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The Long-Term Welfare Effects of Colonial Institutions: Evidence from Central India

Marco Colleoni

Abstract

In Central India, the Narmada River separates two regions that have been ruled by different types of government only during the colonial period, and for reasons independent of their initial economic development. I implement a spatial RDD on village population in the Nineteenth Century as well as in 1901, and I run the same model on proxies of welfare in 2015. My results highlight that divergence has realised where the river overlapped with the colonial border, but not in a neighbouring area where the same Narmada River separates two shores with the same type of former colonial institution. I discuss the following transmission mechanism. The treated group was directly administered by the British with more modern state tools - such as the enforcement of property rights and a transparent taxation system - that made it easier to develop private investment. The most prominent example is the mixed-capital enterprise in charge of the construction of the first trans-continental railway. Infrastructure endowment seems to be crucial for the long-term transmission of the colonial institutional characteristics to the outcomes measured in 2015, which show better average welfare outcomes, as well as higher wealth inequality in the treated group. My work provides an explanation of how the improvement in the quality of the institutions of an embryonic state may sustain the growth of the local markets it deems relevant.

1 Introduction

Colonialism has had heterogeneous applications. Experiences as far apart as the British settlement in North America, the Spanish conquest of the Inca empire, and the Belgian penetration in the Congo basin generally fall under the common notion of colonisation. Yet, historical and geographical characteristics made these regime types substantially different, namely in their capacity - such as the ability of government to collect the taxes, enforce the law, and deliver public goods - as well as in the degree of participation of government's decisions. As a result, a relevant literature stream has been studying whether these different institutional settings have produced diverging effects on the economic development of the countries emerging from the colonial rule. Acemoglu, Johnson, and Robinson (2001) exploit the positive correlation between the plausibly exogenous mortality rates of the settlers and the probability of setting up extractive colonial institutions, inferring their long-term negative welfare effects from a cross-country analysis. Other contributions highlight factors unrelated to climate and the environment that might have played a role in the settlement of the colonial rulers and in the design of more participatory institutions. For example, resistance by preexisting civilisations with their own culture and traditions increased the cost of setting up non-exploitative regimes (Lange, 2009; Hariri, 2012; Michalopoulos and Papaioannou, 2016). Overall, the existing literature on the colonial origins of development tackles the question in broad contexts that gain external validity but are exposed to the risk of forgetting relevant local characteristics, which may raise questions on the identification of the true causal effect, as highlighted by the working paper of Kelly (2020) or by Iversen, Palmer-Jones, and Sen (2013). With the aim to enhance internal validity as well as the understanding of a specific local context, I restrict my attention to India. There, the British gave rise to a variety of government types, by retaining their direct rule over an area roughly equivalent to 60% of the subcontinent at the maximal extension, while leaving the rest as protectorates under the domestic rule of local kings. The first regime was known as British India, and was subject to an increasingly organised administration introduced by the settlers. The latter - whose number approximated 600 - were called Princely States, and each of them maintained autonomous domestic policies, mostly implemented through feudal practices inherited by their previous tradition.

Using a regression discontinuity design along the boundary of British India and the princely states at the level of the Narmada River, I aim to capture the average treatment effect of the directly ruled colonial institutions on proxies of current welfare, such as health and nutrition conditions, as well as wealth indices. Importantly, I am not estimating how India would have evolved in the absence of colonisation, because the control group itself has never satisfied the definition of a fully independent country; in fact, the princely states were protectorates of the British. Instead, in the spirit of the literature mentioned above, I enquire whether the modernly organised regime of British India - which was able to enforce property rights as well as to give incentives to private investment - and the more traditional domestic policy of the native states can be responsible for diverging development outcomes over time. To this purpose, I restrict the attention to an area of Central India with two characteristics that help identifying the effect of those institutional regimes. First, there is availability of historical documents that shade more light on the motivation underlying the British decision to set up their direct rule only on one side of the reference threshold. I bring a first quantitative evidence on some characteristics of the region, which makes me possibly exclude that economic conditions at the time of the settlement have been the drivers of that institutional choice. Second, the border at the level of the river Narmada existed only during the colonial era, and the whole region is currently part of the same state of Madhya Pradesh. Hence, there has been no heterogeneity of political institutions after the end of the British domain. Overcoming these potential endogeneity concerns, I isolate the impact of political institutions on the economy, and I argue that decisions made in the XIX century have substantial consequences on current social welfare. I build on previous works similarly focusing on India, such as those of Banerjee and Iyer (2005) and Iyer (2010). Both may leave space for some unaccounted heterogeneity that has been shown to hinder the causal identification, for example by Kelly (2020). Additionally, Iversen, Palmer-Jones, and Sen (2013) claim Banerjee and Iyer's (2005) wrong imputation of the land-tenure system of Madhya Pradesh, which turns out to be a key driver of their findings[1]. In the spirit of Hariri (2012), Lee (2019) argues that Banerjee and Iyer (2005) may not fulfill the exclusion restriction property of their instrumentral variable, which is defined depending on the time of British conquest[2]. Iyer

[1]Iversen, Palmer-Jones, and Sen (2013) show that the Malguzari system in place in this area, which is normally associated to a Zamindari organisation, had instead little similarity with it, as peasants of Madhya Pradesh enjoyed more rights and protections since the Malguzari Settlement of 1863.

[2]In districts annexed at the beginning of colonisation, the British were more likely to accept the institutional status quo, because these were the richest and most populated areas, and - in case of a rebellion - they would have faced the highest opportunity cost by losing them. Thus, preexisting wealth may prove an alternative channel to the land tenure system, by which an effect on current development may be produced.

(2010) studies the effect of direct British rule on the provision of public goods such as access to the road system, canals, hospitals and schools across the whole India. However, she does not consider the railways network among the outcomes, and her proposed instrumental variable - the Doctrine of Lapse - may bring in timing concerns[3].

In consequence, I intend to contribute to the literature stream of political economy and economic history of India in a triple manner. First, in line with Lange (2009) and Hariri (2012), I show the positive average welfare effects of the colonial regime endowed with a modern institutional setting that took the responsibility of surveying the population and the land for taxation purposes, as well as of enforcing property rights and the rule of law through an organised administration. In line with Roy (2019), I argue that these average effects are not equally spread across the wealth distribution, because they seem to be driven by the top quantiles. In other words, a state design that reduced discretion and let the economy work on its own may have not only produced better effects on average, but also left room for more unequal wealth accumulation. Second, I target a sample that allows to overcome some issues of internal validity without losing sight of the key elements of representativeness, thereby proposing that the estimated effects are causal. Indeed, by considering only two of the hundreds of Indian princely states within my control group, I avoid to pool together an heterogeneous set of traditional states with their own institutions, and a high degree of heterogeneity in population, size and might[4]. In contrast, I am able to refer to local analyses from the colonial times - e.g. those of Malcom (1824) and Davidson (1868) - to detail the specific institutional setup of the treated and control groups in the area. Third, I take advantage of many historical sources - such as travel journals and official administrative gazetteers ranging from 1824 to 1908 - to build a novel database of the population of the towns and the density of the districts of the sampled area at two points in time: the moment of the British take-over in the early XIX Century, and the Indian census of 1901[5]. As a result, I am able to produce some evidence supporting the argument that the region where the British enforced their directly-ruled institutions might not have been richer at the time of their settlement.

In specific, at the conclusion of the third Anglo-Maratha war (1818), the British gained political hegemony over Central India, but they only imposed their direct rule on the land to the south of the River Narmada within the sample under analysis. In contrast, the northern shore was left within the administration of the local rulers, mostly those of Bhopal and Indore. Such decision resulted from a strategy extraneous to economic considerations, since the British have been able to win against the Marathas by exploiting divisions and enmities within the confederation of local rulers. In the case under study, the nawab of Bhopal allied to the British due to his rivalry with Nagpur and disagreements with the Maratha Peshwa, the chief of the confederation. After 1818, the British left the nawab to rule his state under the protectorate scheme. When Sir John Malcom (1824) first traversed an area immediately adjoining the one that would have entered British India,

[3]The Doctrine of Lapse was a policy implemented between 1848 and 1857 by the colonial government of Lord Dalhouise, forcing into Britsh India all native states whose rulers died without heirs. The most prominent among the very few undergoing lapse has been Nagpur. However, the fact that its ageing prince could not have children was known by the British when Lord Dalhouise imposed the doctrine in 1848; thanks to this arrangement, the state of Nagpur - against which the EIC had already fought during the Maratha Wars - was taken over without further sheds of blood in 1854. The doctrine of lapse was finally withheld three years later.

[4]ranging from the extent of the 21-gun-salute Hyderabad to the many small principalities that did not exceed 350 square miles and 10,000 inhabitants

[5]This has been the only official occasion when data from princely states have been also thoroughly collected.

his measurement of some proxies of economic development was no worse on the northern than on the southern shore. In contrast, the census of 1901 - which was extended to the princely states and was reported in detail by means of district-specific gazetteers - hints at a divergence that has protracted until my last measurement with data from the year 2015, even if the Narmada River had ceased to be the border between two different institution types for more than 60 years by then.

Despite the relatively small geographical extension of my sample, the amount of data at disposal for current measurement is not negligible, as I take advantage of an extensive database provided by the Demographic and Health Survey (DHS)[6]. In the main specification used in this analysis, there are 9473 individual respondents scattered across 354 clusters. However, interviews are distinct by gender. In 5449 households, there is at least one female respondent and no male respondent, but the opposite is true in only 112 households; 900 households have at least one respondent per sex. It follows that surveyed men are a mere fraction of surveyed women, and they mostly come from the same household. For this reason, I focus first on women data in the main specifications. As a consistency check, I make sure to repeat the study on men and I find comparable effects. To approximate local welfare, I focus on health and nutrition measures, as well as on some wealth indices.

The main findings are not only statistically but also economically relevant. In 2015, passing the cutoff from former princely states to British India, the outcomes improve by 7.7% of the average level of arm circumference, 7.7% of the average level of Body Mass Index, and 8% of the average level of Rohrer's Index in the linear fit of the main model. Along the same threshold, the probability of being underweight decreases by 18 percentage points, and that of child survival surges by 8. In addition, I have used a household wealth score at the state level to define the deciles of its distribution in the sampled area. Even if the average effect on the wealth score is not statistically significant at the threshold, I find that the bottom and top wealth deciles are more prevalent in British India. Taken together, the results imply that the better average nutrition effects are correlated with higher inequality in the region formerly under the direct rule of the British. This is concordant with the evidence proposed by Roy (2019), according to whom the main beneficiary of the new institutional set up of British India has been the richest part of the population. In parallel, the nutrition and wealth effects vanish or invert in the adjacent area, which is much akin to the main sampled tract, except for the fact that the Narmada River - my estimation cutoff - has never been an institutional border there, because both shores used to belong to native states. The robustness of such findings leads me to conclude that the area formerly managed by direct rule persistently outperforms the protectorate control group in sensitive matters for average welfare, despite the current administrative unity. Yet, this average result is likely driven by the top of the wealth distribution.

In order to understand more precisely when the long-term results had an origin, I have retrieved population and density information from the Census of India of 1901, which includes coverage of the princely states. In a Malthusian setting without significant technological progress, these variables are commonly reputed to be reliable proxies of economic development. With the same RD strategy used to retrieve the positive effects in the main specification of 2015, I isolate positive point estimates on population in 1901. They amount to 35% of the average population in the most conservative output of the linear fit, and to 23% in the most conservative output of the quadratic fit.

[6]They perform detailed interviews mainly concerned with health-related questions in developing countries, and they have implemented extensive networks in India to target the village level.

The information provided by travel gazetteers and the first local censi in the Nineteenth Century also returns mainly positive point estimates, but the difference is statistically and economically negligible in that case. I augment it with other qualitative historical evidence concerning British strategies, showing that their focus on the area was due to its strategic rather than economic importance. Hence, it seems that the specific treatment group I consider in this study was not more developed than the control when the British settled in the Nineteenth Century, but a divergence started to emerge at the beginning of the Twentieth Century.

I justify the current persistence of such an effect that dates back to colonial times, by posing and testing the following theory. The creation of a modern state organisation in the directly ruled side of the Narmada River was pivotal to a profitable interaction between the public and private sectors. The administration of British India enforced property rights in exchange for the payment of a tax determined by means of land settlements that included some provisions to foster private investment. In this spirit, tax rates were usually fixed for at least a decade, and this principle has only been reviewed in more favourable terms to the landlords, when an adverse shock on the economy made the reduction of the tax desirable according to the principles of countercyclical fiscal policy[7]. Such setup contributed to create positive synergies between government and the private sectors, whose climax has been reached in the joint enterprise of the construction of the first transcontinental railway, opening in 1870. As thoroughly described by Davidson (1868)[8], the guarantee of yearly interest payments imposed by British India has been the fundamental factor to achieve the collection of the abundant resources required to face the fixed costs of the new technology. The success of the guarantee lied in the credibility gained by a set of state institutions that - in contrast to those in the control group - have been enforcing property rights and favouring private investment independently of the will of the monarch. The railway infrastructure, which has been brought in place thanks to the aforementioned financial structure, was then among the drivers of the economic growth following Indian independence in 1947, by cutting travel times and trade costs, and ultimately increasing the returns to capital. Indeed, extending the sample used in the long-run analysis by accounting for a further stretch of the border that lies on average further away from the railway, the magnitude of the ATTs on the same outcome variables reduces. This implies that, while there seems to be a long-run effect of the institution per se, this is stronger where such institution posed the conditions to build a long-lasting communication infrastructure.

The rest of the paper brings punctual detail on the evidence that has been anticipated here, and it is organised as follows: Section 2 summarises the main differences across the treatment groups; Section 3 discusses the strategy for the identification of the causal effect, including data collection from the first half of the XIX Century; Section 4 explains the data involved in the current analysis (2015), and the results from the main specification; Section 5 proposes consistency and robustness checks; Section 6 offers an insight on the transmission chain, starting from evidence collected in the year 1901; Section 7 concludes.

[7]See the "Final Report on the Land Revenue Settlement of the Hoshangabad District", 1918

[8]The endeavours of the construction have become so notorious at the time, that Jules Verne's "Journey around the world in 80 days" was set to pass through the railway under analysis.

2 Institutional variation across the treatment groups

As anticipated in the previous section, the objective of this study is to answer the following question: has the type of institution in place during the colonial period produced long lasting effects on local development in Central India? For this purpose, I am going to describe the different systems of government that were in place across the colonial threshold in the sampled area, which is described at Map 1n the appendix. I consider the border between the Central Provinces of British India, and the princely states of Bhopal and Indore of the Central Indian Agency. Districts marked in colour enter the analysis: in pink, those belonging to the treated group; in yellow, those belonging to the control group[9]. In general, institutions with more homogeneous administration and smaller scope for discretion characterised the treatment group, as opposed to those preserving most of the traditional feudal structure of the Maratha Empire on the control side. An important simplification generated by the Indian setting during the colonial era is the absence of armed competition, as the British were unambiguously the hegemonic power of the subcontinent. If this was not the case, different capacities to predate on others would introduce a confounding effect in the analysis. Indeed, absolute monarchs with strong armies could be able to make their country richer thanks to new income accruing from the armed conquest of smaller states, a channel that is clearly alternative to an institutional organisation that favours positive synergies with the private sector - the mechanism that stems out of my analysis. Despite the lack of any variation in the military domain, there are substantial differences in the way British India and the princely states have been organised with respect to the design and implementation of domestic and economic policies, which are going to be detailed in what follows.

The districts coloured in pink at Map 1 make up the treated group. Prior to the British takeover of 1818, they consisted of some peripheral lands under the control of the Marathas of Nagpur, without much relevant human presence[10]. Consistently with the argument of Lange (2009), it didn't come as an insurmountable effort for the British to reorganise this "new country" by means of the land settlement introduced in 1838 under the government of Majour Ouseley, which set up property rights in exchange for the payment of the land tax. From then onwards, the land settlements of this part of British India followed three principles that favoured private investments. First, the amount of the tax was fixed for the full duration of the settlement, thereby minimising the volatility of costs imputable to other causes than climate or geography. Second, there is historical evidence that, especially in the second half of the XIX Century, the tax rates were not set to the maximum that could have been extracted by the quality of the land, with the aim to leave room for productivity-enhancing investment.[11]. Third, eventual revisions of the land settlements before their expiration have only been set in favourable terms to the private sector, e.g. when countercyclical fiscal policies have been implemented by decreasing the land tax as a result of the drought that hit Central India

[9]A caveat should be made about the district of Khargone. Despite it being overwhelmingly part of the state of Indore, a small British exclave existed there.

[10]The Gazetteer of the Central Provinces of India (1870) describes: "At first sight it must seem singular that a given area in this magnificently fertile valley should only support one man, when in the sandy plains of Upper India the same extent of land affords sustenance to three, or even four. But it must be remembered that the Narmada valley is, to all intents and purposes, a new country, which has only been reclaimed from wild forest within the last two or three centuries".

[11]From the "Final Report on the Land Revenue Settlement of the Hoshangabad District" (1918): "Owing to the large areas of culturable waste which were then [1864] available, it was considered unwise to raise the revenue to the pitch that could have been justified by the raise in the profits of cultivation, and Sir Elliott's settlement was therefore a deliberately lenient one.

in 1900. Accurate historical information on the subject can be found in the "Final Report on the Land Revenue Settlement of the Hoshangabad District" (1918)[12]. The fact that the settlements specified their duration implies that land underwent periodical assessments by the civil servants to determine its value and adjust the tax rate accordingly. While an initial effort had been required to set up a state apparatus in charge of these tasks, such organisation then gave the revenues that the districts incorporated in British India disposed to improve their operations. Among others, local censi of the population have been implemented since 1866, reporting the total costs of the civil administration, the number of police forces in each station, and of cases ruled in the town courts, as it emerges from the "Gazetteer of the Central Provinces of India" (1870). In short, a positive feedback loop was generated, whereby landlords and proprietors were subject to the land tax in exchange for having their economic rights enshrined by the state administration. On the political side, direct parliamentary elections were introduced by the Government of India Act of 1919 as the last of a series of reforms that started with the Indian Councils Act of 1861, and went in the same direction of improving accountability. Voting rights were limited to people with property, taxable income, and that paid a revenue of at least 3000 rupees, but were meant to consolidate cooperation between government and proprietors. Last but not least, the opening of new roads and the realisation of reports on their overall conditions[13] underlines the responsiveness of the administration of British India to the improvement of local infrastructure towards an enhanced contribution to the economy of the empire. The most important of the infrastructural undertakings has been the construction of the Great Indian Peninsular Railway, which opened the first direct train connection across the subcontinent in 1870. As it will be detailed in Section 6, the role of the state institutions has been pivotal in this realisation, achieved in cooperation with the private sector as the culminating point of the public-private synergies ensured by this type of state organisation.

The districts coloured in yellow at Map 1 compose the control group. They make up the entirety of the former princely state of Bhopal, while the rest belonged to the state of Indore, and in minor parts to the small states of Dewas and Dhar. Across all these districts, an alternative system was in place, whereby the land was property of the sovereign and leased to his fiduciaries. As John Malcom notes in his "Memoir of Central India" (1824), the pyramidal vassal structure in these princely allowed the existence of a chain of bheits[14] that entitled the fiduciaries to take hold of a further amount of the produce, on top of the sum they were already given by virtue of their office. For example, "The Dewan[15] has, independent from his pay from the prince, certain claims on the collection of every district", and very similar provisions are followed scrolling down the honours ranks[16]. As a result, Malcom noticed that a fair amount of discretion was involved in the process of tax collection, as "neither the chiefs of that nation nor their subordinate officers, have ever limited themselves to their ordinary allowances", producing the historical evidence that "the principle of this part of a Rajpoot principality differs little from the feudal system which formerly existed in Europe". As a result, the lords sought for their own quest of enrichment by virtue of a place into the vassal chain and often took advantage of military crises to consolidate their domain in spite of

[12]"The year 1893 saw the commencement of a cycle of seven lean years. [...] In 1903-05, 62 lakhs [6,200,000 rupees] were remitted by award. [...] The term for which the abated rents and revenues would remain in force was extended til 1915-18. [...] These measures, aided by a series of more favourable seasons, restored the district to a very large measure of its former [1892] prosperity."

[13]For example, see those contained in the Road Tables of the "Gazetteer of the Central Provinces of India" (1870)

[14]an Indian word for something very akin to what would be a corvée in medieval Europe

[15]i.e. the local prime minister

[16]In favour of the Buckshee, the Furnavese, the Mozundars and the Zemindars (or collectors).

the main rulers[17]. Such a type of institution prevented the emergence of a unitary administration, as well as of a careful assessment of the fair conditions of the land that could have accompanied private investment, because the vassals had all interest to maximise their revenues from taxation to strengthen their position.[18]. Consistently, the police has been used as an instrument of personal power, since the office known as Cutwal was rented out to private bidders and vested in "a discretionary power of fine, imprisonment, and slight punishment", according to the same John Malcom (1824). When it comes to the administration of justice, the duties of the judge "were limited to drawing up contracts of marriage, or writing and registering bonds and deeds of sale in his own tribe". Since justice was served separately by village and caste, the Imperial Gazetteer of India (1904) reports that there existed no regular jail in Indore before 1875. In fact, the traditional structure of the princely states under analysis was inherited from the Maratha Empire, of which they were part[19]. Even if some modifications have been gradually introduced via the institute of the British Agent[20], they were implemented with a definite delay, and to a much lesser extent than in the region under direct rule. Indeed, the British administration with respect to the native states seems to have adhered to the principle outlined by John Malcom: to "escape every interference with the internal administration of the country, beyond what the preservation of the public peace demanded". Hence, the form of government of the princely states of this part of the country mostly stuck to the feudal framework described above[21]. For example, as per the "Imperial Gazetteer of India, Provincial Series, Central India Agency" (1904), a regular state police was organised in Indore only in 1902. In contrast, as early as 1870, there were a total of 1635 European and native employees in the police force of the five districts to the south of the Narmada.

In sum, the quasi-experiment at the heart of this paper exploits a discontinuity in the type of state organisation during colonial times, in order to isolate its causal effect on long-term outcomes that are meant to approximate welfare. It should be noted that such discontinuity of institutions existed only between 1818 and 1947, because both banks of the river underwent a similar organisation before the British colonisation[22], and they both have been part of the same federate state after the independence of the Indian Union. During the colonial period, the princely states in the sample have adhered, despite some improvements over the years, to the early Maratha feudal and discretionary structure that did not leave economic agents in the conditions to invest profitably in the land, nor to see their economic rights enforced. Instead, the fiscal and juridical institutions of British India gave space to more property rights, and to implement periodical assessments of the value of the land for the purposes of a modern type of tax policy that included countercyclical interventions in the economy. I predict that this latter type of public management, albeit dictated by

[17]John Malcom (1824): "It has not been unusual, particularly when the country was in a state of confusion, to depute officers high in the state (generally military leaders) to govern large tracts of territory, in which either the revenue of lands, the tribute of Rajas, or the receipts of collectors, were assigned to them for their current and extra expenditure. But these leaders, who have always taken advantage of the times to usurp as much power as they could from the government which employed them, cannot be classed among its officers, or considered as belonging to its regular system of administration."

[18]John Malcom (1824): "In many parts of Malwa [a region on the northern side of the Narmada] the villages are assessed as high as twenty and twenty-one rupees annually for this one demand of public officers"

[19]This is also evidenced by Charles Grant's "Report on the Land Revenue Settlement of Narsinghpur Discrict" (1866)

[20]The sole connection between the native rulers and the colonial government in Calcutta

[21]The legal provisions of the specific autonomy in domestic affairs were acknowledged by the treaty of Mandasor, the present-day Mandsaur at the the end of the third Anglo-Maratha war.

[22]The north belonged to the princes of Bhopal and Indore, the south to those of Nagpur, all being part of the Maratha Empire

British needs and not by benevolence, resulted in an enhanced cooperation between the public and private sector that fostered investment - including the first trans-continental railway - and posed the foundations for a more dynamic economic environment in the long term. After presenting the case that the starting conditions across the two shores of the river might have been comparable (which is the object of Section 3), I measure welfare outcomes - specifically in terms of health proxies and wealth inequality - across the two sides in Section 4.

3 Identification strategy

In a spatial RD setting - such as that which I apply in my analysis - the unbiased identification of the ATT rests upon two crucial properties: no sorting and the exogeneity of treatment. I study them in two distinct subsections, respectively in combination with geographical and historical features of the sampled area.

3.1 No sorting

RD designs isolate the effect of a policy that changes abruptly at the cutoff point of the running variable, by comparing the outcome of interest on observations near such threshold across both sides. For this empirical strategy to have a causal interpretation, the cutoff point must be exogenous; in other words, it must be the case that individuals, when making their location decision, do not take into account the existence of the cutoff for reasons related to the outcome of interest. For example, in the situation of a spatial discontinuity willing to measure the effect of an institutional border on wealth, sorting would happen if economic agents could freely commute across. Indeed, poorer people might gain bargaining power by living in the poorer region and working in the richer, thus facing the lower prices of the former and the higher wages of the latter. This scheme would generate an upward bias in the difference, because of an anticipation effect at the individual level about the existence of the cutoff - which is not imputable to the treatment. Therefore, it is standard practice in the literature of spatial RDD to minimise the likelihood of sorting by taking definite geographical barriers - such as rivers of sizeable importance - as cutoff points. The Narmada River, highlighted in blue at Map 1, overlaps with the colonial border in a specific section within this study. Known in the West since the II century of the current era[23], it flows for a total length of 1300 km from the Maikal Hills into the Arabic Sea, generating a drainage basin of 98,000 square-kilometres. The generous but unstable rainfall at its sources, ranging from 1000 to 1800 mm per year, makes the river unpredictable and unfit for navigation. Even if a development program aiming at the construction of dams is ongoing in present times, the Gazzetteer of the Territories Under the Goverment of the East India Company of 1857 quoted: "The river, notwithstanding the great width of its bed in the upper part of its course, appears to be scarcely anywhere continuously navigable for any considerable distance".[24] Perhaps due to its prominence among the rivers of Central India[25], the Narmada is also an object of pilgrimage in the Hindu religion, as it is considered one of the seven holy rivers of the subcontinent. The very fact that its existence is traditionally associated

[23]the geographer Ptolemy reports it in his Atlas, the first of this kind of books in the history of mankind.

[24]The unpredictability of the river should not lead to think that it may create asymmetrical floods, such that one bank be consistently more fertile than the other. At section 5.1, a placebo test is presented, where I use an index of aridity as outcome variable, showing the absence of any jump.

[25]Its drainage basin is equivalent of South Korea's land area

with Shiva - a key figure of the Hindu pantheon - is indicative of its prominence among the rivers of Central India. Furthermore, there are only 15 bridge crossings in its 400-km span of the region under study. This characteristic not only fosters the intuition that cross-bank movements face a relevant obstacle, but also helps to address the no-sorting argument empirically. At section 5.2, I will present a robustness check by comparing two RD regressions: in the running variable, one has the distance from any shore of the river; the other has the distance from the crossing points only. I acknowledge that the validity of a similar test depends on the outcome of interest, because sorting may in principle induce both an upwards and a downwards bias. However, some variables can be chiefly biased in one direction by the presence of sorting; in this case, the test can prove helpful. For example, the effect of better institutions on wealth risks to be overestimated in the presence of sorting, as per the reasoning exposed at the beginning of this section. Consistently, I find that such effect magnifies in the sorting-prone specification of my sample, leading to the conclusion that the estimates from a likely biased regression are robustly different from those that accrue from my main specification of the model. To mitigate possibly remaining concerns about sorting, I try to control for migration proxies, such as whether the respondent is a de jure resident at her current location, or the percentage of her life spent at the current location. These are post-treatment variables whose addition is likely to bias the causal interpretation of the ATTs. Indeed, an area that is richer by virtue of the treatment is in principle more likely to experiment migration from people in search for better opportunities, which is most likely to put a downward pressure on the estimates that is not imputable to the quality of institutions. However - as it emerges at section 5.3 controlling for these proxies - the estimation results of my preferred specification are almost unaffected, implying that the contribution of migration to the main findings is negligible. Therefore, the arguments introduced here - combined with the evidence provided at sections 5.2 and 5.3 - make the case that the Narmada is a strong barrier that minimises the chances of sorting.

3.2 The exogeneity of treatment

Another fundamental evidence that must be provided for the purpose of isolating the causal effect is that assignment to treatment be unaffected by relevant unobserved characteristics. In other words, beyond making sure that people do not choose their preferred treatment status, assignment to treatment must not depend on elements that are excluded from the model and may impact the outcome of the experiment. This amounts to showing that the British did not impose their direct rule due to a more developed economy or more productive land at the time of the conquest, as these variables would be correlated with the economic outcomes today[26]. For this purpose, a wide set of historical documents, travel reports and census data has been found to explain that the reason behind the settlement of the British in the area responds more to a foreign policy strategy. In consequence, assignment to treatment seems to be orthogonal to the economic conditions at the time it was made, and hence to current development. In the continuation of this section, I explain in greater detail the presence of strategic reasons and the lack of economic justification for such a

[26]Some examples in the literature focus on neighbouring districts like those in my sample, either as their main argument (Becker-Boeckh-Hainz-Woessmann, 2014) or as robustness check (Banerjee-Iyer, 2005; Lee, 2019). The proximity of neighbouring districts and their small scale of influence with respect to the full magnitude of the assignment to treatment in the process of Indian colonisation are used by these papers as crucial components to their argument of exogeneity. Indeed, under such view, assignment to treatment in a small subset of the whole India can be seen as a price shock in small open economies: a mere source of exogenous variation. However, I am in the condition to avoid this type of assumptions to support the argument of exogeneity in my analysis.

choice.

3.2.1 British strategies in the third Anglo-Maratha war

Colonisation reached Madhya Pradesh at a later stage than other parts of India, well after the British had gained direct control over the most economically promising parts of the country. At that point, their policy aimed to consolidate existing power rather than to acquire new conquests, which would have demanded further administrative efforts. Hence, the British took up direct control only of those places that were strategically relevant to fostering their hold on the country. A brief look into history confirms this argument.

British penetration into India started with the East India Company (EIC) in the XVIII century, following the industrial revolution and the spike in demand of textile inputs that the United Kingdom was lacking. Indeed, the EIC itself was a stock company mostly owned by the entrepreneurs in the new textile firms. Hence, in the first years of their presence in the subcontinent, the EIC settled in ports like Bombay, Calcutta and Madras, from where it was easier to ship inputs back to Britain. With the consolidation of these initial hubs, the aim of further profits was at the root of the British expansion, whose fiercest opponent was the Maratha Empire. Despite an initial defeat, the EIC gained control of the cotton-rich coasts of Deccan, and of the fertile Ganges valley with the second Anglo-Maratha war[27]. Map 2 is a map of India showing in pink the territory directly ruled at the end of this war in 1805. Map 3 shows the extension of British India four years after the victory in the third (and final) Anglo-Maratha war of 1818, the event that started the colonisation of Central India. Comparing the two maps, we can observe that - while the second Anglo-Maratha war was made with the purpose to increase profits by the extension of the control over the most economically advanced regions - only few additions to British India followed the third Anglo-Maratha war. Indeed, after 1805, the leading trend has been for the British to create protectorates in the form of princely states. As the chronicle "Notes and suggestions on the Indian affairs", published in the Dublin University Magazine in 1849, puts it: "The great principle hereafter to be followed is forbearance, as it has been that for many years past".

Despite the final stance of third Anglo-Maratha war, which has been crucial to the British acquisition of hegemony over the Indian subcontinent for the following 130 years, the only exceptions to the trend of creating princely states were the area around Poona, and a strip of land on the southern bank of the Narmada River - which constitutes the treatment group in my sample. In fact, these lands were put in direct control because their strategic location allowed the British to merge three groups of separate domains into a stronger entity endowed with territorial contiguity. In specific, Poona[28] lies between the former domains of Bombay and Madras, while the Narmada valley is the shortest passage from Bombay towards the Ganges Plain and Calcutta[29]. On the contrary, all the main strongholds previously subject to the Marathas - such as Bhopal, Gwalior,

[27] Albeit being inland, the Ganges Plain was for long time easily connected to Calcutta thanks to the navigable river

[28] The ancient seat of the Peshwa, the Maratha equivalent of a prime minister, left vacant by its flight in 1819.

[29] A gap of particular relevance in this connection is the fort of Asirgarh, also called the "Key to Deccan". It is located some 40 km to the south of Khandwa, the capital of one of the southern districts included in my sample. Its positioning atop of the easiest access between the Tapi and Narmada valleys made it a much coveted prey since the times of the Mughals.

Indore, Nagpur, and Vadodara – were left under the administration of their native rulers[30], within the protectorate status of the princely states. The fact that, despite their wealth, these cities were not seized into direct rule by the British underlines once more their intentions with regards to the third Anglo-Maratha war: not to take on yet other provinces that would have required a further administrative burden, but to broadly stabilise and fortify their control over India. Indeed, in the early XIX century the British were lacking the military power to seize the whole country by the mere means of force. Rather, they have won the war by cultivating disagreements between the competing Maratha forces, thereby reigning over division, such as in the case of the long-lasting hostility between Bhopal and Nagpur. The nawab of Bhopal - seizing the opportunity to escape the supervision of the Peshwa[31] as well as to strengthen his position against the neighbour - became an allied of the British, and as such has he been treated after their victory[32]. In broader terms, John Malcom's "Memoir of Central India" (1824) explains that the advantage taken by the British out of the rivalries among the local chiefs rested in the ability to play as moderators, thereby managing to become closer to each of the opposing parties than these latter were to each other.[33] Hence, in the sample under analysis, the decision to treat some districts as part of British India rather than leaving them in their native states responded chiefly to a foreign policy view adhering to the old Roman principle of *divide et impera*.

The lack of economic interests is further underlined by the fact that the Narmada valley was scarcely populated at the time. In fact, the "Gazzetteer of the Central Provinces" of 1870 calls it "a new country, which has only been reclaimed from wild forest within the last two or three centuries". Consistently, Andrabi-Kuehlwein (2010) find that the effect of introducing a railway on price convergence is 7 times stronger in this previously isolated area than in the Ganges Valley, where human settlement was abundant, the economy more flourishing, and other types of communication (e.g. via the river) already in place, all of whom prior to the advent of the British. The next subsection will look into the issue by using historical population data.

3.2.2 The treated group was not richer in 1818

In what follows, I argue that the region seized into British India was much less important in economic terms than in political terms, using some archival sources spanning the time around the first stages of the colonisation of Central India. However, the interpretation of historical information dating back of two centuries is not without challenges, and I highlight two of them. First, due to the different timings of the gazetteers and censi under study, the spelling of the names of the towns is subject to changes. When possible, I compare the same town that appears in more than one source, to check the consistency of the information reported. To this purpose, I have been paying particular attention to entries that - albeit with different spellings - refer to the same places across different sources. For example, the town of Maheshwar appears in Malcom's "Memoir of Central

[30] albeit with restricted borders such as in the case of Nagpur

[31] The chief of the Maratha princes

[32] The kingdom of Bhopal has even been enlarged with the donation of Ashta by the British

[33] "The preservation of the peace of the country, as well as its advancement towards prosperity, depends upon our admitting nothing into the manner or substance of our general control which may have a tendency to revive the jealousy or fear which is now at repose." [...] "[Our] agents, within their respective circles, have not only, by their direct intercourse with all classes, established great influence, but spread a knowledge of our character and intentions, which has increased respect and confidence. And they have in almost all cases succeeded, by the arbitration of differences, and the settlement of local disputes."

India" and in the same author's "Index to the Map of Malwa" with the spelling of Mhysir, where he describes it as "a city containing 3500 houses [...] with a large and a well-supplied bazaar". By means of its location description and of comparable coordinates across many sources, I have been able to link Malcom's Mhysir to the town spelled as Muhesur in the Gazetteer of 1857. There, it is said that it "contained 3500 houses in 1820, which - at the usual average - would assign it a population of 17500". Dividing the number of inhabitants by the number of houses, I infer that the "usual average" is five persons per house, a finding which is reinforced by further analysis of the towns that appear in multiple documents. Indeed, the Gazetteer of 1857 reports a "population [of] about 2000" in the town of Mundlaisir, and the Memoir of Central India states that Mundleysir "contained 394 houses". Therefore, I apply the same inference and multiply the number of houses by 5 to get the town population, if only the former information is provided in the documents. Although the vast majority of data are consistent across different sources, it is also the case that some discrepancies exist. In particular, 7 observations in British India - for which the gazetteer of 1870 is the only source of information - are not reported the same population amounts within the pages of the very same document, and I take the average as my standard reference.

Second, information concerning the treated group is mainly found in reports and gazetteers starting from 1857[34], while the control group is mostly the object of two surveys in 1824: Malcom's "Memoir of Central India", and his "Index to the Map of Malwa". Furthermore, population data on the part of the southern shore of the Narmada that entered British India cannot be retrieved further back than 1870, so there is a 50-year lag with the control group on the northern bank[35]. Even if Malcom's reports include the population of some towns and villages located on the southern shore, these are immediately to the west of the area where the river Narmada overlaps with the border between colonial regimes. In particular, they currently lie in the districts of Khargone and Indore, and both used to belong to the princely state of Indore. In consequence, a trade-off emerges on the southern shore. On the one hand, I could use historical data that were measured at the same moment across the two shores, but only in the immediate proximity of what would have become the border of British India and Princely States, so that both banks would have actually remained under princely-state domain. On the other hand, I could use historical data across the whole colonial border, but the treated group is measured 50 years later than the control group in this part of the sample. I present the outcomes of this latter case, because they do not imply losing observations, and they are more conservative[36].

The main outcomes of interest are population and density, because these are recognised by a vast literature in economic history as good proxies of GDP in the Malthusian type of economy that both sides shared in the early XIX century, when technological progress had yet to come. Since the latter is not available, I can collect the population per village across pergunnah, i.e. the small traditional districts of Central India. My prediction, based on the premises of Section 3.2.1, is that

[34] The main references are: "The Gazetteer of the Territories Under the Government of the East India Company and of the Native States" (1857), "The Gazetteer of the Central Provinces" (1870), "The Report on the Land Revenue Settlement of the Narsinghpur District" (1866), and "The Report on the Land Revenue Settlement of the Nimar District" (1868)

[35] Even if some towns are mentioned in the gazetteer of 1857, the population data used by that source are those compiled by Malcom some thirty years earlier. And Malcom's books do not contain population data on the part of the region under study, which would have entered British India.

[36] The specification across the Narmada River in the proximity of the colonial border reports strongly negative ATTs. This implies that - at the threshold - the part along the southern shore of the Narmada, near to where the British would have settled, might have had better development proxies in the XIX Century.

the outcome variables are not the object of relevant changes across the river at the time, because the British did not seem to be willing to seize the richest area but the one more akin to their strategic interests. In short, the collected historical sources range from 1824 to 1870 and mention 239 towns or villages in the sampled area. In 106 cases, I have been able to obtain population data[37]. Information is also provided about the number of villages in 65 pergunnah, i.e. small sub-districts representing the unit of revenue collection in the feudal organisation of the Maratha states. Hence, I can compute the average number of people per village[38]. A map of the towns for which historical population data is available can be consulted at Map 4 in appendix. The balance table at Table A.1A in the appendix shows three average outcomes sampled in the area that would have remained into pricely-state administration (Control group) vis-à-vis the one in British India (Treatment group). Two main facts emerge. First, it is interesting to note that fiscal revenues per capita were considerably higher in the control group. Despite being noisy due to few and imprecise observations, this result may be connected with the stronger fiscal pressure generated by the feudal institutions described at Section 2. Second, average population is higher in the towns of British India, and this seems to go against my prediction that conditions were equivalent at the time of the British settlement in the area. However, it should be noted that this difference is less than 10% of the average population of 5800 reported at Table A.1B, and may be explained by the fact that the measurement of the treatment group has been performed 50 years later than control. In fact, I argue that the difference does not seem to be economically relevant. By comparing population data in the thirty-year span between 1870 and 1901 in those towns that have been sampled on both occasions, the mean population growth is reported around 17% in Table A.1B, even if the data measurement of the census of 1901 has been produced soon after the famine that started in 1893. Hence, I would expect the average difference between two outcomes measured within 50 years in which no major epidemic is reported to be higher than 10%, for the starting conditions to be deemed favourable to the treated group.

For a more empirically grounded argument, I use the full historical database, and I implement a quantitative analysis by means of a very similar model as the main specification in Section 4. In other words, I perform a RDD regression of the following type:

$$[1] \quad Y_c = \beta_0 + \beta_1 T_c + \beta_2 X_c + \beta_3 D_c + \beta_4 T_c * D_c + \epsilon_c$$

The unit of observation is the village or the pergunnah, depending on whether the outcome of interest is the town population or the population per village.

[37] The cities of Bhopal, Reisen, and Sehore are assumed to have 25000, 2500, and 2500 inhabitants respectively, based on the evidence from neighbouring settlements of comparable relevance, i.e. the towns of Vidisha vis-a-vis Bhopal, and Ashta with respect to Reisen and Sehore. I made such assumption because the coverage of the state of Bhopal by the XIX-century sources is on average scarcer than that of Indore. However, Ashta and Vidisha just bordered Bhopal. The former was a town of average dimensions, which the British later assigned to Bhopal state, and I compare it with Reisen and Sehore because these are district seats, i.e. cities that come second in relevance after the capital. Instead, Vidisha was a town of relevant dimensions, which I link to Bhopal city. These guesses are conservative as the population of Bhopal is reported in 1901 at 76000. In addition, Reisen and Sehore are currently district capitals, and the average population of current district capitals recorded in the south is around 5000.

[38] I am thankful to the compilers of the reports and gazetteers used in this process, for having taken note of the geographic coordinates of the places they were describing. Without such help, it would have been much harder to locate the towns, as the spelling of most of them has considerably evolved over time. For example, the town spelled as Mundleysir in 1824 became Mundlaisir in 1857, then Mundlaisur, and finally Mandleshwar

Y_c is the outcome of interest.
T_c is a treatment dummy equal to 1 if the observation unit lies in British India.
X_c is a vector of covariates. Across different specifications, X_c may include some or all of the following: altitude, and the average of temperature and rainfall, measured in the time span from 1985 to 2015.
D_c is the euclidean distance of a town from the colonial border.
Standard errors are robust to heteroskedasticity.
The model is run with a triangular Kernel-weighting function and the MSE-optimal bandwidth selection. To be consistent with the main specification in Section 4 and to be as conservative as possible, I implement an asymmetric MSE-optimal bandwidth selection across the two sides of the cutoff.

Figure A.1 reports the distribution of the towns mentioned in the Nineteenth-century sources, ranked by the distance from what would have emerged as the colonial border, so that it seems there is not a discontinuity in the neighbourhood of the threshold. Figure A.2 depicts a graphical plot of model [1] with linear fit, evenly-spaced bins and the full sample extension, predicting a small positive effect on population at the threshold, and no statistically significant difference. Table 1 reports the estimation outcomes of the coefficient of interest β_1, in RD model [1], up to column (6). In specific, the coefficients of the first three columns arise from a linear approximation of the unknown population regression function, while those of the subsequent three stem from a quadratic fit of the model. Within each set of polynomial orders, the first column comes from a specification that includes all covariates X_c, the second only temperature and rainfall, while the third does not control for X_c[39]. Columns (7) to (9) implement a standard OLS regression, with the same covariates as in the respective RD model. Across all specifications documented with XIX Century data at Table 1, I always fail to reject the null hypothesis of zero at the threshold. Beyond the high p-values and standard errors - which may be attributable to noise in the data - a further pattern is evident from the table. Because this analysis is meant to measure the ATT of a proxy of welfare (such as town population) at the moment in which the British arrived in the area, geographical controls have been added for the sake of completeness but they are in fact redundant. Indeed, at the time when the decision to seize a land and not another was taken, all the geographical characteristics of such land are included in the decision. It is only later, when I aim to extract the effect of the treatment, that I should separate the effect stemming from geographical features such as rainfall and fertility. Therefore, I focus my attention on the coefficients of columns of (3), (6), and (9), where no control is added in the regression model. The RDD with a linear polynomial fit reports an ATT of 850, or 14.6% of the average population. In the RDD with a quadratic fit, this measure halves. In the OLS specification at column (9), it is by construction equal to the differences of the means shown in Table A.1. In all cases, the same reasoning as before applies. Due to the 50-year lag between the measurement of population in the treatment and control groups, higher magnitudes than those emerging from Table 1 would be required to sustain the idea that the area where the British settled was richer at the moment when they seized it. In fact, the average population growth in the 30-year span between 1870 and 1901 - with the famine of 1893-97 emerging in the middle of the two measurements - is around 17%. This implies that the average effect of 14% in favour of a group that has been sampled 50 years later, and within a time-span (1822-1870) when

[39] A more detailed explanation of the differences between the "conventional", "bias-corrected" and "robust" estimations will follow in Section 4

no major epidemic or adverse shock burst[40], does not bring great economic significance (on top of the evident lack of statistical significance). In sum, it seems that - consistently with the historical evidence produced in section 3.2.1 - we might be reluctant to accept that the British settled on a more developed area when taking hold of this part of Central India. At Table A.2 in appendix, I have manually imputed symmetric bandwidths with a progressive 10-km increase in extension on the same sample. The table reports very volatile results, spanning from negative values to an ATT of 3575, but none of them is computed on a MSE-optimal bandwidth. In cases like this, interpretation might chance relevantly depending on which bandwidth one decides to observe. This is why I focus on the optimal bandwidth. In fact, also an alternative estimation method - the OLS estimate at column (9) of Table 1 - is in line with the magnitude of the ATTs estimated in the RDD with the optimal bandwidth at columns (3) and (6).

Table 1

	(1) popul 1800	(2) popul 1800	(3) popul 1800	(4) popul 1800	(5) popul 1800	(6) popul 1800	(7) popul 1800	(8) popul 1800	(9) popul 1800
Conventional	1601.1	3008.7	1700.2	-101.9	2024.0	534.0			
	(3255.5)	(2986.7)	(2665.7)	(4224.5)	(3976.1)	(3769.1)			
Bias-corrected	289.5	1992.8	849.8	328.5	1193.3	410.8			
	(3255.5)	(2986.7)	(2665.7)	(4224.5)	(3976.1)	(3769.1)			
Robust	289.5	1992.8	849.8	328.5	1193.3	410.8			
	(4258.3)	(3974.6)	(3584.6)	(4656.2)	(4920.8)	(4358.4)			
OLS							2302.3	2802.1	516.3
							(3015.6)	(3211.8)	(1919.7)
Observations	106	106	106	106	106	106	106	106	106
cutoff	0	0	0	0	0	0			
N_left	20	23	21	42	42	40			
N_right	18	18	17	21	23	22			
bwidth_left	48082.1	49260.9	48427.7	82207.0	82210.8	77726.8			
bwidth_right	42567.0	35463.7	32614.6	64022.7	78588.0	70451.6			
order	1	1	1	2	2	2			
bwselect	msetwo	msetwo	msetwo	msetwo	msetwo	msetwo			
kernel	Triangular	Triangular	Triangular	Triangular	Triangular	Triangular			

Standard errors in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Regression discontinuity and OLS output. The outcome variable is population in the Nineteenth Century. The running variable is the distance from the colonial border. The observation unit is the town or village. Standard errors are reported in parenthesis. Columns (1) to (6) run a RD model with triangular Kernel-weighting function, first- and second-order polynomial fits, and two different MSE-optimal bandwidth selections across the cutoff. Columns (7) to (9) run an OLS regression. Columns (1), (4), and (7) control for altitude as well as the averages of temperature and rainfall between 1985 and 2015. Columns (2), (5), and (8) only control for the averages of temperature and rainfall. Columns (3), (6), and (9) do not include covariates.

As a more descriptive argument that both treatment groups had on aggregate similar economic conditions when assignment to treatment was made, it should be added that historical references report an almost equal density of population. In 1866, the Nerbudda Division - which matched the extension of the five districts south of the river in my sample - measured 90 people per square

[40] The mutiny of 1857 mostly spared the area

mile[41]. Consistently, the "Memorandum on the Census of British India" of 1870 reports population densities at the district level, and the average of the five districts matches the main finding of 90 people per square-mile. When it comes to aggregate data about the northern shore, it is possible to find some information in the "Gazetteer of the Territories of the Continent of India" (1857), whose author estimates a population density of 98 inhabitants per square mile in the state of Indore. While he is uncertain about the numbers in Bhopal, he reports that the Malwa plateau - which extends across that princely state - is “fertile, producing in abundance and excellence wheat and other grain, pulse, sugar-cane, cotton, and especially opium. [...] Tobacco is also much cultivated, and is of excellent quality". Hence, if the British were solely motivated by the urge of seizing some land with available economic resources, they would have probably reverted to the northern shore, contrary to what they have in fact done. Last but not least, I produce some information contained in the list of Monuments of National Importance of India[42]. As underlined by much historical research and summed up in Section 2, a definite institutional feature of native Indian states until the XIX century was absolutism[43]. Hence, under the assumption that equally fertile lands and productive economies would give similar resources to despotic rulers on both sides of the river to show their power, I compare the number of protected monuments across the treatment groups. I find that, of 22 protected sites lying within the sample, 4 are located in British India, 5 are on some islands along the course of the river, and the remaining 13 - of which two UNESCO world heritages - are on the princely-states area. Having a similar number of monuments across the treatment groups would play in favour of these being economically akin at the beginning of the XIX century, when assignment to treatment was made. Yet, finding more monuments on the northern side, which has never been included in British India, hints to the idea that - as the quantitative analysis implies - the direct rule had been imposed over originally poorer lands[44]. Even I concede that subsequent development may have destroyed some historical monuments at the times of the British colonisation, I do not find trace of this evidence in any historical document.

In conclusion, both qualitative and quantitative historical findings suggest there might have been no difference in development across what would have become the two colonial regimes at the beginning of the British settlement.

4 Data and results

The empirical analysis in this section is based on the information collected by the Development and Health Survey (DHS) in India in the year 2015[45]. This release - which I use as primary reference - collects as many as 700,000 individual observations throughout India. 19,500 of these are located

[41] Estimate included in the Report on the Census of the Central Provinces of 1866

[42] Under the Archaeological Sites and Remains Act of 1958, they are defined as "any structure, erection or monument, or any tumulus or place of interment, or any cave, rock-sculpture, inscription or monolith which is of historical, archaeological or artistic interest, which has been in existence for not less than 100 years"

[43] There was a strong tendency to celebrate the princes, for example, through the construction of mighty palaces and forts like those of Delhi, or shining mausolea like the Taj Mahal of Agra

[44] It should be noted that the federate state itself has its own list of State-Protected Monuments, which one might see as a complement to that cited. Despite the hierarchically lower level of protection, if we take into account the 21 further sites from this list, the northern shore adds to a total of 26 monuments, while the southern side grows to 22

[45] The organisation is funded by USAid, and runs interviews on fertility and nutrition in over 90 developing countries.

in the pink- and yellow-coloured districts of Map 1. In this section, I restrict the sample to where the colonial border overlaps with the Narmada River, i.e. in the stretch from point A to point B of Map 5. As it will be explained in greater detail in the continuation of this paper, I do so for two reasons. First, the river is a definite barrier that allows circulation across the two treatment groups only at few crossings. This minimises the chances of sorting, and hinders convergence. Second, the transmission mechanism of the long-run effect requires the railway that has been built with synergies from the public and private sectors, thanks to the legal provisions (such as the implementation of property rights) and financial innovations that stemmed from the institutions of British India. Hence, this infrastructural channel is by no mean alternative to the institutional setting, rather its complement. Table A.3A shows that the average distance of the border from the railway when it is considered along the overlap with the Narmada River (24,7 km) is less than half the same average distance when the full border is considered (59,4 km). Therefore, in the limitation of the border along the stretch that overlaps with the river, the long-run transmission mechanism can emerge more evidently. A comparison of the findings with the full sample will presented in section 6 to highlight the transmission mechanism that goes from the institution of British India to long-run welfare, passing through the railway infrastructure.

By focusing only on the part of the sample where the border and the river overlap, I include the districts of Betul, Harda, Hoshangabad, Khandwa, and Narsinghpur in the treated group on the southern bank of the river; those of Bhopal, Dewas, Sehore, and Raisen in the control group on the northern bank of the river. Due to the zigzagging course of both the river and the border, I make sure to include in the analysis only those observations whose closest distance is from a point of the border along the overlap with the river. In total, the sample so defined has 9473 individual respondents. 5462 of these belong to the treatment group; the remaining 4011 to the control group. The continuation of this section describes the findings from the outcomes measured in 2015, and is organised as follows. First, I summarise the way in which the survey has been built; then, I explain the main variables of interest; I proceed with the choice of the main specification model and the illustration of the main results; I conclude with possible data issues and solutions to overcome them.

4.1 Survey characteristics

In the survey of 2015, DHS implemented stratification starting from the Indian Census of 2011. Urban and rural areas are considered separately. Within each rural or urban stratum, six approximately similar substrata are created, accounting for the number of households, as well as the percentage of the population belonging to scheduled castes and tribes. Given these substrata, an amount from 38 to 44 primary sample units (i.e. villages) are selected with probability proportional to their population. Given the villages, a fixed number of 22 households is chosen with equal probability. As such, the survey design leaves room for the spatial correlation of the residuals, which requires an upward correction of the standard errors by means of clustering at the village level, in order to keep the assumption of independently distributed standard errors. On the other hand, stratification aims at minimising the efficiency loss, by having that the probability of selection in the survey is independent across strata. Since this construction is not taken into account by the clustering design, the standard errors are an upper bound, which makes inference more conservative. Generally, the selection procedure has been enacted so that the sample be as representative as possible of the total population, but I take advantage of the survey weights, mainly for the purpose of descriptive statistics and robustness checks. The unit of observation in this analysis is the individual respondent, i.e. all women aged 15 to 49 within the households selected with the procedure above described. As anticipated in Section 1, I have considered women's data in my analysis, because almost all interviewed men live in a household with an interviewed woman. In fact, male respondents are just a fraction of female respondents; they answer in a ratio of roughly 1:5, probably because, given the traditional gender roles of this rural part of India, they are mostly at work during the interviews. To confirm such finding, households in which both female and male components respond to the interview are found to over-represent the two richest wealth groups. The fact that I focus on the female sample should not be seen with scepticism, because it doesn't carry any peculiarity. As it will be shown more in depth in Section 5, where I repeat the analysis on the male sample, which leaves the available outcomes unaffected.

4.2 Outcomes of interest and descriptive statistics

The regressor whose effect I am mostly interested in isolating is a binary variable taking values of 1 if a cluster is located in the treatment area, i.e. in the districts on the south of the Narmada river, which were annexed to British India in 1818 and have been ruled by this regime type until 1947. The outcomes of interest are grouped in two categories: proxies of health and proxies of wealth. The former include the child survival ratio per woman, as well as measures of body size and nutrition that are relevant for two reasons. This information clearly matters per se as a definite contributor to human capital formation[46]. In addition, body size and nutrition levels can also be thought as an ordinal approximation of consumption, thus informing us on respondents' income status relative to regional standards[47]. In specific, I consider some measures of body size, whose weighted descriptive statistics are reported in Table A.3B. Arm circumference averages 24.5 cm; the body mass index (BMI), measured by the ratio of weight to the square of height, has a mean of 21.3 $\frac{kg}{m^2}$; the Rohrer's index, which has the third power of height at denominator, is on average 14 $\frac{kg}{m^3}$; the percentage of underweight population, i.e. all observations with BMI<18.5, is roughly 26%. The averages of the first three measures lie within the ranges that in medicine are defined standard for healthy women; this confirms that the data I use are reliable. In particular, what are considered normal values of the BMI span from 18.5 to 24.9, and those of the Rohrer's index range from 11 to 15[48]. The average child survival ratio is 94%, as computed only on women that have given birth at least once. I do not report descriptive statistics of the wealth variables as these are scores assigned to the households based on a DHS classification, and showing such numbers would not give the reader meaningful information. The aforementioned proxies of wealth include a DHS built-in variable, and binary indicators determined by the population deciles. These latter are built to define 10 social groups of equal size and study how they are represented across the cutoff point, with the aim of understanding if inequality varies with colonial institutions. The DHS wealth index

[46] Much literature in development economics focuses on the role of nutrition and health for skill acquisition

[47] According to the US Department of Agriculture, the aggregate expenditure on food in India amounted to 30% of nominal GDP in 2018, in contrast with 7% in the United States. Consistently, the weight carried by food in the construction of the consumer price index in India is roughly twice as much. In addition, FAO estimates the ratio on food over total consumption in India at 50%, implying that food is the prominent component of the consumption basket.

[48] The fact that the average Rohrer's index is closer to the upper tail than the average BMI is simply due to the different importance attributed to height by the two measures, implying that average height is lower in the sampled Indian female population than in the broader samples taken to build the overall ranges

results from splitting a wealth-based score into five quantiles. Such score stems from the aggregation of variables dealing with lifestyle characteristics, i.e. the type of place of residence, per-bedroom occupancy numbers, the source of drinking water and its location, whether water is sanitised before drinking, the type of toilet facility and if it's shared with other households, the type of fuel used to cook and whether the house has a separate room used as kitchen, the main material of roof and walls. In addition, the wealth score also depends on ownership of the following commodities: electricity, radio, television, telephone and mobiles, refrigerator, table, bed with mattress, bicycle, motorcycle, cart, car, land usable for agriculture (and number of hectars), livestock, bank account. The score is defined by means of different amenities across urban and rural locations, in order to be as adhering as possible to what a wealthy lifestyle is in the two areas. For example, owning light livestock - e.g. chickens - can be a sign of wealth in rural areas but not in cities, where, on the contrary, it can be specific of newcomers who left the countryside in search of better opportunities.

4.3 The covariates

Table A.4A, Table A.4B, and Table A.4C offer the balance of all geographic variables available across the treatment groups. For example, they include the aridity index, altitude, and different measures of the ruggedness of the terrain (slope), rainfall, as well as of temperature. Defining the spatial extension of the balance table is not a secondary challenge, because the MSE-optimal bandwidth of the RD model is affected by the covariates included in the model itself. On the one hand, defining the balance table in a very close neighbourhood of the river - e.g. up to 10 km - results in few (or no) unbalanced geographic variables. On the other hand, the MSE-optimal bandwidth estimated by a model that includes few (or none) of the latter is much larger than that; on average, it extends roughly 30 km from the river. Once this latter span is used, almost all covariates emerge as unbalanced. To be as conservative as possible, I add all geographic covariates to the model, but for those that are always balanced across the yearly measurements (such as the mean temperature), or those that clearly make no sense in this setting (such as the amount of frost days). The 50 covariates included in the main specification are not susceptible of being influenced by the treatment status because they pertain to the geographic characteristics of the region. However, when it comes to other potentially relevant confounders, the problem of bad control is worthy of discussion, since it risks to bias the analysis. This is particularly the case with age, which I should ideally control for, because youths may digest quicker or assimilate less fat by means of a different metabolic process. Yet, age can be affected by the institutional characteristics of the treatment, because individuals in richer economies tend to live longer. Religion is also a fundamental variable to consider, since some native princes during the colonial era were Muslim, and this has been the case in Bhopal. Thus, if the prevalence of a religion that posits another conception of the role of women within the household was proven, then differences in body size might be the result of decisions on food allocation by the household heads. However, citizens in India were entitled to practice a different religion than their princes.[49] Indeed, results are robust to the addition of a binary covariate accounting for respondents' current age, as well as for whether respondents are Muslim[50], as it can be observed at section 5.3.

[49]In the Indian Census of 1931 I observe that some 80% of the population belonged to the Hindu majority in the state of Bhopal.

[50]In the sample, there is a strong prevalence of Hindus (89% of the population). Islam is the second most widespread religion, and it amounts to 10%. The remaining confessions - christians, sikhs, buddhists, and jains - have negligible ratios, and they account together for the remaining 1%.

4.4 Main specification and findings

The main specification in my study is the following:

$$[2] \quad Y_{ic} = \beta_0 + \beta_1 D_c + \beta_2 X_c + \beta_3 C_c + \beta_4 D_c * C_c + \epsilon_{ic}$$

where Y_{ic} is one of the outcomes of interest for individual i in village c: arm circumference, BMI, Rohrer's index, percent underweight, child survival, and the wealth score, as anticipated in section 4.2.
D_c is a binary variable for the treatment status described in section 2; it takes value of 1 if a cluster lies in British India.
X_c is the vector of pre-treatment controls, in the number of 50, whose description has been anticipated at section 4.3.
C_c is the distance (in meters) of a cluster from the closest point along the colonial border.
Standard errors ϵ_{ic} are clustered at the village level.
The RD estimation of model [2] entails a triangular Kernel-weighting scheme depending on the distance from the threshold, and the selection of two different MSE-optimal bandwidths below and above the cutoff, outside of which the Kernel-weight is zero[51]. As per equation [2], the linear approximation to the unknown population regression function will be the specification of reference[52]. Yet, to check consistency, I also produce findings where model [2] has been augmented with a quadratic fit of the joint probability of the outcome and the distance[53].

Figure 1 reports the outcomes of arm circumference conditional on the distance from the cutoff point. Bins are generated by the "evenly-spaced" algorithm partitioning the entire support of the running variable, and pooling the clusters into groups of similar distance from the cutoff. Evidence is not affected by a quantile-spaced selection of the bins[54], which can be found at Figure A.3. In both cases, the average arm circumference in the bins is reported on the left axis, while the shadowed area highlights its 95% confidence interval. The treated region to the south of the river is coded with positive distance, while the control group to the north is coded negatively. Even from a first look, a relevant jump at the cutoff point is evident, hinting at a possible causal effect of the treatment, which is going to be justified through deeper analysis in what follows. Furthermore, Figure A.4 extends the glimpse to the existing discontinuities at the river cutoff for all other outcomes under analysis, showing that there seem to be even more pronounced jumps.

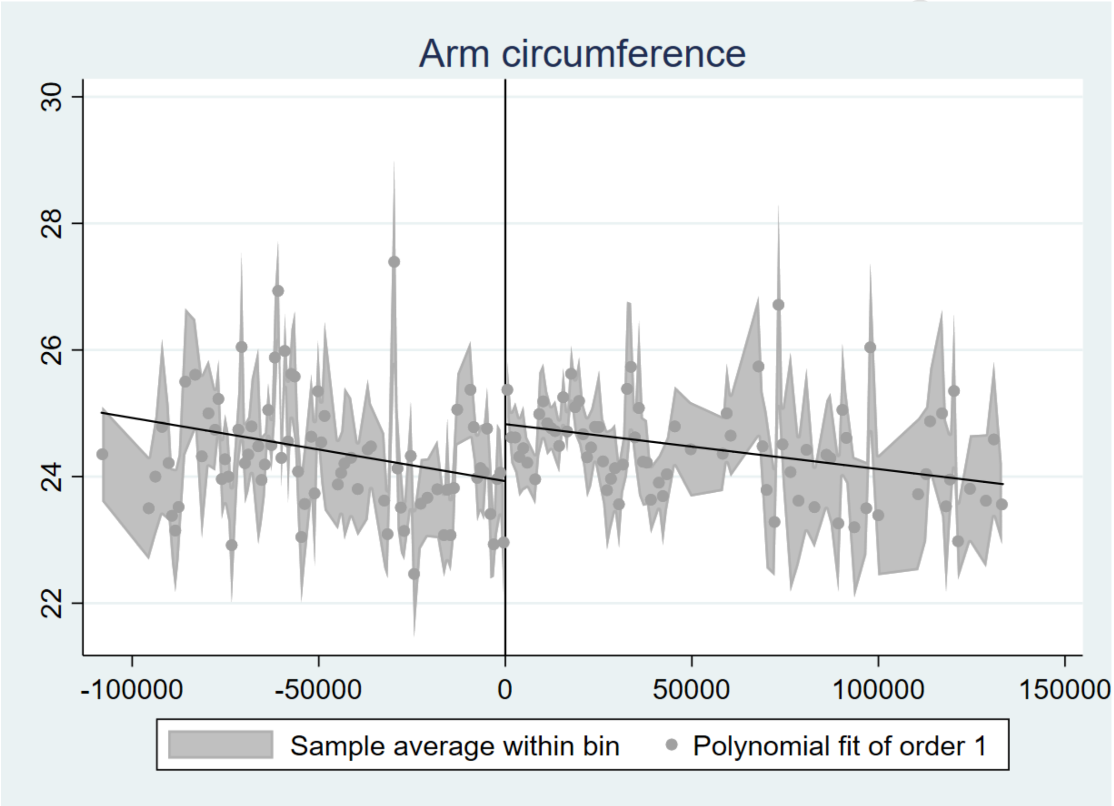
[51] Results are unaltered by estimating a symmetric optimal bandwidth on the two sides.

[52] For the technical arguments in favour of this choice, see Gelman A., G. Imbens (2019), "Why High-Order Polynomials Should Not Be Used in Regression Discontinuity Designs", Journal of Business & Economic Statistics and Cattaneo M., N. Idrobo, and R. Titiunik (2019), "A Practical Introduction to Regression Discontinuity Designs: Foundations", Econometrica

[53] Consistently with Gambel and Imbens (2019), I don't show tables with specifications of polynominal order higher than 2, even if results are not affected by this choice

[54] where these latter are determined by similar population

Figure 1



RD plot fitting a polynomial of order 1 on the outcome of arm circumference in 2015, across the whole sample. The running variable is distance from the border (in meters) when it overlaps with the Narmada River. Bins are selected using the evenly-spaced criterion. Negative numbers identify the region to the north of the river. The shaded area highlights the 95% confidence intervals.

Table 2 includes the estimation of equation [2] by means of a RD method with triangular Kernel-weighting function, MSE-optimal selection of the bandwidth, and a polynominal fit of order 1[55]. Three types of estimates of the ATT - i.e. of the coefficient β_1 in equation [2] - are reported. The reason is that the optimal bandwidth selection is obtained by a non-parametric approximation to the unknown population regression function. Instead of assuming that the relation between the distance and the outcome is linear, the optimal bandwidth is computed so that the point estimate of the coefficient produces the closest linear approximation to the unknown population regression function. But this procedure implies that the standard errors of the point estimates need not stem from the same bandwidth; and the solution to this problem is not unique. "Conventional" is the ATT as estimated through the undersmoothing procedure. Given the kernel function and the poly-

[55] As anticipated, I use two different optimal selectors above and below the cutoff point, both based on the minimum squared error criterion, to account for the asymmetry in the range of primary sample units across the two sides of the river. However, results would only strengthen by means of a symmetric bandwidth.

nomial order that we choose to approximate the unknown true regression function, the algorithm runs the task for producing the optimal bandwidth of the point estimate. The standard errors are estimated from a smaller bandwidth, since this would allow to estimate more closely the population regression function, thereby minimising the bias; but this process involves discretion, which is why Cattaneo et al. (2019) suggest to disregard it for the purpose of inference. The "Bias-corrected" approach runs first a higher-order polynominal[56] than that which is fit, in order to approximate a further degree of the curvature of the true unknown population regression function. With that information, the bias that the confidence interval would suffer if it was estimated using the same bandwidth as the coefficient can be computed and corrected for. The point estimate of the coefficient is then also corrected for this bias, so to be centred in the middle of the confidence interval. The "Robust" approach produces sounder standard errors by including the variation introduced by the estimation of the bias coefficient, which is also supposed to be a random variable in this case. Therefore, Cattaneo et al. (2019) recommend to use this latter approach for the purpose of inference. Looking at the "robust" row of Table 2, in five out of six outcomes there is a statistically significant impact of the treatment, which brings relevant economic interpretations. All else equal, moving from north to south of the cutoff makes women gain around 7.7% of the average arm circumference, 7.7% of the average BMI, and 8% of the mean Rohrer's index. In addition, at the threshold, the treatment decreases the probability of being underweight by 19 percentage points, and increases the child survival rate by 8 percentage points. This latter is defined as the ratio of children alive at measurement time, over the total ever given birth to by an interviewee[57].

[56]Typically one degree more

[57]Clearly, the number of observations is smaller than for the nutrition variables, because not all sampled women have had children.

Table 2

	(1) Arm circ	(2) BMI	(3) Rohrer	(4) uweight	(5) child surv	(6) wealth
Conventional	1.249***	1.426***	0.923***	-0.186***	0.0671**	-30168.9**
	(0.266)	(0.338)	(0.245)	(0.0328)	(0.0231)	(9936.2)
Bias-corrected	1.905***	1.649***	1.125***	-0.196***	0.0854***	-16760.2
	(0.266)	(0.338)	(0.245)	(0.0328)	(0.0231)	(9936.2)
Robust	1.905***	1.649***	1.125***	-0.196***	0.0854**	-16760.2
	(0.415)	(0.441)	(0.315)	(0.0401)	(0.0293)	(13655.5)
Observations	9384	9386	9386	9386	6532	6349
cutoff	0	0	0	0	0	0
N_left	673	594	594	673	502	490
N_right	2323	2820	2708	2968	2297	1874
bwidth_left	14110.5	13202.4	13064.2	13883.9	15077.5	15133.0
bwidth_right	17011.8	19782.0	18815.3	21348.7	26999.1	19496.1
order	1	1	1	1	1	1
bwselect	msetwo	msetwo	msetwo	msetwo	msetwo	msetwo
kernel	Triangular	Triangular	Triangular	Triangular	Triangular	Triangular

Standard errors in parentheses

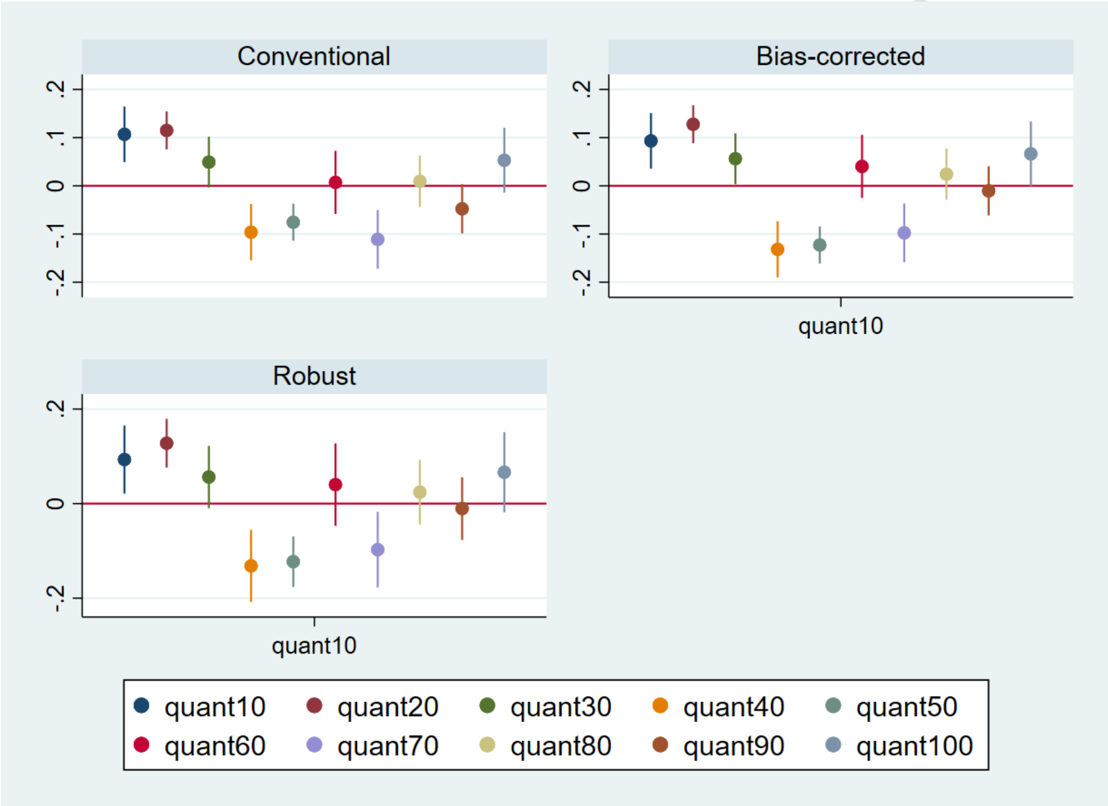
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Regression discontinuity output. The running variable is the distance from a point where the border and river overlap. The outcome variables are measured in 2015. They are: arm circumference (1), Body Mass Index (2), Rohrer's Index (3), the underweight dummy (4), child survival probability (5), and the wealth score (6). The model is run with a triangular Kernel-weighting function and two different MSE-optimal bandwidth selections across the cutoff. The polynomial fit is linear. The observation unit is the individual respondent. Standard errors are clustered and reported in parenthesis. 50 geographic controls are included as covariates.

Table A.5 presents the findings from a RD that implements a quadratic approximation to the unknown population regression function. The point estimates of most variables - especially the BMI, Rohrers' Index, and the percentage of underweight population - are unaltered, delivering the same interpretation as in Table 2. Instead, the magnitude of the ATT of arm circumference drops to 4.8% of its average, but it maintains a definite economic and statistical meaning. As in the case of the linear fit of the model presented at Table 2, the effect on wealth is not statistically different from zero in the "Robust" approach to RD estimation, which is described by Cattaneo et al. (2019) as the most valid for inference.

However, I make a separate focus on the wealth score to understand why it might be the case that this outcome possibly diverges from the nutrition measures. Results are highlighted at Figure 2. First, it should be mentioned that the wealth score is household-specific, which explains why only 6349 of 9473 observations remain in Table 2 and A.5. After obtaining the deciles of this variable across the population, I define ten binary indicators taking value of 1 if an household falls within the respective decile. For example, the variable "quant10" includes all individuals from the lowest to the 10th percentile of the wealth score; the variable "quant20" is composed of all individuals whose wealth ranks from the 10th to the 20th percentile; and the process continues in the same fashion until the definition of the variable "quant100", which includes the top 10% of the wealth score. Running specification [2] on each of the indicators so generated, I obtain ten point estimates for every RD approach, which I plot in ordinal series with their 95% confidence intervals in Figure 2. Across the three approaches, the probability of being in the middle of the distribution always drops in the neighbourhood of the threshold, whereas that of being at the bottom or at the top decile surges. This finding suggests that the treatment - i.e. the institutions of British India - has produced more inequality in the wealth score, despite the lack of an overall average effect at Table 2. Such evidence can be explained by the fact that the enforcement of property rights and private investment has given scope for a polarisation of wealth in British India, which was absent elsewhere due to the discretionary administration in the princely states, where the monarch was the sole owner of the land. Consequently, the average results of the nutrition and wealth outcomes found at Table 2 seem mostly driven by individuals above the median of the wealth distribution, as underlined by Table A.6. This possibly brings to the following implication: British India may have set the conditions to make the area under former direct rule particularly suited to the prosperity of the part of the wealth distribution currently above the median, by means of enforcing property rights and making taxation favourable to private investment. However, I cannot make a causal statement in these regards, because the wealth characteristic upon which I condition by excluding a part of the population in Table A.6 depends on the treatment status, thereby posing a threat to causal interpretation similar to that of a bad control. Instead, it can be retained that the direct administration of British India has generated better nutrition and health outcomes on average in the southern shore, and that this result is positively correlated with a higher prevalence of the top of the wealth distribution of Madhya Pradesh in the same area.

Figure 2



Graph of the point estimates and 95% confidence intervals from the same RD specification as at Table 2, where the outcome variables are binaries measuring inclusion in the deciles of the wealth score in 2015. The "Conventional" (top left), "Bias-corrected" (top right), and "Robust" (bottom left) approaches are reported in separate charts.

In what follows, I introduce some basic variations to model [2] to evaluate the stability of its findings. As it is described in greater detail in section 4.5.3, a first possibility is to take advantage of the survey weights produced by DHS. RD outcomes weighted by survey inclusion probabilities can be observed at Table A.7B, where all coefficients are comparable in magnitude with the corresponding β_1s in the unweighted linear fit of the model presented at Table 2. As it is explained in section 4.5.3 by relying on the work of Deaton (1997), weighting is a useful exercise to understand the correct specification of the model, since a misspecified one would generate contrasting results. The findings from Table A.7B support the argument that this is not the case here, and that the main specification [2] is robust to the inclusion of survey weights. In addition, Table A.7C replicates the model by averaging individual outcomes across DHS clusters, and using these latter as the unit of observation. This is intended as a smoothing exercise to soften any eventual individual outlier. In fact, this specification does not seem to induce relevant differences, because the point estimates are much akin to those in Table 2. Last but not least, I recall that specification [2] fits a linear regression model, but one of the outcome variables introduced in the model is categorical. Indeed, Underweight is a binary indicator with value of 1 if the individual has BMI<18.5. In such circumstance, a trade-off arises: maximum likelihood estimation gives a better fit of the outcome, but I can only estimate the model parametrically without computing the optimal bandwidths for the coefficient and standard errors. Hence, I implement a ML estimation only for the sake of comparison. At Table A.8, the outcome of column (2) stems from a probit model, where all observations within the same optimal bandwidth as that obtained at column (1) have been weighted by means of a triangular Kernel function. The marginal effect of -0.176 implies that treatment reduces the probability of being underweight by almost 18 percentage points, a very similar finding as that of the "Conventional" estimation of the RD model with linear fit presented in column (1)[58]. This is consistent with the previous explanation as the "Conventional" approach is the most akin to an estimation that uses the same bandwidth for both the point estimate and the standard errors. As such, the standard errors at Table A.8 are not valid for inference, but the proximity of the two estimated coefficients across columns (1) and (2) further strengthens the argument already put in place by the implementation of a weighted regression in Table A.7B, i.e. that the linear model seems to be a good approximation of the unknown population regression function, even in the case of a categorical outcome.

In sum, the evidence here presented is consistent in showing that, in the neighbourhood of the cutoff point, the area previously administered by some institutions that fostered property rights and investments scores better - on average - when it comes to current measures of nutrition and body size, as well as to the probability of being underweight and to the child survival ratio. Therefore, in this part of India, the quality of state administration has brought a tangible long-term effect on the average social welfare. Indeed, the outcomes I consider are all definite proxies of health that concur to skill acquisition, which is crucial in the improvement of human capital. However, the decile-based analysis of the wealth index reveals that inequality seems also higher to the south of the threshold, so that these average effects could be driven by the top of the wealth distribution. Section 6 will shed light on the mechanism that may have produced these findings.

4.5 Data issues

In what follows, I describe the three potential issues with the data I have been using, and their likely solutions.

4.5.1 Clustering and stratification

As anticipated at section 4.1, the DHS data are clustered and stratified. The first issue implies the existence of correlation across individual residuals, which would generate a downward bias in the standard errors if not accounted for, and is corrected by means of clustered standard errors. When it comes to the second, an upward bias is produced in the standard errors if I do not take stratification into account, since selection into the survey is independent across strata by design, but this

[58]It should be remarked that in the estimation of column (1) of Table A.8, I have used a different algorithm for dropping nearly multicollinear covariates than in column (4) of Table 2, because it needs to be the same as that provided by Stata default commands, such as those that run the probit model at column (2) of Table A.8. Yet, the "Conventional" point estimate is almost identical to the one obtained with a different criterion to drop near collinear covariates, as done in Table 2.

information is ignored in the computation of the standard errors. In principle, I could increase the estimates' precision by splitting the sample along the main stratification divide, i.e. urban/rural areas. That would result in two separate regressions where standard errors are not overestimated by ignoring stratification. However, the urban/rural divide is affected by the treatment status, and such an estimation would gain precision but lose causal soundness. As a result, I proceed without correcting for stratification, and I am left with an upper-bound estimate of the standard errors of the coefficient of interest β_1. Despite this conservative approach, the results highlighted previously at section 4.4 are generally statistically significant.

4.5.2 Measurement error

Another reason of care with DHS data is that the computation of the distance from the river involves measurement error. Indeed, for confidentiality reasons, the geographic coordinates of the clusters where interviews took place are subject to a random displacement up to 10 km in rural villages[59], and up to 2 km in urban neighbourhoods. This would be particularly problematic if the misplacement caused a cluster located in one treatment group to be imputed in the other. However, such error is eliminated from my sample, because DHS reports the true district[60] where each cluster is located, and district boundaries overlap with the Narmada River along its flow within the main sample. Hence, I am able to assign the observations to their true treatment group.

In addition, the survey compilers implement a correction, such that the probability of displacement is equal for any point inside the circle, thereby avoiding that higher values of displacement be more likely due to the greater area of the region far away from the origin. In fact, the average displacement is merely 1.1 km across my replications. As the sample under analysis extends for more than 100 km from cutoff in both directions, I expect the bias induced by clusters displacement to be almost null. However, I can conceive some strategies to deal with it. First, an intuitive possibility is to increase the number of points that compose the cutoff line, whose coordinates are then extracted to compute the distance between the clusters and the river. For example, if the true location of a cluster was 10 km from the river but it got displaced 1 km in parallel, then I would capture the true distance by having another point exactly 1 km in the same direction along the river. Yet, this approach helps eliminating measurement error only in parallel to the river.

A second possibility is to follow the method described by Warren, Perez-Heydrich et al. (2016). We have that $x_c^i = x_c^t + u_c$, where x_c^t is the true (unknown) distance from the river and u_c is the measurement error of cluster c, caused by displacement. Suppose that x_c^t has mean μ_t and variance σ_t, while u_c is identically and independently distributed with mean $\mu_u = 0$ and variance σ_u. Then, the best linear unbiased predictor (BLUP) of x_c^t conditional on x_c^i is:

$$E(x_c^t|x_c^i) = \mu_t + \frac{\sigma_t}{\sigma_t + \sigma_u}(x_c^i - \mu_t).$$

The main issue is to estimate the unknown parameter σ_u. To that purpose, I need multiple replications of the displacement function on each already displaced cluster. Suppose to have 5 such replications. Then, I define w_{cj} as the distance of the newly displaced cluster c from the river, at the particular displacement j. At this point, the initial displaced location of cluster c, i.e. x_c^i, becomes the known true location of the same newly displaced cluster. It follows that $\hat{\sigma_u}$ can be

[59] But only 1% of the villages is set to 10 km; the rest is displaced by 5 km at maximum.

[60] Districts are the third-level state administration in India.

estimated by getting the sample variance of the difference $(w_{cj} - x_c^i)$, and then averaging it across displacements j. With this estimate $\hat{\sigma_u}$, I can back up the variance of x_c^t, which was earlier called σ_t. Knowing that $x_c^i = x_c^t + u_c^i$, I have the sample variance of the initially displaced clusters $\hat{Var}(x_c^i)$, and the estimated $\hat{\sigma_u}$. Therefore, $\hat{\sigma_t} = \hat{Var}(x_c^t) = \hat{Var}(x_c^i) + \hat{\sigma_u} - 2\hat{Cov}(x_c^i; u_c)$.[61] Finally, I estimate $\hat{\mu_t}$ as the sample average of x_c^i, because of the assumption that $\mu_u = 0$. [62] Having all the required parameters, I compute:

$$\hat{E}(x_c^t|x_c^i) = \hat{\mu_t} + \frac{\hat{\sigma_t}}{\hat{\sigma_t} + \hat{\sigma_u}}(x_c^i - \hat{\mu_t}).$$

For each cluster, I input the value emerging from the expression above as the distance variable C_c in the main specification [2], and I get the regression outcomes at Table A.9. It can be observed that the point estimates of the treatment effect are almost identical to those of Table 2. Furthermore, for five out of six variables, all coefficients of Table A.9 are greater than their counterpart in Table 2. Thus, if a bias arises by not correcting for measurement error in the distance at Table 2, it seems to be a downward bias. In consequence, the analyses in this paper are carried out without implementing the correction for measurement error here described. Indeed, the lack of correction for displacement is more likely to undermine the findings, as seen by comparing Table 2 with Table A.9. Also in light of the various robustness checks that follow in the next section 5, it seems more probable that data holding a given interpretation retain it despite a measurement error introduced for privacy reasons, rather than aligning by chance to convey such interpretation.

4.5.3 Weighting scheme

Last but not least, the DHS, as any reputable survey, has been designed to be as representative as possible of the total population. Recalling section 4.1, the probability of selection of a household within a primary sample unit (village or neighbourhood) is constant, but that of PSUs themselves is not. Thus, a weighting scheme is provided. In particular, individual weights in the women's survey result from $W = \frac{1}{\pi_{hs}\pi_{whs}}(\frac{n_s}{N_s})^{-1}$,
where π_{hs} is the probability that household h in stratum s is selected,
π_{whs} is the probability that women w in household h in stratum s replies,
the second factor is the inverse of the households' response rate within their stratum s.
Table A.7A reports the average survey weight across the districts under study. If Harda and Hoshangabad seem to be oversampled, the districts of Bhopal - and to a lesser extent those of Indore and Khargone - are undersampled. For this reason, all descriptive statistics mentioned here, such as those at Table A.4A, use survey weights.

Nonetheless, the question is more subtle when it comes to using weights in regressions. It may be intuitively good to do so if the relation between the regressors and the outcome is heterogeneous across strata, because weights account for the inclusion probabilities within strata. In my case, this would mean that the weighting scheme should be applied in regression if the relation between the

[61] It should be noted that Warren, Perez-Heydrich et al. (2016) define $\hat{\sigma_t} = \hat{Var}(x_c^t) = \hat{Var}(x_c^i) - \hat{\sigma_u}$. This choice is almost numerically equivalent to $\hat{\sigma_t} = \hat{Var}(x_c^t) = \hat{Var}(x_c^i) + \hat{\sigma_u} - 2\hat{Cov}(x_c^i; u_c)$, after plugging all estimated parameters in $\hat{E}(x_c^t|x_c^i)$.

[62] It should be noted that the parameters $\hat{\mu_t}$, $\hat{\sigma_t}$ and $\hat{\sigma_u}$ are estimated separately depending on the cluster location type (urban or rural) because they are affected by random displacement, which differs based on location type.

distance from the Narmada River and measures of body size is likely to change across urban and rural areas, as these are the fundamental characteristics upon which stratification is performed in the DHS[63]. On the other hand, Deaton (1997) compares the efficiency and consistency of ordinary and weighted least squares, finding that the only case in which WLS restores consistency is the estimation of the constant term β_0 in equation [2], which is why WLS is useful in descriptive statistics. Concerning the regression coefficient β_1, OLS and WLS are both inconsistent if the model is not correctly specified; and they are both consistent if the model is correctly specified, but OLS is more efficient in that case. As a consequence, WLS seems to be most useful to test the correct specification of my regression model in equation [2]. As it can be observed by comparing Table 2 and Table A.7B, the two produce very similar outcomes, which do not change in any way the interpretation of the results. Indeed, even in the case for which the linear fit is the most dubious - i.e. the binary outcome Underweight - the point estimate from a linear approximation is not much different from one closer to the unknown population regression function, as shown in the parametric check at Table A.8. The most worrisome variable in terms of robustness to this weighting exercise is wealth. Despite remaining not statistically different from zero in both occasions, it shows a negative point estimate in Table 2 and a positive coefficient in Table A.7B. However, it should be remarked that my interpretation of the findings does not depend on such variable. The most relevant implication of the wealth outcome is the evidence of inequality at Figure 2, which stems from categorical variables defined from the deciles of the wealth variable, not on the variable itself.

5 Robustness checks

In this section, I apply various sensitivity tests, in order to show the robustness of the main findings. First, I report placebo tests using other outcome variables, as well as arbitrary cutoffs different from the true one. Second, I perform a heterogeneity analysis by defining the cutoff only by means of the 15 bridge crossings over the river. Third, I vary the composition of the districts in the sample, and I add post-treatment variables to check consistency. Fourth, I focus on an area to the west of the main sample, where both sides of the river were administered by princely states. Finally, I repeat the analysis on the sample of male respondents, and on that of women with a male member of the household answering the survey.

5.1 Basic placebo tests

One advantage of using RDD in an empirical study is that some falsification tests are immediately implementable. Indeed, to sustain a causal interpretation, the cutoff is meant to be relevant only to the outcome variable of the regression; otherwise, the effect is confounded. This potential confusion can be checked simply by substituting other candidates for the main outcomes, and by running a regression with the same cutoff point and running variable. The first row of Figure A.5 shows a chart of the 95% confidence intervals[64] of exogenous geographical features - temperature in Celsius degrees, and the aridity index - by distance from the river. It is evident that, differently from using proxies of consumption as outcomes, there is no significant difference at the Narmada

[63] For example, one might think that, if urban areas are richer on average, there should be less inequality, and thus the effect of colonial institutions at the cutoff should be milder than in rural villages.

[64] The lower bound is coloured in blue and the upper bound in yellow.

cutoff. For example, in the case of average temperature, a generally increasing relation emerges up to 50 km south of the river, from where the amount of information at disposal begins to be scarce, thus behaving in an unpredictable way. The same pattern is clear for the aridity index, from which it is evident that there is no discontinuity at the level of the river; hence, there is not even room for the argument that one bank might be geographically favoured in fertility by specific mud deposits due to the stream of the river. Another straightforward placebo test that can be introduced in RDD is the manipulation of the cutoff point. As oer Lalive and Melly (2020), the idea is to estimate the ATT at different fake cutoffs while using only the observations on one side of the true threshold, in order to avoid contamination from the true ATT. In my sample, I can arbitrarily move the supposed location of the river at the mean of the distance from the cutoff on both sides, and I find that the statistical significance of the discontinuity at the placebo cutoff is lost. The second row of of Figure A.5 is realised in that spirit. On the one hand, I only consider the southern shore and impose a cutoff 33 km south of the true location of the river, at the mean point; in the same spirit, I only consider the northern shore with the cutoff located 49 km north of the true river. In both cases the effect vanishes, implying that it just exists at the true discontinuity cutoff, thus strengthening the argument that the proxies of income only jump where the old colonial border was set. I conclude that the placebo tests do not impeach the findings at section 4.4.

5.2 Heterogeneity analysis at the bridges

One of the main challenges to using RDD in a spatial setting comes from the possibility of sorting. However, I can take advantage from a definite characteristic of the geography of the Narmada valley: that there are only 15 bridge crossings along the whole 400-km border included in the sample. As documented in section 3.1, the passages across the Narmada have always been a scarce good, due to the geological conformation of the river, and the irregular flow of the waters. In fact, the forts located along the river (and sometimes even on the islands within its course), which are counted as monuments of national relevance in the list quoted at section 3.2.2, served the purpose of protecting such crossings, especially in the districts of Khandwa, Harda, and Hoshangabad. Since the crossings are the only locations in the sample where sorting is can happen, I implement a test by coding the running variable as the distance of the clusters from the bridges, instead of the usual distance from any shore. If the southern bank is currently more developed than the other, then it may be that results are affected by the fact that utility-maximising individuals have the incentive to relocate according to their convenience. In fact, this reasoning is partially matched by the data. Table A.10 reports the outcomes as in the standard regression [2], with the only difference in the running variable mentioned above. How should the possibility of sorting affect nutrition variables? The answer is not trivial. Indeed, sorting-prone locations allow for commutes between a poorer side where living costs are lower, and a richer side where wages are higher, so that the less affluent people concentrate more on the former area. Yet, whether the richer population that faces higher prices or the poorer population that faces lower prices have a higher ability to improve their food consumption is ex-ante unclear. Evidence from Table A.10 shows that all outcomes but that of arm circumference strongly increase, suggesting that sorting may make the poor relocate in the control group in the proximity of the border. A definite stance in this direction can also be taken from the wealth variable. I recall that this is a proxy generated by DHS compilers based mostly on the features of the housing where interviewees live, such as the type of roof, as well as access to tap water, flush toilets, and communication networks. In sorting-prone locations, the ATT of this measure intensifies, signalling that less affluent people may strategically locate on one side of the border to benefit from the opportunities on the other side. In fact, the coefficient of wealth becomes even positive and significant at the 95% confidence interval in the Bias-corrected approach, which is never the case in the main model at Table 2. In sum, the common trait of the point estimates at Table A.10 is that their magnitudes are substantially higher than their counterparts in Table 2 for five out of six variables of interest. Across all six variables, such magnitudes are significantly different than those in Table 2[65], implying that this sorting-prone estimation produces very different outcomes than the main specification model. If I found that there was almost no difference among two models, one of which is prone to sorting by construction, then I would have concluded that the other is most likely biased as well. However, it does not seem to be the case in my sample. Hence, these findings seem to confirm that the Narmada River[66] is a definite geographical barrier minimising the chances for sorting.

5.3 Geographic and post-treatment sensitivity checks

In a further battery of robustness checks, I vary the geographical composition of the sample and the included covariates, in order to show the robustness of the main causal effect. First, I run the main specification while dropping the district of Bhopal. In order to keep the observations as balanced as possible across the two treatment groups, I also drop one district from the side of British India. As Bhopal is the only fully in-land[67] district of the control group, I drop the only fully-inland district in the treated group, i.e. Betul. The reason for dropping the district of Bhopal is not only that it is undersampled by the survey; for that purpose, I have used the weighted regressions of the main specification, and I have already shown that the fundamental results at Table 2 are unaltered. However, on December 3rd 1984, the city of Bhopal was affected by gas leaks from the pesticide plant of Union Carbide India; some 500,000 people have been exposed to the inhalation of methyl isocyanate, a highly toxic gas with strong resistance to water; the official number of deaths is around 3800. Even if the contaminated area was restricted mainly to the neighbourhoods in the proximity of the plant, the possible long-term health consequences could adversely impact on the body-size outcome measures. Despite the terrible health problems relating to the disaster, no emigration or subsequent economic downturns have been registered; on the contrary, the city - with a population of 750,000 at the time - maintained a stable population growth around 4.3% throughout the '80s, and hosts now more than 1.7 million people, ranking 16th in India. Hence, the potential negative spillovers of this tragedy on the other districts are very limited, and for my purposes it seems sufficient to eliminate the data coming from the district of Bhopal in order to understand whether there is any confusion from adverse long-run health effects in the main specification [2]. Indeed, Table A.11A shows that the magnitude of the causal effect on arm circumference and Rohrer's index sligthly decreases, passing from 7.7% to 5% of the average, and from 8% to 5% of the average, respectively. However, the BMI shows a relevant drop, becoming not statistically different from zero. In contrast, the underweight probability, child survival, and the wealth variable (in both its weighted and unweighted specification) increase in magnitude with respect to Table 2

Table A.11B implements a further geographical sensitivity test. As a reminder, the main speci-

[65] Arm circumference drops to almost zero

[66] I recall that the running variable is distance from the stretch of the border that overlaps with the Narmada River

[67] It does not border the Narmada River

fication at Table 2 is performed on 9743 observations whose clusters fulfil these criteria:

- They belongs to the 9 districts that lie in the proximity of the overlap between the colonial border and the river Narmada.
- Their minimum distance from the colonial border lies within the stretch that overlaps with the Narmada River.

At Table A.11B, I relax the first constraint. In consequence, their number rises to 11,315. However, the economic and statistical significance of the coefficients are unaltered with respect to the main specification. Arm circumference is 6.8% of its average, BMI is 6,3%, Rohrer's Index is 5.3%. Underweight and child survival strengthen in magnitude, and wealth keeps being not statistically different from zero as in Table 2. In sum, it seems that the criterion for inclusion in the analysis does not matter, once the stretch of the border that overlaps with the river is considered in the study.

Last but not least, I check for the robustness of the main findings to the addition of some post-treatment covaraites in the regression. As anticipated at section 4.3, age and the religion of the household's head may be important confounders to deal with. The former can affect the nutrition outcomes via the metabolic processes, while the latter may affect them by means of different cultural conceptions about the roles of the each household member. Both variables are influenced by the treatment status, so they typically entail the problem of bad controls, and as such can induce a bias in the causal interpretation of the estimation. For example, by virtue of better infrastructure, the average life expectancy can be higher in the southern shore, leading to an over-representation of elderly individuals, and thereby to higher measures of body size because of possibly slower metabolic processes. In contrast, the over-representation of a religion where the role of the women might be considered as less relevant is likely to produce lower within-household bargaining power, resulting in less food allocation. In addition, I try to account for the possibility of migration in the sample, by means of two other covariates: a binary variable measuring whether the individual is a de jure resident in the town or village where she is surveyed, and the ratio of the years lived in the actual place of residence to the respondent's current age. These are also affected by the treatment status, because institutions that have made an area richer may also have influenced the current scope for migration. In specific, if we are willing to assume that utility-maximising economic agents seek for better opportunities, there should be more non-de jure residents in the richer area, as observed in Table A.12. However, the post-treatment variables are mostly balanced across the groups. In fact, Table A.13A shows that the ATTs of the outcomes of interest are almost unaltered by the addition of the covariates accounting for age, religion, and migration. Table A.13B has been produced separately to introduce the proxy of stability of the place of residence, because this is the only unbalanced control, and because adding it entails some observation loss. However, the differences between these two - as well as between both of them and Table 2 - seem irrelevant.

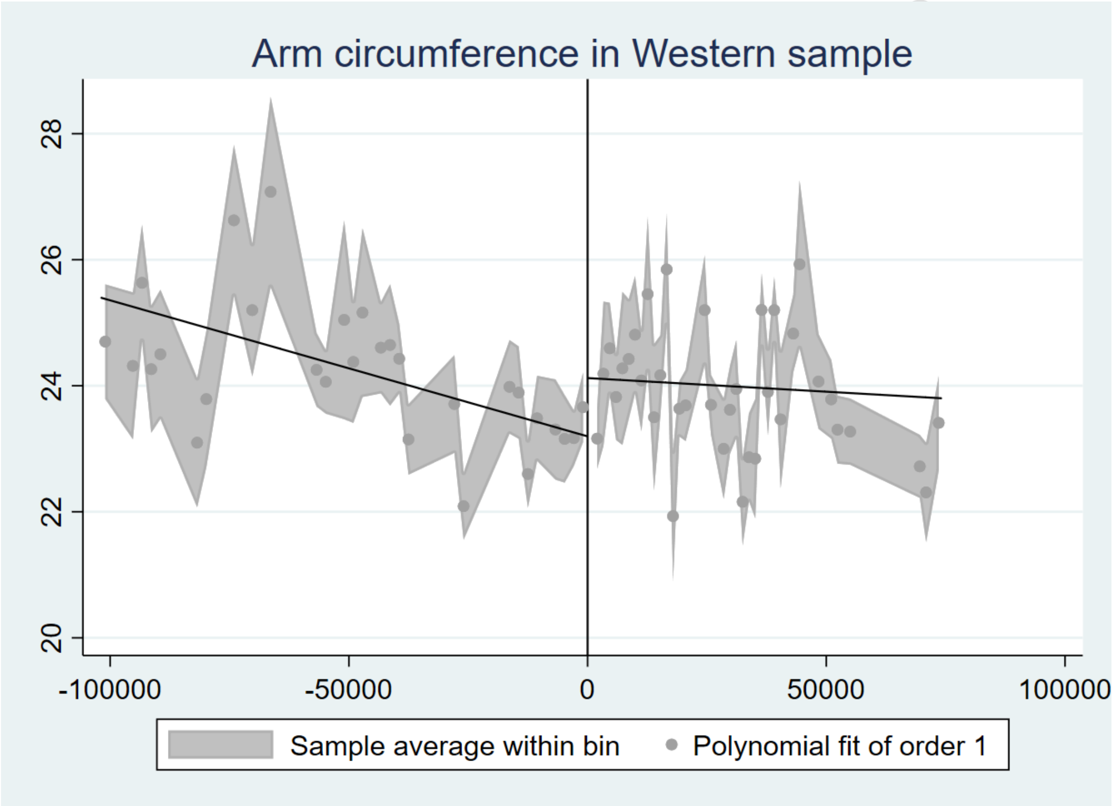
5.4 RDD in a neighbouring sample

Up to now my proposed sensitivity tests have underlined that the treatment effect on the proxies of consumption reported in the main specification [2] is not dependent on particular cases. The robustness check I propose here is the most relevant to sustain the positive argument, i.e. that the findings from the main specification are the specific causal effects of the colonial institutions. For this purpose, I focus on two other groups of districts across the banks of the river, making sure that they span a region where the Narmada has never been the border between British India and

Princely States. This condition is met just to the west of the main sample, where the districts of Barwani and Khargone on the southern shore were administered by local princes, as much as those of Dhar and Indore on the northern[68]. Because, however, a British exclave is present in Khargone district (as it can be observed at Map 4), I limit the analyis to the west of such exclave, i.e. to the west of 75.8*E. In the sample so defined, there are around 3400 observations scattered across 114 clusters. The regression model is the same as in the main specification [2]. Figure 3 plots the distance from the river and arm circumference (in cm) using evenly spaced bins, in the same spirit as Figure 1. The result is clear: if there was a discontinuity where the Narmada used to separate different colonial regimes, it disappears where the same river flows within lands which have had the same colonial experience. Such evidence is even more tangible at Table 3, which reports the same RD model as in section 4.4, while employing it in the different sample above described. It should be noted that all effects invert in sign, thereby implying that the southern shore is poorer in this setting, which fact is consistent with the evidence found at the beginning of the colonial period and described in section 3.2.2. In particular, the effect of passing from the northern to the souhtern shore is -7.5% of the average of arm circumference, -3.6% of the average of body mass index, and -5.4% of Rohrer's index. The probability of being underweight spikes by 30 percentage points, and that of child survival is in fact zero. The ATT of wealth is not statistically different from zero. Thus, it seems that where both shores have been left to princely state administration, the initial gap not only was not inverted but probably intensified, which is consistent with a setting where no major event changed the status quo. In other words, consistently with a long-term protraction of the historical findings of section 3.2.2, the nutrition coefficients are negative, the probability of being underweight increases on the southern shore, and that of child survival returns a negative point estimate. This leads to the conclusion that, in a sample where British India was not administering the southern shore, this latter is currently not better than the control group, when it comes to the same outcomes of interest as presented in section 4.2.

[68]It should be noted that the district of Khargone extends mostly to the south of the river, but it includes also a smaller part on the northern bank. To minimise the possibility of attributing an observation to a wrong treatment group, I drop all clusters located within 1.5 km from the river in that district. This should be considered as a conservative approach because the average displacement is 1 km.

Figure 3



RD plot fitting a polynomial of order 1 on the outcomes of arm circumference in 2015, across the Western sample. The running variable is distance from the Narmada (in meters). Bins are selected using the evenly-spaced criterion. Negative numbers identify the region to the north of the river. The shaded area highlights the 95% confidence intervals.

Table 3

	(1) Arm circ	(2) BMI	(3) Rohrer	(4) uweight	(5) child surv	(6) wealth
Conventional	-0.718*	-1.160***	-0.671***	0.0546	0.00257	17054.7
	(0.337)	(0.194)	(0.131)	(0.0318)	(0.00623)	(10301.0)
Bias-corrected	-1.842***	-0.764***	-0.767***	0.304***	-0.000185	10976.1
	(0.337)	(0.194)	(0.131)	(0.0318)	(0.00623)	(10301.0)
Robust	-1.842**	-0.764	-0.767*	0.304*	-0.000185	10976.1
	(0.607)	(0.493)	(0.360)	(0.136)	(0.0220)	(27579.2)
Observations	3420	3421	3421	3435	2483	2189
cutoff	0	0	0	0	0	0
N_left	396	341	427	452	304	247
N_right	607	477	477	444	291	299
bwidth_left	13157.6	11086.2	13829.6	14176.5	13770.5	12625.9
bwidth_right	16878.3	13890.4	13911.9	12751.6	11310.2	14044.4
order	1	1	1	1	1	1
bwselect	msetwo	msetwo	msetwo	msetwo	msetwo	msetwo
kernel	Triangular	Triangular	Triangular	Triangular	Triangular	Triangular

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Regression discontinuity output in the Western sample. The outcome variables are measured in 2015. They are: arm circumference (1), Body Mass Index (2), Rohrer's Index (3), the underweight dummy (4), child survival probability (5), and the wealth score (6). The model is run with a triangular Kernel-weighting function and two different MSE-optimal bandwidth selections across the cutoff. The polynomial fit is linear. The observation unit is the individual respondent. Standard errors are clustered and reported in parenthesis. 25 geographic controls are included as covariates.

Table A.14 extends the study to a second-order polynomial fit in the adjacent sample, showing some consistency with the previous evidence. Overall, in the sample where the Narmada separates two sides that have been equally governed by princely states, the findings hint at an opposite result. If anything, it seems to be the northern shore to enjoy a higher level of welfare in present times, as much as it happened in the early XIX century. Thus, the positive effects found in the main specification are specific to a setting where a modernly organised state apparatus - such as that of British India - has generated new institutions in the treated group.

5.5 Analysis with the male sample

I recall that the study has female respondents as individual observations in all specifications up to now. In this last sensitivity check, I am going to focus on data collected from men. As anticipated at section 4.1, male respondents are considerably scarcer than their female counterparts: in the same sample as used by the main specification, I observe only 1569 respondents. Among these, 1421 individuals belong to the same household as at least a woman who has also been recorded in the DHS. Only the remaining 148 live in different households than any sampled woman, as it is clear at Table A.15A. As per Table A.15B, households where there is at least one respondent per sex are generally richer: the top quintile of wealth records 24.8% of the population. Instead, as per Table A.15C, respond the same top quintile amounts to 21.6% in households where only women respond. Such discrepancy is perhaps due to culturally specific gender roles. In more traditional families of poorer rural areas, the job split may be such that women stay home to take care of the family, and thus have more time for the surveys, while their husbands may not be present at all when enumerators reach out to the field. Conversely, richer men may need to work less, and might have more time to respond the survey. Knowing from Figure 2 that individuals in the top decile of the wealth distribution tend to locate more to the south of the cutoff, I expect that the causal effect to be stronger. Table A.16 includes results from the first- and second-order polynomial fits of the main RD model [2] on arm circumference and the wealth score, the only outcomes of interest available in the male sample. Consistently with the fact that male respondents come from richer households and that - as seen at Figure 2 - these latter are located more on the southern shore, the point estimates are higher in the second-order fit of the model at column (3) than the corresponding in column (1) of Table A.5. The average arm circumference of men in the sample is 26 cm, as opposed to 24.7 for women; even so, the coefficient of 2.781 as in column (3) implies that the effect of passing from north to south is equivalent to a 10% gain with respect to the average male arm circumference. In the first-order fit of the model, I do not observe a similar increase with respect to the linear fit in Table 2; if anything, the opposite happens. However, I also observe an almost identical ATT of arm circumference by restricting the sample of women to those with at least a male respondent in the household, as done by comparing column (1) and column (2) of Table A.16. Moreover, consistently with Tables A.15B and A.15C - that shows that households tend to be richer when at least a male respondent is present - the point estimates of the wealth score of the households with at least a male respondents at columns (5) and (7) of Table A.16 are both positive, while this is not the case at column (6) of both Table 2 (the first-order fit of female respondents) and at column (6) of Table A.5 (the second-order fit). However - perhaps due to the scarcer availability of data in the male sample - the precision of the estimates is low, and the magnitude of the standard errors prevents any statistically significant interpretation. For comparison, columns (2), (4), (6) and (8) of Table A.16 report the point estimates from the same specification run on female respondents who are paired with at least a male respondent in the same household. Consistently with the scarcer availability of information, a comparable lack of significance emerges also in this case, while - I recall - this does not happen in the full female sample. What is most interesting is that, by comparing the outcomes of female and male respondents, the point estimates go in the same direction, and are slightly higher in magnitude in the male sample. Thus, by not taking account of male individuals in the main specification at Table 2, I am - if anything - underestimating the global results.

6 Transmission channel

In Section 3, I have documented that the starting conditions were no better on the southern shore at the time when treatment began. Sections 4 and 5 have presented evidence on the fact that the area administered by British India has currently higher nutrition and health outcomes than the control group. By virtue of the RDD estimation - which compares areas around the cutoff point, so that the only variation is the type of colonial institution - I have proposed a causal interpretation of the findings. Yet, an important question that still needs to be answered is: When exactly has the divergence materialised? Answering this point is crucial for the understanding of the mechanism through which the effect of the institutions is observed in 2015. After providing some evidence that railway construction is a good candidate transmission channel, I describe how the different institutional setting affects the possibility to build that infrastructure, and how this latter may affect health and nutrition outcomes in the long-run.

6.1 Divergence in the late XIX Century: The role of the railways

For the purpose of isolating a transmission mechanism, I refer to historical sources that rely on the Census of India of 1901. As opposed to its previous and subsequent versions, it didn't simply propose a detailed measurement of British India. The census was also extended to generate an official account of the regions under princely states management. Data referring to the sampled area that stem from the census of 1901 are reported in the following documents, all published around 1908: the "Imperial Census, Provincial Series, Central Provinces" and the "Imperial Census, Provincial Series, Central India Agency" are more detailed versions of the broader "Imperial Census", and study the regions to the south and north of the River Narmada, respectively. In addition, the district gazetteers of Betul, Hoshangabad, Narsinghpur, and Nimar include an even more in-depth analysis of the towns and villages under the administration of British India in this part of the Central Provinces, while the "Bhopal State Gazetteer" and the "Indore State Gazetteer" concern the area then ruled by the two princely states[69]. These sources propose a more systematic coverage than those available in the early XIX Century, and they sample both treated groups at exactly the same point in time. In the same region that has been analysed across sections 4 and 5 (but for the robustness check at section 5.4), I retrieve 234 towns and villages, as well as 45 pergunnahs and tahsils across the two sides of the river. Among them, all pergunnahs are available to the analysis, and 193 villages and towns are endowed with population data. Comparing the average population across the two measurements, the following facts emerge, as visible at Table A.17: first, it sinks because the official census of 1901 covers also more remote villages, which could not be reached by the first informal measurements of the early XIX Century; second, the treated group has higher average population than control.

Table 4 summarises the results on the neighbourhood of the cutoff point by means of a RDD specification similar to model [1] used in section 3.2.2. While in Table 1 the running variable is distance from the colonial border considered in its full extent, Table 4 uses the distance from the colonial border where it overlaps with the Narmada River, in the same spirit of the long-run outcomes of sections 4 and 5. All outcomes in Table 4 and Tables A.18A to A.18C are consistent in highlighting a positive effect on the southern shore. Table 4 uses population in the villages as outcome variable. The specification that includes all geographic covariates and a linear fit of the model at Column (1) proposes an average increase of 1072 inhabitants, equivalent to 37% of the average population sampled in the area in 1901, which is equal to 2876. All other first-order fits of the model at columns (2) and (3) are consistent in magnitude. Furthermore, columns (4) to (6) implement a RD specification with quadratic fit, and the magnitudes of the effect are stable around 23% of the average population. Columns (6) to (9) report the effect of a OLS estimation. Overall, results seem fairly consistent in sign and magnitude with the other point estimates[70].

[69]The small part that used to be under the management of Dewas and Dhar chiefs is covered by the "Western States Gazetteers, Malwa".

[70]But for the OLS without any covariate at column (9). This stems from a comparison of means, where the highly populated cities of Bhopal (76,500) and Indore (86,600) drive the results up in the control group

Table 4

	(1) popul 1900	(2) popul 1900	(3) popul 1900	(4) popul 1900	(5) popul 1900	(6) popul 1900	(7) popul 1900	(8) popul 1900	(9) popul 1900
Conventional	1285.8	1260.1	1350.5	977.6	969.6	975.9			
	(831.5)	(841.4)	(845.1)	(1012.4)	(1012.5)	(1025.7)			
Bias-corrected	1097.7	1019.5	1152.3	653.6	659.1	649.3			
	(831.5)	(841.4)	(845.1)	(1012.4)	(1012.5)	(1025.7)			
Robust	1097.7	1019.5	1152.3	653.6	659.1	649.3			
	(1003.0)	(1007.3)	(1010.0)	(1113.5)	(1112.5)	(1121.0)			
OLS							593.4	525.7	-816.3
							(888.4)	(823.6)	(1143.2)
Observations	189	189	189	189	189	189	189	189	189
cutoff	0	0	0	0	0	0			
N_left	27	27	27	35	35	35			
N_right	58	55	58	62	62	62			
bwidth_left	20713.2	19948.7	20183.5	31720.2	31709.8	31862.6			
bwidth_right	33634.3	32762.7	34034.6	45262.8	45479.6	43978.9			
order	1	1	1	2	2	2			
bwselect	msetwo	msetwo	msetwo	msetwo	msetwo	msetwo			
kernel	Triangular	Triangular	Triangular	Triangular	Triangular	Triangular			

Standard errors in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Regression discontinuity and OLS output. The outcome variable is population in 1901. The running variable is the distance from a point where the border and river overlap. The observation unit is the town or village. Standard errors are reported in parenthesis. Columns (1) to (3) run a RD model with triangular Kernel-weighting function, first-order polynomial fit, and two different MSE-optimal bandwidth selections across the cutoff. Columns (4) to (6) run a RD model with triangular Kernel-weighting function, second-order polynomial fit, and two different MSE-optimal bandwidth selections across the cutoff. Columns (7) to (9) run an OLS regression. Columns (1), (4), and (7) control for altitude as well as the averages of temperature and rainfall between 1985 and 2015. Columns (2), (5), and (8) only control for the averages of temperature and rainfall. Columns (3), (6), and (9) do not include covaraites.

In the same spirit as with XIX-century data, Table A.18A manually defines symmetric bandwidths with a 10-km increment at each specification. As in the case of Table A.2, there seems to be some volatility in the estimates, so I focus on results from the optimal bandwidths, such as in Table 4. Table A.18B uses population density as the outcome variable, and shows an increase by 20 people per square mile in the specification with all available geographic covariates in the average pergunnah that is located just to the south of the cutoff. These estimations are performed on a smaller sample than those using village population as outcome as the number of pergunnah is smaller than that of towns. As such, their reliability might be questionable, but their findings go in the same positive direction as with population, which fact strenghtens the suggestions that the divergence observed in 2015 dates back to a precise moment during the colonisation of India, between mid-XIX century and 1901. In fact, the first transcontinental railway built in the country has been operating in the British-Indian stretch of land under study since 1870. Therefore, the evidence produced by Table 4 and and Table A.18B make the railway a definite candidate for the long-term transmission of the institutional effects highlighted in Section 4.

As it is explained in more detail in the continuation of this section, the construction of the railway crucially depended on an interest guarantee that British India gave to those private investors willing to participate in the project. In principle, nothing prevented the princely states to do the same.

But the rule of law and investment-prone legislation in the treatment group have added much to the credibility of the enterprise, while it is unsure that the more discretionary powers of the princes and vassals in the native states might have equally achieved to raise funds for the project. Hence, the transmission chain I propose in this study is the following.

1. The southern side of the Narmada was strategically but not economically appealing to the British, when they added it to their direct colonial domains in 1818.
2. The annexation came with the development of institutions that favoured the private enterprise, by means of the recognition of economic rights and a more transparent bureaucratic apparatus capable of gaining the credibility required to have positive synergies with the private sector.
3. This opened up the scope for a collaboration in the construction of the railway, which would not have been possible without the state guarantee placed by British India.
4. The infrastructure led to the enhancement of trade, higher returns to capital, and ultimately better average welfare outcomes in British India, which are evident starting from the divergence documented in 1901.
5. Surviving the colonial institutions, the railway is the driver of the long-term transmission measured by the main findings of 2015.

In what follows, I intend to be clearer about points 3 and 4. First, in section 6.2 I show that the fixed costs and organisational enterprise necessary to the construction of a railroad require the presence of an organised and credible state apparatus as that of British India. Second, in section 6.3 I bring some evidence on how the railways may have led to economic growth, building on established references in the literature as well as from data available in the main sample.

6.2 From the institutions of British India to railway construction

The location of the first railways built in India is contained at Map 6. By 1870, three crucial communication axes were completed: the Ganges valley, the Bombay-Madras link, and the connection of these two via the transcontinental railroad passing by the area under study. These three connections made up the core infrastructural plan whose discussion and planning started as early as in the 1840s[71]. As it is evident, these railroads are located almost entirely in land under the administration of British India, coloured in pink in the map. The main reason is related to institutional characteristics that allowed an easier access to capital. In what follows, I refer to "The railways of India" by Edward Davidson (1868), a comprehensive review of the process and of the terms of construction. From this first-hand source, I obtain details on the building phase of the Bombay-Allahabad line, which passes though the sample under study, and was initiated in 1853 to be concluded in 1870. Importantly, the same source contains relevant pieces of information about the nature of the interactions between the public and private sectors that underpinned the construction of this railway. In 1849, the East India Company and the Great Indian Peninsula Railway (GIPR)[72] reached an agreement that remained in place even after the Crown took over the colonial government from the former in 1858, and whose salient points are the following. The GIPR pays a deposit of 500,000

[71] For a detailed discussion of the strategic routes, see E. Davidson, "The Railways of India", 1868.
[72] The private company in charge of the construction of the infrastructure.

pounds to the government, and pays all construction costs, raising the money from the financial market - mostly through British shareholders. The colonial government gives the GIPR the free lease of the land involved in the construction for 99 years, and pays a yearly interest guarantee of 5% on the inflowing capital for the next 25 years. In exchange, the colonial government has full access to and control of the GIPR's books, and has the final word on the route to be selected[73]. This provision has overcome the risk embedded in the high fixed initial capital expenditures that typically threaten the development of network industries. Instead, it offered an almost certain remuneration to the economic agents that were willing to participate in the endeavour. Indeed, if the government missed an interest payment, the shareholders would have had the right to the immediate reimbursement of the principal. If the company was unwilling to continue the construction, the government would have had the right to seize all its assets (including the deposit) and continue with the construction. Profits were meant to be shared between the government and the GIPR until the repayment of the amounts spent by the former on the guarantee; from that moment, they would have only accrued to the latter, and consequently to the shareholders. By virtue of this scheme, the private company gained access to investors that would have been reluctant without the risk-free component of the public guarantee; the government gained ease of operation by letting the company manage the details of the construction, while in fact taking all relevant decisions, as if it had raised an ordinary loan[74]. Such cooperative interaction would have proven very difficult without a credible player such as British India, whose modernly organised apparatus kept records of the administration and established a reputation of respecting the rule of law. Furthermore, the terms of the agreement tackle two possible arguments. First, territories in British India are not selected thanks to the private investors' or the company's home-bias, as neither is in charge of selecting the route. Second, the central government of the United Kingdom did not subsidise the operation, so there is not an issue of easier access to funding, independently of the quality of colonial institutions.

In sum, the crucial instrument that has made the railway possible pins down to financial engineering, since only the guarantee of interest placed by British India allowed to accumulate the resources required for the technology to be implemented. Such guarantee has worked because it added a trusted component to the enterprise, thanks to the credibility that British India - differently from the native states - had gained even with Indian capital owners by abiding with the rule of law and setting up institutions that respected economic rights. In Davidson's words: "The amount of capital required by the railways of India was very large, and could not possibly have been raised by joint-stock companies without the aid of a guarantee of interest by Government." Stated differently, "it would not be possible to obtain the vast amount of capital required for the successful conduct of such enterprises, unless some security could be given to the public that there would be a certainty of adequate return for the money that they might advance." [...] "The great, the immense, advantage which the guarantee to the capital of joint-stock companies has given, has consisted in the ready and unfailing supply of money needed for construction."[75]. The success of the exchange with the

[73] As Davidson (1868) says: "In consideration of the above grants of aid, the Government has the power to select the line, to define the limits of all works, to supervise expenditure and operations in England and in India, to examine accounts, to inspect works and line under or after completion, to regulate tolls and time-tables, and generally to control the affairs of the railway company."

[74] Concerning "The issue of an ordinary loan by Government at 4 or 5 per cent" and the "railway guaranteed capital", Davidson (1868) affirms that "in fact the security is precisely the same in either case".

[75] When explaining why native bankers were underrepresented in the financing of Indian railways, Davidson attributes the cause to former mismanagement of private companies, underlining that things are completely different in the railway case: "When railway companies, though in truth but differing slightly from Government agencies for

private sector was such that the amount collected from financial markets for the construction of railways in India via the state guarantee reached 76 million pounds at Davidson's writing. In this respect, the institutional features of British India are crucial in the explanation of how the former has managed to build the infrastructure that played the role of transmission channel to the nutrition and wealth outcomes observed in sections 4 and 5.

6.3 From railway infrastructure to current welfare

The positive effect of railroad endowment on economic outcomes (including proxies of income) is explained by a rich literature in development and transport economics. For example, Donaldson (2018) evidences the economic gains introduced by the railways of India. As these facilitated the possibility of communication and reduced trade costs, the yields per acre in the districts with a railway increase on average by 16% in his setting. In addition, Jedwab-Moradi (2016) analyse this effect in Ghana, where increasingly profitable cocoa plantations have been grown during the 1920s, becoming the crucial player of the country's economy. The authors use a twofold approach to isolate the effect of the railways on urbanisation in 1931 and 2000, as well as on cocoa production in 1927. First, they restrict the sample to one railway opened for military and mining reasons in 1903, before the cocoa business started; second, they extend the sample to the whole set of the country's railroads, instrumenting them by means of straight lines. In both cases, they find a strong positive effect on urbanisation and cocoa production, suggesting that the presence of railways increases the productivity of the economy by allowing to cultivate lands that would have been otherwise unprofitable. With the enhanced possibility of profits comes human settlement, and the birth and growth of cities, which are later reached by the roads due to increasing returns to size. I apply such evidence to my sample, with particular reference to the estimation by Andrabi-Kuehlwein (2010). Measuring the impact of railway connection on price convergence across Indian districts, they find the magnitude of the aggregate effect to be surprisingly small. One of the two reasons the authors explain in the paper is that some railways - especially between Calcutta and Delhi - have been overlapping already existing trading routes (such as the Ganges), which had made convergence in prices happen before the advent of the British. On the other hand, in the authors' own words, "an interesting counterexample was the decision not to connect Bombay directly to either Calcutta or Delhi by rail. Instead, the British built a line from Bombay to Allahabad, midway between Calcutta and Delhi, through Jubbulpore. Since this was a less traversed commercial route, one would expect to see a greater than average decrease in price dispersion among districts along this route." The railway Andrabi and Kuehlwein refer to is precisely the transcontinental infrastructure crossing my sample. Hence, their findings confirm the argument that the railroad was not constructed to profit from preexisting trade or economic dynamism in the region, but to create a link between different parts of India under British control. Quantifying this idea, the authors report that "the effect of introducing railways along the Delhi-Calcutta route [...] or within the South Indian region is less than the average effect for all of India. In contrast, the effect of railways on districts along or near the Bombay-Allahabad line is 7 to 37 times greater than that of the Delhi-Calcutta line." In sum, the finding by Andrabi-Kuehlwein (2010) speaks again in favour of the historical evidence that there was not much on the Narmada southern bank before the introduction of the direct British

carrying out a great and improved system of intercommunication, appeared in the great capitals of India as quasi-independent bodies, their wealthy men could not divest themselves of the suspicion which would have inevitably attached itself to any similar joint-stock undertaking that might have commenced business in India without the support and supervision of Government" rule, which makes the argument of Jebwab-Moradi (2016) on the economic effect of the railways applicable to my case. Thus, their explanation is applicaple to my sample: the railway is positively related to economic outcomes (such as my proxies of income) because it immediately fosters production and urbanisation. These two elements generate positive spillovers over time, through job specialisation, innovation and further network investments due to increasing return to size.

Figure A.6 confirms the overall idea by showing a regression discontinuity from the railway stations within the treatment group (i.e. the southern bank). It is evident that the closest a bin is to a station, the higher is the average arm circumference, in a concave-shaped function fit that reaches its global maximum along the railroad. To corroborate further this evidence, I present two specifications that take advantage of the full border between the Central Provinces and the native states of Bhopal and Indore. As it might be remembered from Table A.3A, the average distance of the border from the railway when the full border is used is twice as much the average distance when the part of the border that overlaps with the river is used. It follows that, in such specifications, the railway channel is less strong than in the main models presented in sections 4, 5 and 6.1. Unsurprisingly, also the estimation results are weaker in magnitude. At Table A.19A, all reported point estimates from the RD model keep being positive, but their magnitude ranges from 3.3% to 18% of the average population, which is equal to 2574. At Table A.19B, the nutrition variables maintain the statistical significance of the Robust coefficients[76], but their magnitude shows a generalised drop: 2.4% of the average in arm circumference, 4.5% in BMI, 3.8% in Rohrer's Index. While keeping the same sign as in Table 2, the probability of being underweight and the percentage of child survival are not distinguishable from zero. The wealth variable shows a weakly positive point estimate. Overall, this findings confirm the important role of the railway infrastructure in the transmission of the long-run result.

To conclude, I have shown in sections 4 and 5 that there is a positive and robust causal effect of the institutions of British India on proxies of current health and nutrition. In this section, I have explained some reasons why this finding is likely to pass through the railway channel. Indeed, there is a positive correlation between the colonial regime endowed with more modern institutions and infrastructure construction, as well as between the railroads and economic and health outcomes. When it comes to the evidence of Figure 2 - that the region formerly under British India shows also more inequality in wealth distribution - it must be said that the implementation of property rights is a typical institutional characteristic of the treatment group. Property is responsible for the long-term transmission of the economic differences, if it is freely transmissible across generations, and there is no reason to suspect otherwise in a democracy such as India. Further, the presence of the railway might have been accentuated the proprietors' gain by giving them access to a vaster market for goods that enhanced returns to capital.

7 Conclusion

I have focused on a region of India where the socio-economic conditions were arguably homogeneous at the time of the arrival of the British. Once the area was seized by them, the colonial border between my treatment group (British India) and my control group (the princely states of Bhopal

[76]The p-value of arm circumference is 0.058

and Indore) was set in the middle of what is now the federate state of Madhya Pradesh. Since 1956, the two treatment groups newly enjoy legislative and institutional uniformity. Yet, I observe a significant difference across them when it comes to measures of body size that relevantly add to human capital formation, as well as in the wealth distribution. In the main specification, crossing the border from the former princely-state domain to the former British India results in a spike in nutrition values around 7% of the respective average, as well as in a reduction of the underweight population and in a greater probability of child survival. Such difference is traced back to the colonial regime. First, it already emerges using data from the 1901 census. Second, the colonial era has been the only period in which the two sides of the river experimented different institutional frameworks. Third, when two other sets of treatment and control groups in the neighbourhood of the main sample area are analysed - such that the river has never been an institutional border - the ATT collapses to zero, or is inverted. The robustness checks and placebo tests give further evidence in favour of the causal interpretation of the effect of colonial institutions. Such effect is likely to happen thanks to positive spillovers between the public and private sectors. The more efficient bureaucracy of British India implemented transparent methods of tax collection, which - as opposed to the feudal administration of Princely States - aimed to enhance private investment[77]. Shared public-private plans of infrastructure building have been implemented in railroad construction. This, in turn, boosted production in the remote areas of Central India, whose distance from the main trade hubs had previously hindered the development of economic activities. Due to increasing returns to capital, the initial advantage of the southern bank might have transmitted over the decades, resulting in the difference observed in the year 2015. However, the benefits accruing from the definition of property rights and from the incentives to private investment have come together with different patterns of wealth accumulation, so that the treated group shows higher inequality in addition to the better average effects on the selected measures of welfare. Overall, this paper contributes to the literature of development economics and economic history of India by narrowing down the analysis to a region where causal identification is sustainable, showing that districts directly ruled by the British are currently better off in terms of average nutrition variables but not in terms of social equality. Furthermore, the paper contributes to the literature in political economy by underlining that more modern institutions abiding with the rule of law and the respect of economic rights - among which property - favour economic growth. I acknowledge that the effect is internally valid to the sample under study, and may not be extended to areas that were initially located on thriving trade routes, whose wealth could have determined the seizure by profit-oriented settlers. Confirming this local evidence in other parts of the world with similar characteristics could be the subject of relevant future studies.

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- Novel database of population in Central India in the early XIX and XX Century.
- RDD: divergence in development in favour of British India during the colonial era.
- British-Indian institutions favoured investment and synergies with private sector.
- The railway resulted from these and is the main long-run transmission channel.
- RDD: persistence on nutrition proxies, but higher inequality than control in 2015.

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