iyer (2005), Iyer (2010), Dell (2010), Acemoglu et al. (2012)). Several interesting potential mechanisms have been identified, such as property rights, land tenure, public goods and barriers to entry. While most of these are related to physical capital, the empirical evidence is weaker for factors related to human capital. This paper exploits the variation within Peru provided by the assignment of *mita*, a colonial institution introduced in the sixteenth century, to propose migration as an additional channel of persistence to those presented by Dell (2010).

Dell (2010) is a prominent example of the aforementioned literature. The *mita* is a forced labor system instituted by the Spanish government in Peru and Bolivia from 1573 to 1812. The study proposes a regression discontinuity design (RD) to exploit the discrete change at the boundary of the subjected region: communities on one side were forced to send a percentage of their adult male population to work in mines every year, while communities on the other side were exempt. Once the study establishes that the *mita* has a long-term effect on household consumption and the prevalence of stunted growth in children, it examines possible channels of persistence. Since *haciendas* (rural estates with an attached labor force) were developed outside the *mita* boundaries, the long-term presence of large landowners in *non-mita* districts are hypothesized to have provided a tenure system that encouraged public goods provision.[1]

What if *mita* triggered a substantial process of migration?[2] This event would then constitute a negative shock on human capital within the region subjected to *mita*, both on extensive and intensive margins. On the one hand, the reduction of a significant percentage of the adult male population in the context of a labor-intensive economy should have affected the potential output of the subject area. On the other hand, as in any other migration process, selective migration should have taken place. The literature on migration supports migrant selection in labor and health market outcomes.[3] Since ability, health and other characteristics are highly heritable, the initial differences generated by *mita* could have persisted over the years. Hence, migration is a potential channel through which *mita* may have influenced contemporary underdevelopment in subjected districts. Moreover, to the extent that this migratory movement was oriented toward the non-subjected region, the *mita* would be doubly responsible for the regional differences. In this regard, Dell (2010) recognizes migration as a channel of persistence and provides some statistical evidence[4], but the lack of data prevents her from conducting an

[1]As for public goods, education and roads are analyzed. The evidence is little for a persistent *mita* effect through access to schooling.

[2]We define migration broadly as the population movement that became permanent due to the incentives faced by indigenous (see Section 2.2) or simply because they died due to the harsh labor and weather conditions.

[3]On the one hand, Borjas et al. (1992) suggest that regions that pay higher returns to skills attract more skilled workers than regions that pay lower returns. On the other hand, Halliday & Kimmitt (2008) find that, among men, poor health is associated with less geographic mobility.

[4]The paper provides statistical evidence for only 29 out of the 299 districts of analysis. The data correspond to the 1689 Cusco parish reports. The percentage of individuals with ancestors not from their district of residence was 52.5% in 14 *non-mita* districts and 35% in 15 *mita* districts.

econometric analysis.[5]

This paper proposes indicators constructed from surnames of current population to provide empirical evidence on migration caused by the application of *mita* in the past. Specifically, we use the Electoral Roll of 2011 to construct the following indicators at the district level: number of surnames, number of surnames found only in the district of residence and number of surnames present only in the area of residence (*mita* or *non-mita*). The main idea behind the indicators is that the surnames within a community should, in principle, remain the same over time, except when a whole family out-migrates or dies (taking their surname out of the community) or when a family with a locally absent surname immigrates (bringing their surname to the community).[6] Once the sensitivity of these indicators to migration is established, we estimate the effect of *mita* on them by following an RD design similar to the one proposed by Dell (2010) to exploit the discrete change at the boundary of the affected region. Hence, assuming that *mita* and *non-mita* districts are comparable near the arbitrary boundary, differences in surnames would indicate a substantial migration process or a population decline. Our results indicate that *mita* districts currently have 47% fewer surnames than *non-mita* districts, 65% fewer surnames exclusive to one district and 93% fewer surnames exclusive to one area. The results, robust to different specifications of the RD polynomial and other specification tests, reveal that *mita* had an important effect on migration.

The case of *mita* is particularly appealing for the use of current surnames to analyze historical migration. A natural question is whether sizable differences in surnames existed before the Spanish conquest in 1532. We are confident that this was not the case because indigenous people did not have surnames before the arrival of the Spanish. The inhabitants of Peru used simple names with no surnames (Domingo de Santo Thomas (1560, pp. 156-157)). The introduction of surnames was a consequence of mass baptisms conducted by the Spanish since their arrival, as part of a process of conversion of indigenous people to Christianity. In general, this process did not find strong opposition among the indigenous (Hemming (1970)). A consequence of baptism was identification through first name and surname. Section 2.1 provides a further explanation of the usage of surnames by indigenous people.

The usage of surnames as a source of information for scientific research has a long history in biological anthropology and some specific applications in economics. This tradition began with Darwin (1875), who used surname data to compute the frequency of marriages between cousins in England to investigate the possible harmful effects of consanguinity of parents.[7] Yasuda & Morton (1967) revived the work of Darwin, and Lasker & Kaplan (1985) proposed isonymy and inbreeding coefficients from surnames distributions. Several later studies have used surname

[5] Dell (2010) writes that "the paucity of data and complex patterns of heritability that would link historically selective migration to the present unfortunately place further investigation substantially beyond the scope of the current paper."

[6] It is also possible that some individuals change their surname, that is, that some sons acquire different surnames than their fathers (bringing their surname to the community). This happens only in a very small fraction of families. Guell et al. (2014) develop a novel methodology that relies on this "mutation" to analyze intergenerational mobility.

[7] George Darwin was the son of Charles Darwin, the famous naturalist and geologist, and his first cousin Emma Wedgwood.

analysis to infer the genetic structure of populations.[8] In the field of economics, surnames have recently been used in specific subfields, such as consumption patterns (Collado et al. (2012)), racial discrimination (Bertrand et al. (2012) and Bertrand & Mullainathan (2004)) and intergenerational mobility (Guell et al. (2014) and Olivetti & Paserman (2015)). One of the few economic articles that link surnames and migration is McClure (1979), who investigates migration in England during the Middle Ages using place-name surnames, that is, names derived from the names of towns or villages.

The proposed strategy raises a few possible concerns. First, it is natural to suggest the utilization of population size rather than indicators built from surnames. However, the elasticity of population size to migration is much larger than the elasticity of the number of surnames. Hence, while a small and recent migration process can change population size, only a sizable and early migration process can affect our indicators. Furthermore, population size is very sensitive to the rates of birth and mortality, while the number of surnames is fairly stable to changes in these variables. We will see later that the probability of reproduction affects surnames only when all individuals possessing a specific surname bear zero offspring; moreover, conditional on reproducing, surnames are unaffected by the number of offspring.[9] Second, since we use the current population to construct our indicators, we are not able to assert econometrically whether migration took place immediately after *mita* or at some point between 1812 and 2011. We do, however, provide historical evidence that shows that *mita* was followed immediately by massive population movements. Finally, to the degree that indigenous have migrated from the subjected region to the non-subjected one, ours is not a conventional RD in the sense that the control group does not remain unchanged as a consequence of the treatment. However, we do not interpret our estimations as a reduction of surnames in the treatment group, but as a difference between the treatment and control group that would not have taken place without *mita*.

The positive association between *mita* and migration provides evidence for the causal chain proposed by North and Thomas (1973) and recently reinforced by Acemoglu et al. (2014): fundamental determinants → proximate determinants → economic development. More specifically, we argue that the colonial institution of *mita* generated a substantial migration that lowered human capital in the subjected region. This in turn explains why *mita* districts have a lower average level of household consumption today. In contrast with the hypothesis that historically low human capital is the real driver of differences in long-run economic performance (Glaeser & Shleifer (2002) and Gennaioli et al. (2013)), we show that human capital itself was affected by *mita*. At the same time, our paper confirms the potential of exploiting variation within countries to identify channels of persistence. While most of the previous literature has found proximate determinants related to physical capital, we propose a factor directly related to human capital.

Our paper proposes a novel usage of current surnames to analyze past migration patterns or

[8]Rodríguez-Larralde has articles on isonymy in Germany (Rodríguez-Larralde et al. (1998)), Switzerland (Barrai et al. (1996)), France (Scapoli et al. (2005)), Spain (Rodríguez-Larralde et al. (2003)), Texas (Rodríguez-Larralde et al. (2007)), Venezuela (Rodríguez-Larralde et al. (2000)), Paraguay (Dipierri et al. (2011)) and Bolivia (Rodríguez-Larralde et al. (2011)).

[9]One can also suggest the ratio of number of surnames to population size. This ratio is another inadequate choice due to the above-explained problems of the denominator.

population declines when historical data to conduct a direct econometric analysis on migration is not available. This methodology may add, for instance, to the burgeoning literature that applies RD designs when a geographic or administrative boundary splits units into treated and control areas. Interesting examples are the historical border of the Austro-Hungary, Prussia and Russia empires (Becker et al. (2016), Bukowski (2015), Grosfeld & Zhuravskaya (2013)), the Dai Viet-Khmer boundary (Dell et al. (2015)) and the frontier between Castile and the Nasrid Kingdom of Granada (Oto-Peralías & Romero-Ávila (2016)). This literature usually discusses the existence of migration because a variation in the composition of the treated and control areas changes the interpretation of the coefficient of interest. Without migration, units within the control group remain unchanged and the coefficient is the effect in the treated area. With migration, the coefficient is the difference between the treated and control areas after the treatment. Hence, current surnames can help determine the actual case.

The paper is organized as follows: Section 2 provides some historical background and context surrounding the enactment of *mita*; Section 3 explains how surnames can be used to unveil migration processes in the past; Section 4 describes the data used in the present study; Section 5 details the empirical strategy; Section 6 presents the results; Section 7 presents several robustness checks; finally, Section 8 offers conclusions.

2 Historical background

2.1 Introduction of surnames in Peru

The inhabitants of Peru, before the Spanish conquest in 1532, used simple names with no surnames (Garcilazo de la Vega (1609, p. 28)). The first Quechua grammar, compiled by the Dominican missionary Domingo de Santo Tomás (1499-1570), reports that natives received a name twice in their lives (Domingo de Santo Thomas (1560, pp. 156-157)). The first name was assigned at birth by parents, who were inspired by a situation or event that they linked to their child's birth.[10] Another name was imposed at adulthood, which replaced the previous one. This used to be the name of other person, such as the father, the grandfather or an important member of the lineage.[11] Hence, surnames as we understand nowadays were not used by the inhabitants of Peru.[12]

The introduction of surnames to Peru was related to the process of conversion of indigenous people to Christianity. This process started the same day that the Spanish arrived in 1532, as it was thought to provide the moral support for indigenous conquest.[13] The first signifi-

[10]A gesture made by the baby at birth, an activity developed by the father at the time of birth, a word said by the mother when she saw the baby, or, perhaps, the name of an animal.

[11]Huaman Poma (1936: fol. 65) explains that some ancestors with animals' names obtained them for bravery in combat.

[12]Consider, for instance, the names of some sons and daughters of Huayna-Cápac, the supreme Inca that ruled the Inca Empire when Pizarro first sailed down the Pacific: the names Huascar (male), Atahualpa (male), Manco (male), Paullu (male), Quispe Cusi (female) and Marca Chimbo (female) have nothing in common.

[13]According to the Spanish Dominican friar Bartolomé de las Casas, for instance, the only way in which the Spanish Crown could occupy the Americas without endangering the King's hopes for salvation was to convert the natives to Christianity, after which they would become loyal subjects of Spain. See Hemming (1970, p. 650).

cant action of this process was the mass baptism of indigenous, who had to immediately cease idolatrous practices and all rituals that went against Church law and contradicted Catholic commandments (First Council of Lima, 1551).[14] The initial process of conversion to Christianity, including mass baptisms, did not find opposition among indigenous people. According to Hemming (1970), "They flocked to mass baptisms even if they understood almost nothing of the crude interpreting of Spanish sermons. They found no difficulty in exchanging the official Inca religion for Catholicism.".[15] The problems arose later when Spanish priests began to realize that behind many indigenous customs and traditions they were hiding pagans cults that would have been considered idolatry.

A consequence of baptizing the indigenous population was the identification through first name and surname.[16] While there is no evidence of a direct mandate on how to establish first name and surname, typically the first name was Hispanic (it follows the calendar of saints or other criteria), whereas the surname was typically an ethnic name. Hence, most of the surnames are related to the community of origin, defined by racial, linguistic, religious and kinship affinities.[17] In fact, the chronicler Garcilazo de la Vega (1609, p. 28) confirms that the assigned surnames contain information on the origin of the indigenous person and he uses the word surname as a synonym of "caste" throughout his famous book *Comentarios Reales de los Incas*. It is sometimes possible to find that indigenous people received their original name as surname. To illustrate, consider the case of an indigenous girl named Curicuillor, who became Leonor Curicuillor after baptism (Hemming (1970, pp. 401-402)). In fact, the Jesuit missionary Pablo José Arriaga mentions that, in ordinary usage, indigenous people say their native name first and the Christian after (Arriaga (1621, p. 64)). Moreover, the few indigenous names reported by Domingo de Santo Thomas (1560, pp. 156-157) are frequent surnames of the present-day population.[18] These surnames can also be considered ethnic since, as previously explained, most of them were names inherited from ancestors. It is also possible to find that some indigenous people received an Hispanic surname after their *encomendero*.[19]

The baptisms and consequent assignment of surnames was of course a gradual process that was not completely finished when the *mita* was introduced by Viceroy Toledo in 1573. However, this viceroy conducted an important census in 1572, precisely in order to collect information for the assignation of *mita*. It is sensible to think that significant progress was made with the identification process during the census because it was essential for the allocation of taxes. Similarly, the process of assigning names was not without problems.[20] Importantly for our

[14]The council formalized this order in 1551, but baptisms started immediately after the Spanish arrival. In fact, the supreme Inca Atahualpa received baptism and was then killed.

[15]The author explains that this was due to the similarities between the two official religions and the fact that military successes of the Spanish were considered a visible proof of their god's superiority.

[16]To the best of our knowledge, there is no study on the process of assignation of names. However, several books provide valuable guidance, such as Hemming (1970), Glave (1992) and Alaperrine-Bouyet (2007).

[17]A similar procedure was used with African slaves by the Spanish. The African ethnic name or the occupation of the slave was used as surname. See Lockhart (1982, p.225).

[18]This is the case of Condor (which means buzzard), Huaman (eagle), Quispe (shining stone), Curonina (worm of fire) and Poma (lion).

[19]The *encomienda* was a legal system that granted the right to use indigenous manpower to some Spanish individuals known as *encomenderos* as a reward for services to the crown.

[20]Glave (1992) (p.87) mentions that a group of indigenous became confused when reporting their surnames to the Spanish authorities. He illustrates with the case of Hernando Cana, whose original name was not Hernando

purposes, these problems were observed in all the conquered territories, including of course the *mita* and *non-mita* areas.[21]

2.2 *Mita*

The *mita* was a forced labor system designed by Viceroy Francisco de Toledo in 1573 (40 years after the Spanish conquest of Peru) to allocate indigenous labor to mines and refineries. Specifically, 17 provinces (over 200 indigenous districts) were chosen to provide one seventh of their male labor force each year (see Cole (1985, p. 3), Tandeter (1983, p. 3) and Bakewell (1984, p. 83)). The wage paid to an average indigenous person forced to work under this mandatory regime is estimated at somewhere between a third and a half of the wage received by a free worker (Cotler (2005, p. 54)). The most frequent destination of these workers was by far the Potosí mine, the largest source of silver in the Spanish Empire.[22] Indeed, in the sixteenth century, this area was regarded as the world's largest industrial complex, the result of large-scale extraction of silver ore (UNESCO (2010)).[23]

In order to gather information for the implementation of *mita*, Toledo organized a general census the previous year (Census of 1572) which recorded 1,077,697 indigenous people (Cole (1985, p. 2)). The *mita* was assigned by the establishment of an arbitrary boundary that divided the territory into *mita* and *non-mita* areas (see the map in Apendix B). The border was established by following two criteria: elevation and distance to the Potosí mine. On the one hand, most of the selected communities were located in colder highland area (Sanchez-Albornoz (1983)). Since the Potosí mine was situated over 4,000 meters above sea level (13,000 feet), miners needed workers acclimated to the harsh weather conditions. On the other hand, many historians note that administrative costs, such as traveling wages and enforcement costs, increase as distance to the mines grew. In fact, the migration was not of men alone, but of entire families (Gil Montero (2013)).[24]

The *mita* created incentives for emigration. Even though an indigenous person that abandoned his village lost his land, he had an incentive to become free of *mita* obligations by

and whose surname corresponded to his ethnic origin. Additionally, Arriaga (1621, pp. 27,64) reports that some indigenous people took their surnames after the divinities they worshiped. The religious authorities opposed this and other alleged idolatries through three councils that took place in Lima (1551, 1567-1568 and 1582-1583), after which the usage of surnames inspired by indigenous divinities was expressly forbidden.

[21]To the extent that these problems affected both the *mita* and *non-mita* area, they do not affect our identification strategy.

[22]A general labor grant conducted by Toledo in 1578 concluded that the annual *mita* workers in Potosí numbered 14,181 (Tandeter (1983, p. 83)). *Mita* workers in Huancavelica, the second most important destination, numbered at most 3,200 (Sanchez-Albornoz (1988)).

[23]The *mita* was originally designed by the Incas. Indeed, "the world *mita* is derived from the Quechua *mit'a*, meaning a turn or a period of service" (Cole (1985, p. 1)). The Inca Empire used manpower to conduct large public works, such as roads, bridges, forts, administrative centers, temples, aqueducts, mining and other activities. Despite the Spanish adopted the term, historical evidence supports independent assignment. Although the colonial *mita* targeted several economic activities, mining was by far the most important (Sanchez-Albornoz (1988)). In the rest of the paper, we will refer to *mita* as the forced labor system instituted by the Spanish crown.

[24]To illustrate, consider the case discussed by Cotler (2005, p. 54). The trip from Chucuito to Potosí took two months and the movement of 7,000 individuals (including women and children) with the help of 40,000 llamas.

permanently leaving his district of residence. One way was running away to a district not subject to *mita*. A citation from the memoirs of the Viceroy de la Palata illustrates this problem: "To get rid of these annoyances, the Indians have found the easiest path across the Andes,... because only by standing at the closest province that was not included in the *mita*, were they exempt from this obligation".[25] [26] Another way was by not returning to the original community once the duty was fulfilled, but to a city to work as unskilled labor (Lockhart (1982), p. 264). Sanchez-Albornoz (1983) explains that, apart from avoiding a new draft, indigenous workers in Potosí had two additional disincentives to return. First, they feared finding their land uncultivated and unsown. Second, as they had not participated from collective activities, they had lost the surplus that they usually obtained. Hence, these indigenous people went from transitory migrants to permanent migrants.

Historical research suggests that there is a link between the migration generated by *mita* and the emergence of a new social group among the indigenous called *forasteros* (foreigners). They lived on Spanish farms or indigenous districts distant from their native region. Sanchez-Albornoz (1983) explains that the *forasteros* constituted an excluded social group and their isolation was inherited by subsequent generations. Despite substantial efforts by the Spanish authorities to stop permanent migration[27], the *forasteros* organized themselves becoming small-scale traders, artisans and farm employees. Historical documents from different sources[28] reveal *forasteros* and *yanaconas*[29] made up around 40% of the total indigenous population. Additionally, historical documents suggest that the migration process began soon after the establishment of *mita*: a small census conducted in 1645 (72 years after) already shows that 37% of indigenous people were *forasteros* or *yanaconas*, while another small census conducted around 1690 shows that the indigenous population in the subjected region had been reduced to 55% of the volume counted by Toledo in the Census of 1572 (Sanchez-Albornoz (1983)).

The *mita* introduced by Toledo in 1573 lasted 250 years until Simón Bolívar abolished it in 1825 (Cole (1985)). Historical evidence strongly supports that, contrary to what one might expect, this long-lasting institution experienced only small reforms. The Viceroy Toledo was aware of the migration movements, but he had hoped draw the indigenous back into their districts of origin. The Viceroy La Palata attempted to include the *forasteros* into the *mita* draft and also to enlarge the subjected region. However, this reform was met with great opposition and barely came into force. The Viceroy Monclova considered abolishing the *mita*, but ultimately chose to persist in applying it. Sanchez-Albornoz (1983)) explains that the order introduced by Toledo lasted, not because of its own merits, but because of the stiffness of the colonial system.[30]

[25] Taken from Sanchez-Albornoz (1983).

[26] The indigenous chronicler Guamán Poma de Ayala provides a more dramatic description: "For all these grievances, and not go to the mines to suffer [...], the Indians are absent from their villages. Others fleeing the mines, others escape on the roads" (Guamán Poma de Ayala (1615)).

[27] "By royal command, the Indians should be collected in their villages, there should not be indigenous in cities [...]. And should be punished if they fail" (Guamán Poma de Ayala (1615)).

[28] See for instance Cotler (2005, p. 75), Tandeter (1983, p. 87) and Sanchez-Albornoz (1983)

[29] In principle, *yanaconas* were indigenous people reserved for specific activities by the Spanish and they were therefore exempt from *mita*. However, a legal loophole was exploited to avoid being drafted. Over time, *yanaconas* and *forasteros* were considered a single group.

[30] None of these reforms compromises the identification strategy of Dell that we reply. One can be argue that

3 The usage of surnames to unveil migration

An important feature of surnames, both in the Anglo-Saxon and Hispanic conventions, is that they are inherited from the father (the surname of the father is passed down). We propose to construct indicators from current surnames to reveal migration in the past. The main idea behind the indicators is that the surnames within a community stay the same over time, except in the following three cases: when an entire family out-migrates (taking their surname out of the community), a family dies out (eliminating their surname from the community), and a family with a locally absent surname immigrates (introducing their surname into the community).[31] Hence, the structure of surnames within a community changes if and only if a large enough migration process or a mortality displacement takes place. Specifically, the indicators we propose are the number of surnames and the number of exclusive surnames, which are defined as those found solely in one location. An exclusive surname contrasts with a common surname, which is found in more than one location. In order to explain how these indicators are affected by migration (or population decline), we apply our reasoning to the hypothesis that *mita* caused individuals to migrate out of the subjected region.

We begin by assuming a simplified situation with two districts[32]: a *mita*, and a *non-mita* district. Table I presents the eight cases that arise when a family out-migrates by combining two possible kinds of surnames (exclusive or common), two possible places of arrival (the *non-mita* district or an outside location), and two possible types of migration: total migration (in which all members of a family migrate), and partial migration (in which some members stay). The eight rows shown in Table I correspond to these cases, while the columns correspond to the effect caused by migration on number of surnames and number of exclusive numbers.[33] We now proceed to analyze the effects of the hypothesized migration process.

We argue that if a migration process is large enough, it decreases the number of surnames in the *mita* district, but increases it in the *non-mita* district. The first row shows the case of a family with an exclusive surname that totally out-migrates from the *mita* to the *non-mita* district. In this case, we observe that the number of surnames in the *mita* district decreases because no family member stays, while the number of surnames in the *non-mita* district increases because anyone there has that surname. The second row shows the same case except that the family out-migrates to an unobserved district (outside the scope of analysis). Hence, we note that the number of surnames in the *mita* district decreases, while the number of surnames in the *non-mita* district remains the same. The third row is a partial migration of an exclusive surname from the *mita* to the *non-mita* district. We do not observe any change in the number of surnames in the *mita* district because some family members stayed; however, the number of surnames in the *non-mita* district increases because the surname was locally absent. Additionally, we note that the indicator is not sensitive to a partial migration of an exclusive surname

a couple of districts in the control group were included in the *mita* area by Viceroy La Palata at some point, but then the effect found by Dell would be a minimum bound.

[31] In order to facilitate the explanation, we define family broadly as all the individuals with the same surname.

[32] The political organization of Peru includes, from the largest to the smallest units: departments, provinces and districts.

[33] An upward-pointing arrow signifies an increase; a downward arrow signifies a decrease; and a dash indicates no effect.

Table I: Surnames as migration indicators[a]

Family	Size of migration	Arrival	Number of surnames *mita*	Number of surnames *non-mita*	N. exclusive surnames *mita*	N. exclusive surnames *non-mita*
Exclusive surname	total	*non-mita*	↓	↑	↓	↑
Exclusive surname	total	outside	↓	-	↓	-
Exclusive surname	partial	*non-mita*	-	↑	↓	-
Exclusive surname	partial	outside	-	-	-	-
Common surname	total	*non-mita*	↓	-	-	↑
Common surname	total	outside	↓	-	-	↑
Common surname	partial	*non-mita*	-	-	-	-
Common surname	partial	outside	-	-	-	-

[a]An upward arrow signifies an increase; a downward arrow signifies a decrease; and a dash indicates no effect.

family from a *mita* to an unobserved district. Rows from 5 to 8 provide the same analysis but for the out-migration of a family with a common surname. We observe a decrease in the number of surnames in the *mita* district when migration is total.

We also claim that the number of exclusive surnames decreases in the *mita* district and increases in the *non-mita* district as a result of the hypothesized migration process. The last two columns of Table I illustrate the effect on this indicator. If an entire family with an exclusive surname migrates to the *non-mita* district (first row), the number of exclusive surnames in the *mita* decreases and, at the same time, it increases in the arrival area. Similar results are found in the rest of the cases. It should be noticed that if all members of a family with a common surname emigrate to the *non-mita* district, the number of exclusive surnames remains the same in the *mita* district; however, since this surname is no longer found in the *mita* district, the number of exclusive surnames increases in the *non-mita* district.

Overall, the analysis of Table I reveals that a migration process from the *mita* district to the *non-mita* district generates the expected effect on the two indicators. On the one hand, the number of surnames decreases in the *mita* district in four out of the eight possible cases, and remains unchanged in the other four. Similarly, the indicator in the *non-mita* district either decreases or remain unaltered. On the other hand, the number of exclusive surnames decreases in the *mita* district in three out of the eight possible cases and stays the same in the other five, while it either increases or does not change in the *non-mita* district. Importantly, the fact that both indicators remain unaltered in some cases reveals that, in order to generate an observable change in the indicators, the migration process has to be substantial. In this sense, the participation of entire families in this process plays an important role.

We now go beyond the assumption of two districts. Indeed, the *mita* and the *non-mita* areas have several districts within them. In this context, the number of surnames and the number of exclusive surnames can be computed for each district, and the previous analysis remains. One can argue that the number of surnames may change not only as a result of a migration from a *mita* district to a *non-mita* district, but also because of a migration between *mita* districts or between *non-mita* districts. This potential bias is minor because, in these cases, the average number of surnames within each area would not change substantially. However, to be cautious, we propose two indicators: "district-exclusive surnames" is the number of names only found in one district and "area-exclusive surnames" equals the number of names in a district that are exclusive to the area (*mita* or not) to which the district belongs. In other words, to be area-exclusive, a surname needs to be absent, not from any other district, but only from the other area. The last paragraph of Section 4 provides examples to illustrate.[34]

What about a population decline caused by a high mortality rate? In the analysis of Table I, such an event is similar to a migration from the *mita* district to an outside location (rows 2, 4, 6 and 8). It is possible to observe an effect on the indicator if all members of a family die (rows 2 and 6). Hence, in order to generate an observable change in the indicators, the mortality displacement has to be considerable.

The usage of surnames to unveil migration patterns caused by *mita* may raise some questions. The first concerns the use of the proposed indicators in place of population size, which in some ways might seem a natural choice. We argue that the number of surnames is better than population size because the former is less sensitive to migration than the latter. Appendix A develops a simple model, adapted from Guell et al. (2014), to demonstrate formally that the elasticity of number of surnames to migration is much smaller than the elasticity of population size to the same variable (see proposition 4). Hence, while a short and recent migration process modifies population size, only a large and deep-rooted migration process affects the number of surnames. We also believe that the number of surnames is better because it remains fairly stable as birth and mortality rates change, while population size changes substantially. Appendix A also shows that the probability of reproduction affects the number of surnames only when all individuals possessing a specific surname bear zero offspring. Moreover, conditional on reproducing, the number of surnames is unaffected by the number of offspring (see propositions 1 and 2). One can also suggest working with the ratio of number of surnames over population size. However, the expected outcome for this variable is no clear because of the above-mentioned sensitivity of population size to recent and small migration processes, and also because of its high elasticity to birth and mortality rates.[35]

The second question is whether the number of surnames is affected by the mortality displacement after *mita*. Rather than deny this possibility, we emphasize it. In fact, this section just showed that mortality is a determinant of the number of surnames.[36] This feature is important to our purpose because, when we refer to *mita*, the linkage between migration and mortality displacement is indissoluble. Historical sources indicate that indigenous died because

[34]We construct a fourth indicator taking into account the fact that the *mita* area have (in sum) a larger population. To address this potential problem, we randomly select *mita* districts such that the sum of the population equates the total population of the *non-mita* area. The results, available upon request, do not differ.

[35]In any case, Section 7 will present regressions using our three proposed indicators, but controlling for current population as a robustness test. In all the cases, the results remain qualitatively the same (see Table X).

[36]Moreover, by the same analysis used in Table I, we conclude that a population decline needs to be larger than a migration process to generate an observable change in the indicators, because it does not produce any change in the *non-mita* area.

of the harsh labor and weather conditions in mines.[37] This relation between migration and mortality displacement after *mita* explains why we have previously defined migration broadly as the population movement that became permanent because the indigenous decided so or because they died.

Finally, since surnames are inherited from the father, one can argue that analyzing surnames in the context of migration involves limiting the focus to male migration. This is indeed the case, as *mita* was a forced labor system which exclusively targeting men.

4 Data

We examine the effect of *mita* on past migration by testing whether it affects the number of surnames and exclusive surnames of the current population. As we use an RD approach similar to the one proposed by Dell, we restrict the analysis to the same districts examined in her study. Dell focuses exclusively on the segment that transects the Andean region in southern Peru, because elevation, ethnic distribution and other observables are statistically identical there. This homogeneity favors the assumption that all relevant factors besides the treatment vary smoothly at the *mita* boundary, as required by the RD approach.

Our district level data is constructed from two sources. First, we employ the Peruvian Electoral Roll of 2011 (ER 2011) to construct the three indicators (explained in Section 3) at the district level. The ER 2011 is the list of potential voters used to elect the President and Vice Presidents for the period 2011-2016, as well as the 130 members of the Peruvian Congress. It contains the names, surnames, identification number, gender and district of residence of the voting population, regardless of whether they exercise their right to vote. The voting population is composed of all citizens aged 18 and older. On the other hand, we use the data provided by Dell (2010)[38], which includes the list of *mita* and *non-mita* districts, their latitude and longitude, average altitude, average elevation, distance to the *mita* boundary, distance to the Potosí mine and the distance to Huancavelica. Additionally, we use data on demographics and tributes of 1572 of these areas. We link both databases through the district name.[39]

The ER 2011 was provided by the National Office of Electoral Processes[40] exclusively for the area under analysis, that is, the departments of Apurimac, Ayacucho, Arequipa, Cuzco and Puno[41]. According to the National Registry of Identification and Civil Status, the number of

[37]The Indian chronicler Guamán Poma de Ayala (1615) narrated that a great amount of natives died in the mines due to the poor labor conditions and punishments. Bakewell (1984) describes the area as cold with a nasty climate, strong winds and much sand and dust.

[38]Published on *http://scholar.harvard.edu/dell/publications*.

[39]Dell (2010) amply describes the matching process between them.

[40]Peruvian elections are organized by three institutions: first, the National Registry of Identification and Civil Status maintains the civil records; second, the National Office of Electoral Processes is in charge of the logistics of the process, including the counting of votes; finally, the National Jury of Elections monitors the legality of the campaign and elections themselves.

[41]It should be noted that, like Dell (2010), we only focus on a subsample of districts to ensure that *mita* and *non-mita* districts are statistically identical. In the rest of districts, much of the boundary coincides with the Andean precipice.

Peruvians identified by an identification number has grown substantially in recent years, from a coverage rate of 61.85% in 2006 to 97.10% in 2011. Importantly, if we restrict the analysis to the population aged 18 and over, the coverage rate reached 100% in 2010 (RENIEC (2011)). This explains why we have chosen ER 2011 from among the other Peruvian electoral rolls.

Peru follows the Hispanic naming convention. Individuals have two surnames: the first is inherited from the father (it is his first surname), the second from the mother (it is her first surname). In contrast to females in Spain who rarely modify their surnames when they marry, married females in Peru may voluntarily add their husband's surname to their own.[42] This worked by replacing their second surname with the first surname of their husbands preceded by the word "*de*", which means "of". From 2009 on, the procedure implies maintaining their two surnames and adding the first name of their husbands preceded by the word "*de*".[43] In order to avoid any possible bias, we focus exclusively on the first surname (henceforth "surname"), which is not subject to any modification due to changes in marital status.

The ER 2011 provides information on the 1,383,523 inhabitants over the age of 18 in the 299 districts of analysis, with a total of 16,571 surnames represented. A small number of the most frequent surnames make up a large percentage of the population, with a large number of low frequency surnames. The 10 most popular surnames[44] cover around 18% of the sample population. As a reference, Guell et al. (2014) computed that this percentage is 11% in Catalonia-Spain.

As mentioned in Section 3, district-exclusive surname may be defined as a name solely found in one district, and area-exclusive surname as a name solely found in one area. In order to illustrate these definitions, consider the case of the surname Chancos, which is found in the district of Huancapi of the department of Ayacucho, and is not found in any other district of the sample. This is an exclusive name according to both definitions. In contrast, Achapuma is found in four *mita* districts (Juliaca, Sicuani, Mosoc Llacta and Acopia) but it is not found in any *non-mita* district. This surname is not exclusive by the first definition, but it is according to the second one.

5 Estimation framework

Section 3 shows that the number of surnames and the number of exclusive surnames (in both versions) are sensitive to migration. In order to examine the effect of *mita* on past migration, we apply the same identification strategy used by Dell (2010). It involves using an RD to exploit the discrete change at the boundary of the subjected region: communities on one side were forced to send adult male population to work in mines; and communities on the other side were exempt (for more details, see the map in Appendix B). The treatment is a deterministic

[42] Article 20 of the Peruvian Civil Code states "To the son correspond the first surname of the father and the first surname of the mother". Article 24 recognizes as a legal right of married women using their husband's name added to their own.

[43] For more details, see the following legal provision: Resolución Jefatural N^{o}370-2009-JNAC/RENIEC.

[44] Most frequent are: Quispe (84,041 individuals), Mamani (43,360), Huamán (24,711), Condori (20,716) and Flores (14,707).

and discontinuous function of longitude and latitude. Hence, provided that *mita* and *non-mita* districts are comparable near the arbitrary boundary today, differences in surnames would indicate a migration process or a population decline. The equation to estimate is:

$$m_{db} = \alpha + \gamma mita_d + X_d'\beta + f(geographic\ location_d) + \phi_b + \epsilon_{db} \quad (1)$$

where m_{db} is the surname indicator for district d along segment b of the *mita* boundary; $mita_d$ is a dummy equal to 1 if district d was subjected by *mita* and 0 otherwise; X_d is a vector of covariates, which includes weighted average elevation and slope of district d; $f(geographic\ location_d)$ is the RD polynomial, which controls for smooth functions of geographic location; and ϕ_b is a set of boundary fixed effects. The boundary has been divided in four equal length segments b and ϕ_b identifies which of these four is the closest to the capital of district d. This variable is used to compare observations in close geographic proximity.

A semiparametric RD estimation is used to distinguish the effect of *mita* from the smooth effects of geographic location.[45] In our baseline specification, $f(geographic\ location_d)$ is a quadratic polynomial of longitude and latitude that includes interactions with *mita* ($x + y + x^2 + y^2 + xy + x \cdot mita + y \cdot mita + x^2 \cdot mita + y^2 \cdot mita + xy \cdot mita$). On the one hand, we use a quadratic polynomial instead of a cubic one because estimators based on high-order polynomials (from third on) can be misleading according to Gelman & Imbens (2014). On the other hand, we introduce interactions with *mita* to avoid our results to be driven by the stiffness of the polynomial. This is the method of choice and it is subject to different robustness checks in Section 7.

A final important feature in our estimation is that the sample is limited to districts within 100, 75 and 50 km of the *mita* boundary. Moreover, following Dell (2010), we exclude from the main analysis Metropolitan Cusco, the concern being that its current level of development may be determined by its status as the former capitol of the Inca Empire. Metropolitan Cusco is composed by one *mita* and eight *non-mita* districts. Section 7 provides results incorporating these districts back into the analysis.

The strategy used requires that all the covariates vary smoothly at the cutoff, i.e., in the absence of treatment, the treated and control groups (located near the *mita* boundary) would have similar characteristics. Dell (2010) focus exclusively on the Andean range in southern Peru (see the map in Appendix B) and proves that all relevant factors besides treatment vary smoothly at the *mita* boundary in the selected zone. This includes geographical variables (elevation and slope), population variables (such as percentage of indigenous population, number of men, and boys and females) and economic variables (such as tribute rate in 1572 and percentage of tributary population). Given the nature of our study, we focus our attention on the variables related to population. Table II provides historical evidence that treated and control groups (located near to the *mita* boundary) have similar populations in 1572, not only in terms of size, but also in terms of structure. The first row shows the size of the population. There are no significant differences between *mita* and *non-mita* districts before the enactment of the *mita*.

[45] A nonparametric RD technique cannot be applied due to the small number of observations. See Imbens & Lemieux (2008).

Rows from 2 to 4 provide information on the population structure. There are no significant differences in the rate of men, women or boys. The fifth row of Table II shows the average tribute contributions per adult[46] and finds no significant difference. In addition, rows from 6 to 9 show the share of the tributes revenues between the Spanish and the Indigenous Mayors, and find no significant difference. We provide this information with the purpose of contrasting contribution levels between Indigenous Mayors and the Spanish population, which includes nobility, priests and judges. This gives prima facie evidence that the population structure was similar, so the type of surnames (Spanish or Indigenous) should also be similar. Note that there are some small but significant differences between the share of tributes revenues received by the Spanish Nobility and Spanish Priests in *mita* and *non-mita* districts. We believe that this should not make any difference in the structure of surnames between both areas because surnames do not differ among Spanish due to their occupation.

[46]It is presented in logarithms.

Table II: 1572 Demographics[a]

Variable	Bandwidth 50 Mita	Bandwidth 50 No mita	Bandwidth 50 s.e.	Bandwidth 75 Mita	Bandwidth 75 No mita	Bandwidth 75 s.e.	Bandwidth 100 Mita	Bandwidth 100 No mita	Bandwidth 100 s.e.
Population	4582.80	3025.83	(1127.32)	5443.81	3351.24	(1567.33)	4893.71	3349.02	(1320.27)
Demographics structure									
% Men	0.25	0.24	(0.008)	0.25	0.25	(0.007)	0.26	0.25	(0.010)
% Women	0.54	0.56	(0.009)	0.54	0.55	(0.009)	0.53	0.55	(0.013)
% Boys	0.21	0.20	(0.007)	0.20	0.20	(0.007)	0.21	0.20	(0.007)
Tributes	1.63	1.60	(0.020)	1.62	1.61	(0.018)	1.61	1.60	(0.018)
Share of tribute revenues									
% Spanish Nobility	0.62	0.63	(0.014)	0.60	0.64	(0.017)**	0.60	0.64	(0.016)**
% Spanish Priests	0.21	0.20	(0.009)	0.22	0.19	(0.011)**	0.21	0.19	(0.011)*
% Spanish Justices	0.13	0.12	(0.006)	0.13	0.12	(0.007)	0.13	0.13	(0.006)
% Indigenous Mayors	0.04	0.04	(0.003)	0.05	0.04	(0.003)	0.06	0.04	(0.010)
Obs.	**35**	**30**		**47**	**37**		**63**	**41**	

[a] The data are taken from Dell (2010). The unit of analysis is the district. The first three columns show t-tests for observations that are 50 km from the *mita* boundary, the following columns show the same results expanding the boundary to 75 and 100 km. The t-tests for the share of tribute revenues are also presented by Table I of Dell (2010). Standard errors for the difference in means in parentheses. Differences that are significantly different from zero are denoted by: *** p< 0.01, ** p<0.05, *p<0.1.

6 Results

6.1 Preliminary evidence

Table III provides summary statistics by indicator for the full sample as well as for those districts subjected to *mita* and those districts exempt. The first one is the number of surnames by district. The mean of this variable is 394.4. While the average number of surnames of *mita* districts is only 331.2, the average of the *non-mita* districts is 532.2, a statistically significant difference of about 200 surnames. The second is the number of exclusive surnames by district, which has an average of 25.2. The average number of district-exclusive surnames is only 20.2 in the area subjected to *mita* and 36.2 in the exempt area. The difference is close to 16 and is statistically significant. The third variable is the number of area-exclusive surnames. As explained in Section 3, these surnames are those found only in the respective area (*mita* or *non-mita*). Since exclusivity is defined more broadly, the mean of this variable is 52.4, which doubles the average of the previous definition. The mean of this indicator is 40.8 in the *mita* area and 77.6 in the *non-mita* area. The difference is close to 37, which again is statistically significant.

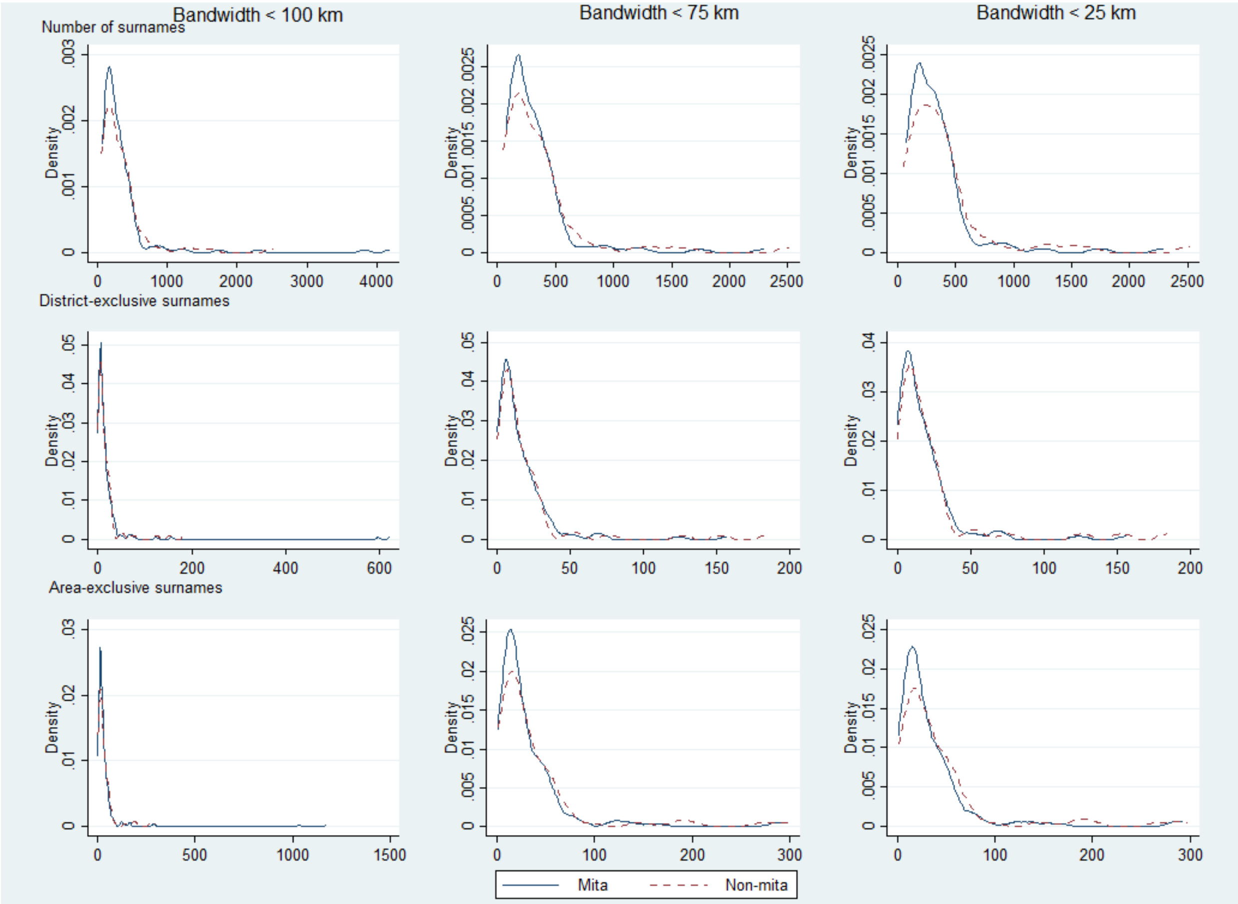
Table III: Indicators of migration[a]

Variables	Obs.	Full sample			Mita	Non-mita	Diff
		Mean	Min	Max			
Number of surnames	299	394.385 (36.498)	51	5,188	331.171 (31.178)	532.245 (92.893)	-201.074** (77.878)
District-exclusive surnames	299	25.244 (4.276)	0	699	20.234 (4.281)	36.170 (9.840)	-15.936* (9.179)
Area-exclusive surnames	299	52.351 (8.463)	1	1,392	40.795 (7.834)	77.553 (20.649)	-36.758** (18.133)

[a]T-tests made for our three outcomes. The unit of analysis is the district. Standard errors in parentheses. Differences that are significantly different from zero are denoted by: *** p< 0.01, ** p<0.05, *p<0.1.

We now graphically examine shifts in the distribution of surnames by area. The first horizontal panel of Figure 1 shows density functions for the number of surnames separately for those falling inside and outside the *mita* area. The first graph of this panel limits the sample to those districts within 100 km of the *mita* boundary, and the second and third graphs restrict it to fall within 75 and 50km, respectively. In the three cases, both distributions are heavily right-skewed, but mass in the distribution for those districts subjected to *mita* falls to the left of the distribution for those that are not. Interestingly, the shift increases while we consider districts closer to the boundary. The second and third horizontal panels repeat this exercise, using as dependent variables the two definitions for number of exclusive surnames. Similar patterns are observed.

Figure 1: Distribution of indicators built from first surname by area[a]



[a]The first column shows the distribution of the three outcomes of the districts that are 100 km from the *mita* boundary; the following columns show the same results contracting the boundary to 75 and 50 km.

Overall, Table III and Figure 1 suggest that *mita* is associated with reductions in the number of surnames. If *mita* and *non-mita* districts are comparable near the arbitrary boundary, this pattern is consistent with a migration process. We now turn to the econometric analysis.

6.2 Estimation results

Table IV presents the main results of the econometric estimation. As explained in Section 5, our preferred specification for $f(geographic\ location_d)$ is a multidimensional RD using a quadratic polynomial of latitude and longitude, which includes interactions with *mita*. This provides flexibility, enabling the treatment effect to be differentiated from the functional form. Each horizontal panel of Table IV corresponds to the three proposed indicators: number of surnames, number of district-exclusive surnames and number of area-exclusive surnames. The columns correspond to three possible sub-samples: districts within 100 km, 75 km, and 50 km of the boundary.

Table IV: Principal results[a]

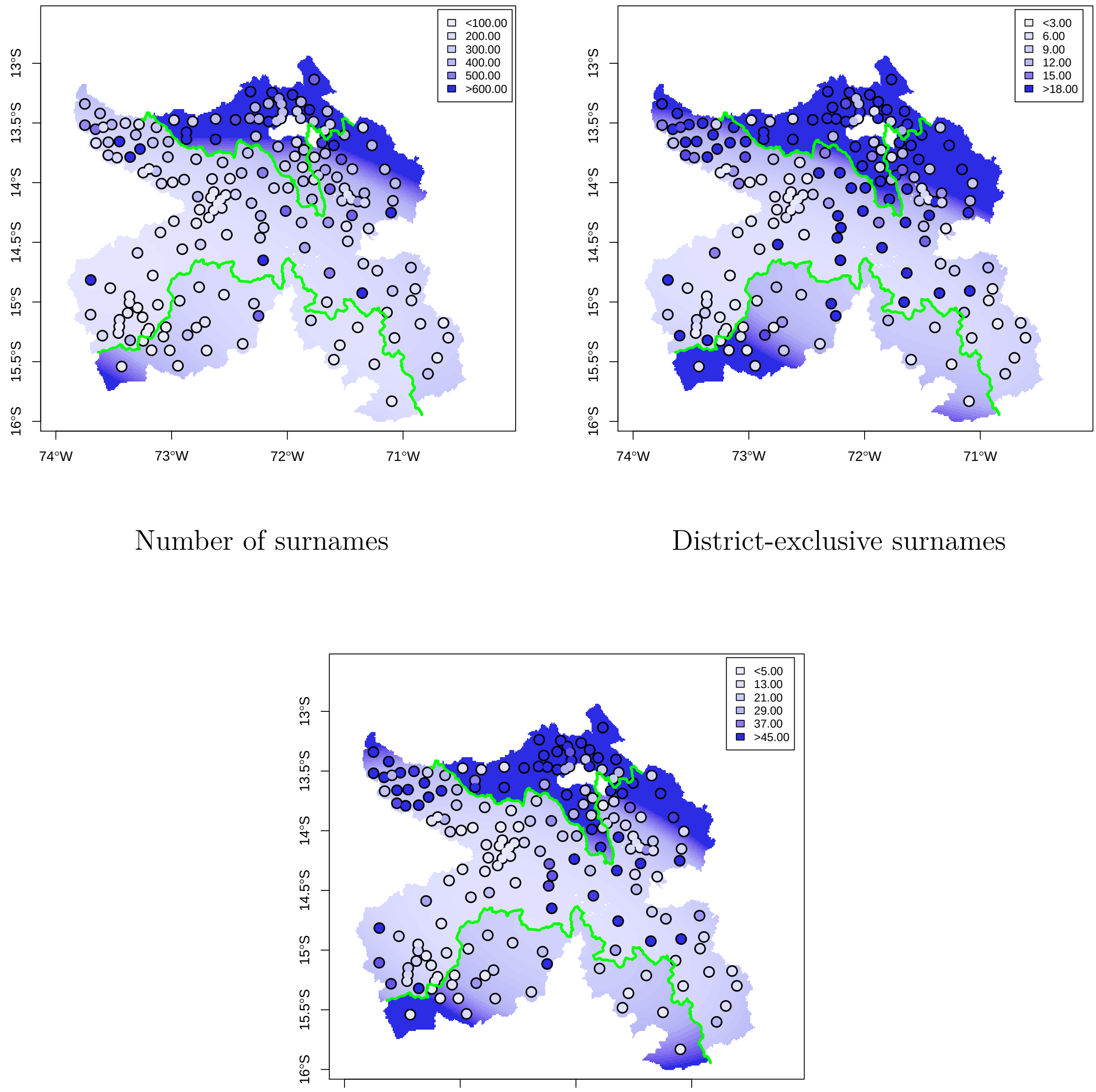
	Closeness to the *mita* boundary		
	<100 km	<75 km	<50 km
A. Log Number of surnames			
Mita	-0.453***	-0.429**	-0.467**
	(0.172)	(0.180)	(0.192)
B. Log District-exclusive surnames[b]			
Mita	-0.732***	-0.601**	-0.647**
	(0.264)	(0.276)	(0.314)
C. Log Area-exclusive surnames			
Mita	-0.974***	-0.953***	-0.930***
	(0.246)	(0.261)	(0.299)
Observations	289	239	185

[a] The unit of analysis is the district. All regressions are multidimensional RD using a quadratic polynomial of latitude and longitude that includes interactions with *mita*. All regressions include geographic controls and boundary segment fixed effects. Robust standard errors in parentheses. Coefficients that are significantly different from zero are denoted by: *** $p< 0.01$, ** $p<0.05$, *$p<0.1$.
[b] This variable equals $ln(\textit{number of district-exclusive surnames}+1)$. This transformation in done to preserve the entire sample because some observations are equal to zero (7 obs. in the larger bandwidth, 5 and 2 in the following bandwidths).

The first row of Table IV estimates that the *mita* districts have from 43 to 47 percentage points fewer surnames than the *non-mita* districts. The second row shows that the *mita* districts have from 60 to 73 percentage points fewer surnames than the *non-mita* districts. The third row shows that the difference in the number of exclusive surnames following the broader definition ranges from 93 to 97 percentage points. Notice that, for each variable, the point estimate remains stable as the sample is restricted to districts closer to the *mita* boundary. Moreover, all of the nine point estimates are statistically significant at the 1% or 5% level.[47]

[47] Appendix C estimates the same specification as Table IV, but using a bootstrapping technique. The results when we use random resampling are essentially the same.

Figure 2: Plots of the outcomes against longitude and latitude[a]



Number of surnames

District-exclusive surnames

Area-exclusive surnames

In order to show our results graphically, Figure 2 contrasts the data values and the predicted values within a map of the area of study. There is one subfigure for each of our three indicators built from surnames. Every map includes the boundary that divided the territory: the intermediate zone is the *mita* area, while the upper and lower zones are the *non-mita* area. The data and predicted values are contrasted as follows. On the one hand, every map includes one dot for each district[48] and the color of this dot represents the data value. On the other hand, every map includes a background that shows predicted values. The background is a finely spaced grid of latitude and longitude, where the color of every tiny square represents the predicted value from Equation 1.[49] Figure 2 is useful for two reasons. First, we can assess how our equation fits the actual values by comparing the color of the dots and the color of the closest background. Second, we can observe the discontinuity by contrasting the shades inside and outside the *mita* boundary.[50]

Overall, Table IV and Figure 2 confirm econometrically what Table III and Figure 1 suggest statistically, that is, that *mita* introduced important differences in the number of surnames. As discussed in Section 3, these differences can only be explained by migration.

7 Specification tests

Having presented the main results, we then assess whether the results are sensitive to the particular specifications we have selected and whether the assumptions we have made can be supported by additional empirical evidence. We start by examining robustness to different specifications of the RD polynomial. We focus our attention on the selected interacted quadratic polynomial of latitude and longitude. Table V presents three groups of columns, where each group corresponds to the three proposed indicators: number of surnames, number of district-exclusive surnames and number of area-exclusive surnames. Within each group, the columns correspond to three possible sub-samples: districts within 100 km, 75 km, and 50 km of the boundary. Each horizontal panel of Table V examines robustness to the following specifications: linear, quadratic (our baseline) and cubic. It also includes an ordinary least squares estimation. Notice that the differences between *mita* and *non-mita* are always statistically significant, whether we use linear, quadratic or cubic polynomials (first, second and third panels, respectively). The exceptions are two regressions of the linear polynomial in the narrowest bandwidth, probably due to the small number of observations; and four regressions of the cubic polynomial, which is arguably due to the large number of terms.

We go deeper in the specification analysis by examining robustness to different polynomials of elevation and slope. This is important because, as explained in Section 2.2, elevation was another criterion used by Viceroy Toledo to assign *mita*. Panel A of Table VI shows our main results as a baseline while Panels B, C and D show the results for quadratic, cubic and quartic polynomial, respectively. The *mita* effect is markedly stable for these changes and we obtain significance in 36 out of 36 cases.

We also report, for the sake of completeness, estimates from the three baseline specifications of $f(geographic\ location_d)$ used by Dell (2010). Each of the first three horizontal panels of Table VII corresponds to these specifications. Panel A shows the results of a multidimensional

[48]Each dot is located in the latitude and longitude of the district capital, but its color represents the data value for the whole district.

[49]Figure 2 uses our baseline specification, that is, the quadratic polynomial of latitude and longitude interacted with *mita*.

[50]The white area corresponds to the excluded Metropolitan Cusco, the former capitol of the Inca Empire.

RD using a cubic polynomial of longitude and latitude. Most of the coefficients does not have the expected sign and they are not statistically significant in any case. The high order of the polynomial is likely cause of this misleading estimation (see Gelman & Imbens (2014)). Panel B presents the results for a traditional single-dimensional RD using a cubic polynomial of the Euclidean distance to the Potosí mine. Controlling for this variable may reduce a potential bias because the distance to Potosí was a criterion for assignment the *mita*. As explained in Section 2.2, the greater the distance to Potosí, the less likely that a district was deemed eligible for *mita* by the Viceroy Toledo. Moreover, the distance to Potosí was a potential determinant of out-migration. We obtain a negative significant effect in nine out of the nine point estimates with this specification. Panel C estimates the results for a single-dimensional RD using a cubic polynomial of the distance to *mita* boundary, similar to traditional one-dimensional RD designs. We obtain a negative difference in nine out of the nine estimations with this specification, but the size is smaller than when using the previous specification. In fact, the point estimate is significant in only three out of nine cases. This is likely related to a positive bias in the estimation when we do not control for the distance to Potosí.[51] In order to provide evidence on this bias, we present a fourth specification, not included by Dell (2010). Panel D presents the results for cubic polynomials of both distance to *mita* boundary and distance to Potosí. We obtain again a negative significant effect in nine out of the nine point estimates with this specification.

It is important to test whether the population structure prior to the enactment of *mita* was similar between the subjected region and the control region. If it were found not to be, this would raise concern that the assumption underlying our analysis does not hold. Dell (2010) has conducted a rigorous analysis of this question, which we replicate in Table VIII. Each of the first three horizontal panel of Table VII corresponds to one of the specifications of Dell (2010), while the last horizontal panel corresponds to our specification. As was preliminarily shown in Table II, the population size before the *mita* was similar and also the structure of population by age, gender and race.

In order to address other concerns related to how comparable the districts inside and outside the *mita* catchment were, we analyze the results of Equation 1 using different samples. In Table IX, we report only estimations for the smallest bandwidth (i.e. <50km) using the quadratic polynomial that includes interactions with *mita*. In Panel A, we include the baseline results. In Panel B, we include ten districts of Metropolitan Cusco[52], which we had excluded as a precaution, since their current level of development may be determined by its historically central position as part of the capitol of the Inca Empire. In Panel C, we exclude seven Inca states because, in the times of the Inca Empire, these areas were destinate for religious purposes and were not used for productive activities.[53] In Panel D, we exclude the districts in which *mita* boundary coincides with a river, which makes it possible to verify that there is no endogeneity

[51]This positive bias stems from two factors: first, the negative relation between the distance to Potosí and the probability of being a *mita* district, and second, the negative relation between this distance and the number of surnames, as it decreases the probability that people return to their district of residence after finishing the *mita*. The interaction of these two factors generates a positive bias that decreases the absolute value of the point estimates.

[52]We include eight *non-mita* districts (Cusco, Ccorca, Poroy, San Jerónimo, San Sebastián, Santiago, Saylla and Wanchaq) and two *mita* districts (Lucre and Oropesa).

[53]The excluded districts are: Chinchaypujio, Limatambo, Calca, Lamay, Maras, Ollaytantambo and Yucay. These districts belong to the Cusco department.

due to geography.

Finally, we examine the robustness of our results to the introduction of some control variables. Panel A of Table X shows our main results as a baseline. Panels B includes the Euclidean distance to the Potosí mine as a control variable. As explained before, this distance was a criterion for the assignment of *mita* and it was a potential determinant of out-migration. Panel C examines the robustness of the preferred specification to the introduction of current population size as a control variable. Panel D includes both the Euclidean distance to the Potosí mine and current population size. In all the cases, the results remain qualitatively the same. They show that, even if we compare districts of the same population size or equally far from the Potosí mine, the sizable differences in the number of surnames remain.

Table V: Specification tests: RD polynomials[a]

	Log Number of surnames			Log District-exclusive surnames[b]			Log Area-exclusive surnames		
	<100 km	<75 km	<50 km	<100 km	<75 km	<50 km	<100 km	<75 km	<50 km
A. Polynomial of latitude and longitude interacted with *mita*									
Interacted linear polynomial									
Mita	-0.209**	-0.176**	-0.138	-0.305**	-0.315**	-0.230	-0.357***	-0.364***	-0.298**
	(0.089)	(0.087)	(0.096)	(0.128)	(0.126)	(0.142)	(0.130)	(0.131)	(0.151)
Interacted quadratic polynomial - Baseline									
Mita	-0.453***	-0.429**	-0.467**	-0.732***	-0.601**	-0.647**	-0.974***	-0.953***	-0.930***
	(0.172)	(0.180)	(0.192)	(0.264)	(0.276)	(0.314)	(0.246)	(0.261)	(0.299)
Interacted cubic polynomial									
Mita	-0.351*	-0.322	-0.435*	-0.524	-0.324	-0.248	-0.848***	-0.764**	-0.591*
	(0.192)	(0.208)	(0.229)	(0.333)	(0.338)	(0.380)	(0.283)	(0.297)	(0.349)
B. Ordinary Least Squares									
Mita	-0.138	-0.140	-0.161*	-0.168	-0.232*	-0.200	-0.198	-0.286**	-0.312**
	(0.091)	(0.089)	(0.089)	(0.121)	(0.120)	(0.134)	(0.122)	(0.125)	(0.137)
Observations	289	239	185	289	239	185	289	239	185

[a]The unit of analysis is the district. Panel A shows the results for different specifications of the polynomial of latitude and longitude interacted with *mita*, while Panel B shows the results without using any polynomial. All regressions include geographic controls and boundary segment fixed effects. Robust standard errors in parentheses. Coefficients that are significantly different from zero are denoted by: *** p< 0.01, ** p<0.05, *p<0.1.
[b]This variable equals *ln*(*number of exclusive surnames* +1). This transformation in done to preserve the entire sample because some observations are equal to zero (7 obs. in the larger bandwidth, 5 and 2 in the following bandwidths).

Table VI: Specification tests: elevation and slope polynomials[a]

	Number of surnames			District-exclusive surnames[b]			Area-exclusive surnames		
	<100 km	<75 km	<50 km	<100 km	<75 km	<50 km	<100 km	<75 km	<50 km
A. Linear polynomial of elevation and slope - Baseline									
Mita	-0.453***	-0.429**	-0.467**	-0.732***	-0.601**	-0.647**	-0.974***	-0.953***	-0.930***
	(0.172)	(0.180)	(0.192)	(0.264)	(0.276)	(0.314)	(0.246)	(0.261)	(0.299)
B. Quadratic polynomial of elevation and slope									
Mita	-0.462***	-0.434**	-0.521***	-0.730***	-0.577**	-0.669**	-0.969***	-0.933***	-0.982***
	(0.174)	(0.184)	(0.196)	(0.265)	(0.275)	(0.313)	(0.247)	(0.262)	(0.300)
C. Cubic polynomial of elevation and slope									
Mita	-0.554***	-0.544***	-0.566***	-0.749***	-0.620**	-0.715**	-1.027***	-1.013***	-1.056***
	(0.172)	(0.176)	(0.197)	(0.272)	(0.282)	(0.313)	(0.256)	(0.270)	(0.305)
D. Quartic polynomial of elevation and slope									
Mita	-0.571***	-0.536***	-0.566***	-0.774***	-0.606**	-0.720**	-1.057***	-0.998***	-1.048***
	(0.173)	(0.177)	(0.195)	(0.272)	(0.283)	(0.314)	(0.256)	(0.274)	(0.308)
Observations	289	239	185	289	239	185	289	239	185

[a] The unit of analysis is the district. All regressions include the quadratic polynomial of latitude and longitude interacted with *mita* and geographic controls and boundary segment fixed effects. Robust standard errors in parentheses. Coefficients that are significantly different from zero are denoted by: *** p< 0.01, ** p<0.05, *p<0.1.

[b]This variable equals $ln(\textit{number of exclusive surnames} + 1)$. This transformation in done to preserve the entire sample because some observations are equal to zero (7 obs. in the larger bandwidth, 5 and 2 in the following bandwidths).

Table VII: Specification tests: results using specifications proposed by Dell (2010)[a]

	Log Number of surnames			Log District-exclusive surnames[b]			Log Area-exclusive surnames		
	<100 km	<75 km	<50 km	<100 km	<75 km	<50 km	<100 km	<75 km	<50 km
A. Cubic polynomial of latitude and longitude									
Mita	0.057	0.066	0.053	0.006	0.116	0.137	-0.039	-0.037	-0.017
	(0.126)	(0.136)	(0.149)	(0.177)	(0.192)	(0.213)	(0.175)	(0.196)	(0.213)
B. Cubic polynomial of distance to Potosí									
Mita	-0.172*	-0.175*	-0.207**	-0.268**	-0.282**	-0.288**	-0.397***	-0.426***	-0.446***
	(0.096)	(0.097)	(0.095)	(0.135)	(0.134)	(0.138)	(0.137)	(0.141)	(0.143)
C. Cubic polynomial of distance to *mita* boundary									
Mita	-0.101	-0.107	-0.159*	-0.124	-0.184	-0.191	-0.173	-0.252**	-0.323**
	(0.089)	(0.088)	(0.091)	(0.121)	(0.120)	(0.138)	(0.121)	(0.125)	(0.140)
D. Cubic polynomials of distance to Potosí and distance to *mita* boundary									
Mita	-0.185*	-0.168*	-0.198**	-0.268*	-0.267**	-0.271*	-0.403***	-0.412***	-0.434***
	(0.098)	(0.098)	(0.095)	(0.138)	(0.135)	(0.138)	(0.141)	(0.142)	(0.145)
Observations	289	239	185	289	239	185	289	239	185

[a]The unit of analysis is the district. Panels A, B and C show the results using the same specifications proposed by Dell (2010), that is, cubic polynomials of latitude and longitude, distance to Potosí and distance to the *mita* boundary, respectively. Panel D shows the results using cubic polynomials of distance to Potosí and distance to the *mita* boundary. All regressions include geographic controls and boundary segment fixed effects. Robust standard errors in parentheses. Coefficients that are significantly different from zero are denoted by: *** p< 0.01, ** p<0.05, *p<0.1.

[b]This variable equals $ln(\textit{number of district-exclusive surnames}+1)$. This transformation in done to preserve the entire sample because some observations are equal to zero (7 obs. in the larger bandwidth, 5 and 2 in the following bandwidths).

Table VIII: Population structure in 1572 and Tributes revenues[a]

	Population 1572	Men	Percent Women	Boys	Log mean tribute	Share of Tribute Revenues Spanish Nobility	Spanish Priests	Spanish Justices	Indig. Mayors
A. Cubic polynomial of latitude and longitude									
Mita	101.816	-0.002	-0.009	0.011	0.020	-0.010	0.004	0.004	0.003
	(1,574.765)	(0.009)	(0.016)	(0.012)	(0.031)	(0.030)	(0.019)	(0.010)	(0.005)
B. Cubic polynomial of distance to Potosí									
Mita	1,967.153	0.006	-0.011	0.005	0.019	-0.013	0.008	0.006	-0.001
	(1,305.021)	(0.007)	(0.012)	(0.010)	(0.029)	(0.025)	(0.015)	(0.009)	(0.004)
C. Cubic polynomial of distance to *Mita* boundary									
Mita	2,077.044*	0.007	-0.008	0.001	0.040	-0.009	0.005	0.003	-0.001
	(1,090.424)	(0.007)	(0.010)	(0.008)	(0.030)	(0.018)	(0.012)	(0.006)	(0.004)
D. Interacted quadratic polynomial of latitude and longitude									
Mita	103.328	0.025*	-0.009	-0.016	0.148***	-0.013	-0.004	0.009	0.011
	(3,224.628)	(0.014)	(0.029)	(0.025)	(0.043)	(0.046)	(0.031)	(0.020)	(0.008)
Observations	65	65	65	65	65	65	65	65	65

[a] The data are taken from Dell (2010). The unit of analysis is the district within 50 km to the *mita* boundary. Panels A, B and C use the cubic polynomials of latitude and longitude, distance to Potosí and distance to the *mita* boundary, respectively. These are exactly the same regressions presented by Table V of Dell (2010). Panel D shows the results using our baseline specification, that is, the quadratic polynomial of latitude and longitude interacted with *mita*. All regressions include geographic controls and boundary segment fixed effects. Regressions for the share of men, women and boys weight by the square root of the district's total population; regression for the tribute rate in 1572 weights by the square root of the district's tributary population; and regressions for the share of tribute revenues weight by the square root of total population in 1572. Robust standard errors in parentheses. Coefficients that are significantly different from zero are denoted by: *** p< 0.01, ** p<0.05, *p<0.1.

Table IX: Specification tests: different samples[a]

	Number of surnames	District-exclusive surnames[b]	Area-exclusive surnames
A. Baseline			
Mita	-0.467**	-0.647**	-0.930***
	(0.192)	(0.314)	(0.299)
Observations	185	185	185
B. Includes Cusco			
Mita	-0.609***	-0.795**	-1.072***
	(0.199)	(0.311)	(0.298)
Observations	195	195	195
C. Excludes Inca estates			
Mita	-0.549***	-0.793**	-1.040***
	(0.198)	(0.318)	(0.303)
Observations	178	178	178
D. Excludes rivers			
Mita	-0.463**	-0.622*	-0.907***
	(0.195)	(0.316)	(0.300)
Observations	183	183	183

[a] The unit of analysis is the district within 50 km from the *mita* boundary. All regressions include the quadratic polynomial of latitude and longitude interacted with *mita*, geographic controls and boundary segment fixed effects. Robust standard errors in parentheses. Coefficients that are significantly different from zero are denoted by: *** p< 0.01, ** p<0.05, *p<0.1.

[b]This variable equals $ln(number\ of\ exclusive\ surnames + 1)$. This transformation in done to preserve the entire sample because some observations are equal to zero (7 obs. in the larger bandwidth, 5 and 2 in the following bandwidths).

Table X: Specification tests: adding controls[a]

	Number of surnames			District-exclusive surnames[b]			Area-exclusive surnames		
	<100 km	<75 km	<50 km	<100 km	<75 km	<50 km	<100 km	<75 km	<50 km
A. Baseline									
Mita	-0.453***	-0.429**	-0.467**	-0.732***	-0.601**	-0.647**	-0.974***	-0.953***	-0.930***
	(0.172)	(0.180)	(0.192)	(0.264)	(0.276)	(0.314)	(0.246)	(0.261)	(0.299)
B. Controlling for the distance to Potosí									
Mita	-0.447**	-0.429**	-0.467**	-0.737***	-0.601**	-0.649**	-0.975***	-0.954***	-0.936***
	(0.172)	(0.181)	(0.193)	(0.264)	(0.276)	(0.314)	(0.246)	(0.261)	(0.298)
C. Controlling for population in 2011									
Mita	-0.377**	-0.323**	-0.337**	-0.618***	-0.463**	-0.476*	-0.871***	-0.814***	-0.757***
	(0.148)	(0.133)	(0.139)	(0.235)	(0.222)	(0.251)	(0.224)	(0.210)	(0.234)
D. Controlling for the distance to Potosí and population in 2011									
Mita	-0.374**	-0.325**	-0.339**	-0.626***	-0.464**	-0.480*	-0.875***	-0.817***	-0.765***
	(0.148)	(0.133)	(0.139)	(0.236)	(0.221)	(0.249)	(0.224)	(0.210)	(0.233)
Observations	289	239	185	289	239	185	289	239	185

[a] The unit of analysis is the district. All regressions include the quadratic polynomial of latitude and longitude interacted with *mita* and geographic controls and boundary segment fixed effects. Robust standard errors in parentheses. Coefficients that are significantly different from zero are denoted by: *** p< 0.01, ** p<0.05, *p<0.1.

[b]This variable equals $ln(\textit{number of exclusive surnames} + 1)$. This transformation in done to preserve the entire sample because some observations are equal to zero (7 obs. in the larger bandwidth, 5 and 2 in the following bandwidths).

8 Conclusions

This paper identifies migration as a channel through which *mita* influenced contemporary economic development. We propose three indicators built from surnames of the present-day population to analyze migration processes in the past. We estimate the effect of *mita* by exploiting the plausible exogenous variation in its assignment that was documented by Dell (2010). Our results show that *mita* districts currently have 47% fewer surnames than *non-mita* districts; 65% fewer surnames solely present in one district; and and 93% fewer surnames solely present in one area (*mita* or *non-mita*). We argue there is no reason other than migration to explain these differences across the boundary. Our results are robust to different specifications of the RD polynomial and other specification tests.

This study sustains the causal chain proposed by North and Thomas (1973) by which institutions are a fundamental determinant, human capital is a proximate determinants and economic development is the final result. This contrasts with existing theories that argue that human capital, and not institutions, is the real driver of differences in long-run economic performances. Hence, we found that the colonial institution of *mita* generated a substantial migration out of the subjected region, which implies a negative shock on human capital (both on the extensive and the intensive margins). We argue this explains why *mita* districts have a lower average level of household consumption today.

The methodology we present shows that surnames may reveal whether an important migration process took place in the past when historical data is not available. In particular, it may contribute to the literature that applies RD designs when a geographic or administrative boundary splits units into treated and control areas. Current surnames may help determine whether there was migration or not, which affects the interpretation of the estimations: without migration, coefficients are the effect in the treated area; with migration, coefficients are the difference between the treated and control areas after treatment.

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Appendix A

A simple model for the number of surnames

We develop a simple model to contrast the evolution of population and surnames. The initial setup is similar to the one proposed by Guell et al. (2014). The population at date t consists of N_t individuals. Each of them reproduces with probability q and, conditional on reproducing, gives birth to m sons (clearly, $m \geq 1$). Individuals lives one single period, that is, generations do not overlap. In this context, $N_1 = N_0 qm$.[54]

We denote by Ω the fixed and discrete set of surnames. Each individual is associated with one element $s \epsilon \Omega$. The number of elements of Ω is S. All the elements of Ω are not active in period t, but only a subset of $S_t < S$ elements. For simplicity, we assume that the number of individuals that share the same surname at date zero is fixed and equal to $\frac{1}{\theta}$, where $\theta \epsilon \langle 0, 1 \rangle$. This implies $S_0 = \theta N_0$. In this context, the probability that all fathers possessing a specific surname s bear zero offspring is $(1-q)^{\frac{1}{\theta}}$. This is also the probability that a surname vanishes at date zero and therefore $S_0(1-q)^{\frac{1}{\theta}}$ is the number of surnames that disappear at period one. Hence, $S_1 = S_0 - S_0(1-q)^{\frac{1}{\theta}}$.

Property 1. *The number of active surnames is less sensitive to changes on the probability of reproduction than the size of population.*

Proof. Take partial derivatives of S_1 and N_1 with respect to q. On the one hand, $\frac{\partial S_1}{\partial q} = N_0(1-q)^{\frac{1}{\theta}-1}$. On the other hand, $\frac{\partial N_1}{\partial q} = N_0 m$. Clearly, $\frac{\partial S_1}{\partial q} < \frac{\partial N_1}{\partial q}$. ■

Property 2. *The number of active surnames, conditional on reproducing, is not sensitive to changes on the number of sons; the size of population is.*

Proof. Take partial derivatives of S_1 and N_1 with respect to m. On the one hand, $\frac{\partial S_1}{\partial m} = 0$. On the other hand, $\frac{\partial N_1}{\partial m} = N_0 q$. ■

These two propositions sustain our statement that birth rates, composed by the probability of reproduction and the number of offspring, may affect the number of surnames but that the effect is small.

We now turn to consider migration. Consider two districts named A and B. To focus on the consequences of migration, we assume that $q = 0$. The population at date t is denoted by N_t^A and N_t^B. The probability to migrate from A to B is p^A and the probability to migrate from B to A is p^B. In this context, $N_1^A = N_0^A + p^B N_0^B - p^A N_0^A$.

We denote by Ω_t^A and Ω_t^B the subset of active surnames at time t in district A and B, respectively. The number of elements of these subsets are S_t^A and S_t^B. For the sake of simplicity, we make two assumptions for the initial period. First, $\Omega_0^A \cap \Omega_0^B = \phi$, that is, there are no common surnames at time zero. Second, $S_0^A = \theta N_0^A$ and $S_0^B = \theta N_0^B$.

[54] Guell et al. (2014) assume $qm = 1$, that is, a growth rate equal to zero.

The surnames within, say, district A change under two scenarios. On the one hand, a surname s disappears from A if every person holding that surname out-migrates, which happens with a probability $(p_A)^{\frac{1}{\theta}}$. Thus, the number of vanished surnames in A due to out-migration is $S_0(p_A)^{\frac{1}{\theta}}$. On the other hand, a surname s appears in A if an individual from B migrates to A, which happens with a probability p_B. To the extent that the number of immigrants is $p^B N_0^B$, the number of surnames they bring to A is $\theta p^B N_0^B$. In this context, $S_1^A = S_0^A + N_0^B p^B \theta - S_0^A (p^A)^{\frac{1}{\theta}}$.

Property 3. *Suppose two equally sized districts with the same positive probability of migration. While the number of surnames within each districts increases, population size remains the same. In particular, the number of common surnames increases and the number of exclusive surnames decreases.*

Proof. Observe that, under the provided assumptions, $S_1^A = S_0^A \left[1 + p^A - (p^A)^{\frac{1}{\theta}}\right]$, where the last factor is greater than one. Additionally, $N_1^A = N_0^A$. ■

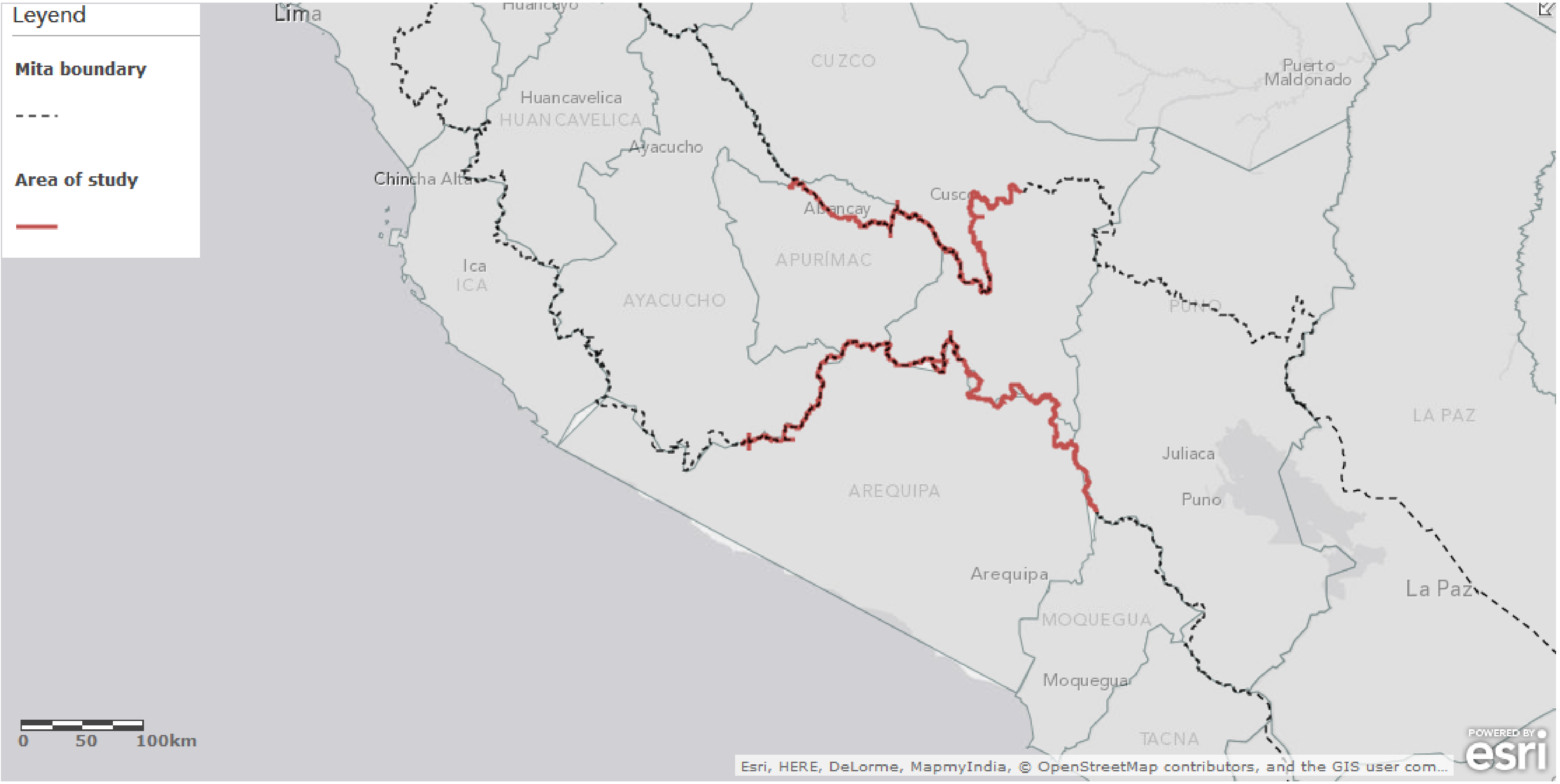
The aim of this property is only to contrast the dynamics of population and surnames.

Property 4. *The number of surnames is less sensitive to changes in the probabilities of out-migration or immigration than population size.*

Proof. Take partial derivatives. On the one hand, for changes of p^B, the derivatives are $\frac{\partial N_1^A}{\partial p^B} = N_0^B$ and $\frac{\partial S_1^A}{\partial p^B} = N_0^B \theta$. On the other hand, for changes of p^A, the derivatives are $\frac{\partial N_1^A}{\partial p^A} = -N_0^A$ and $\frac{\partial S_1^A}{\partial p^A} = -N_0^A (p^A)^{\frac{1}{\theta}-1}$. ■

Appendix B

Figure 3: Map of the area of study[a]



[a]Data from Dell (2010). The *mita* boundary is in black while the area of study is in red. The districts inside the mita boundary contributed to the *mita*, the others were exempted. Current Peruvian (and Bolivarian) Administrative Divisions are in light gray.

Appendix C

Table XI: Results using bootstrap estimation[a]

	Closeness to the *mita* boundary		
	<100 km	<75 km	<50 km
A. Log Number of surnames			
Mita	-0.453**	-0.429**	-0.467**
	(0.196)	(0.183)	(0.228)
B. Log District-exclusive surnames[b]			
Mita	-0.732***	-0.601*	-0.647*
	(0.257)	(0.340)	(0.331)
C. Log Area-exclusive surnames			
Mita	-0.974***	-0.953***	-0.930***
	(0.243)	(0.283)	(0.303)
Observations	289	239	185

[a]The unit of analysis is the district. All regressions are multidimensional RD using a quadratic polynomial of latitude and longitude, including interactions with *mita*. All regressions include geographic controls and boundary segment fixed effects. Results are calculated using nonparametric bootstrap estimation with 100 replications. Robust standard errors in parentheses. Coefficients that are significantly different from zero are denoted by: *** p< 0.01, ** p<0.05, *p<0.1.

[b]This variable equals *ln*(*number of district-exclusive surnames*+1). This transformation in done to preserve the entire sample because some observations are equal to zero (7 obs. in the larger bandwidth, 5 and 2 in the following bandwidths).