The impact of geography and institutions on Indian economic development

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Abstract

This thesis contributes to the debate on the fundamental determinants of economic growth and development. It tests the importance of geography and institutions in the long run development of India. It consists of three chapters, the first two of which are self-contained, while the third builds on ideas emerging in the preceding chapters.

The first chapter investigates the role of rainfall variability in determining development in late colonial India. An original dataset on rainfall shocks is employed to show that rainfall variability and specifically negative shocks are significantly associated with lower district level literacy. Both *ex-ante* and *ex-post* coping strategies that could explain such an effect are explained and evidence of the impact of rainfall shocks on agricultural incomes and school enrolment is provided alongside.

The second chapter estimates the causal impact of colonial land revenue institutions on long run rural development in India. A novel village-level dataset that links colonial era villages to a modern village census is used in a geographical Regression Discontinuity Design (RDD) framework. Results indicate that villages assigned to landlords in the colonial era have lower literacy, irrigation and public good provision at the start of the 21st century. The channels proposed include migration, public good provision and the differential influence of the railways.

The third chapter attempts to explain how institutions have had persistent impacts in India. To do so, it traces the influence of historical institutions in explaining patterns of success in the implementation of the land reforms and the uptake of Green Revolution technologies across the different states of independent India. The key determinants in both cases are identified and their relationship with historical land tenures is examined. Quantitative evidence for the significance of institutions in the take-up of High Yielding Varieties (HYVs) is presented, alongside evidence of a more restricted role for rainfall variability.

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Declaration

I, Vigyan, declare that this thesis titled "The impact of geography and institutions on Indian economic development" is a presentation of original work and I am the sole author. This work has not previously been presented for an award at this, or any other, University. All sources are acknowledged as references.

Chapter 1 is part of a joint project with Professor Sue Bowden. An earlier version of this chapter was presented at the 2016 Economic History Society (EHS) Workshop in Manchester and more recently at the Workshop for South Asian Economic History at the LSE. While this is part of a joint project, I carried out the data collection and empirical analysis, and wrote the first draft.

Chapter 2 and Chapter 3 are both sole authored. Earlier versions of Chapter 2 were presented at the World Economic History Congress in Boston, the 2018 Lancaster PhD Summer School in Applied Microeconomics, the Coase Institute Workshop in Bratislava, the Economic History Society conference in Belfast, the Royal Economic Society Conference at Warwick, and the European Historical Economics Society conference in Paris.

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Introduction

Why are some places poor and others rich? This thesis consists of three essays that explore economic development, each of which broadly addresses this age-old question in economics.

Previous work on the topic has argued that differences in environmental conditions (‘geography’)[1] and in the rules and norms that shape human incentives (‘institutions’) are crucial in explaining divergent economic paths. These have often been presented as competing hypotheses, although there is now a wealth of evidence for the importance of both in shaping economic outcomes. This body of work has also emphasised that historical differences in geography or institutions can be powerful determinants of current levels of income and development.[2] For India in particular, the most influential research has indicated that historically assigned land revenue systems had persistent and significant impacts on long run economic outcomes. The argument made is that regions where the colonial state settled revenue demands with landlords as opposed to with cultivators have lower agricultural productivity and lower public good provision in post-independence India, caused by higher conflict between the elites and the masses (Banerjee and Iyer, 2005).

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India makes for a fascinating context to explore such questions because economic growth in India has been both idiosyncratic and lopsided. The annual real GDP growth was 3.7% from 1950 to 1980 increasing to 6% or over in all the subsequent decades since.[3] The rapid take-off in growth rates is attributed to liberalising reforms in the 1980s and (more prominently) in the 1990s that dismantled the centrally planned economy and opened up the economy by

[1]This thesis focusses on the first nature geography related to physical characteristics such as climate rather than second nature geography involving the spatial interaction of economic agents.

[2]Influential work using cross country data that emphasises role of institutions includes Easterly and Levine (2003), Acemoglu et al. (2001) and Acemoglu and Johnson (2005). Additional evidence on importance of specific types of institutions has been provided by Dell (2010), Nunn (2008) and Michalopoulos and Papaioannou (2013). Studies that argue for independent effects of geography include Gallup et al. (1999), Sachs (2003) and Alsan (2015).

[3]Based on data from the World Bank available at https://data.worldbank.org

dramatically reducing tariffs (DeLong, 2003). This transformation of the Indian economy - from a relatively stagnant economy to one of the world's fastest growing ones - is remarkable but India stands out further due to the nature of its transformation.

The most striking feature of rapid economic growth in India has been that it has been driven by expansion in services, not manufacturing. Between 1950 and 1990 services grew at a slower rate than industry, but this pattern was reversed in the high growth period post-1990 (Gordon and Gupta, 2005). To an extent, this unique expansion in services was simply a matter of convergence to the norm due to earlier state neglect, but a significant segment of this sector (specifically: communication, business services, and financial services) went beyond the international norm and contributed more to GDP growth than manufacturing (Eichengreen and Gupta, 2011). Meanwhile, the performance of the agricultural sector has been relatively disappointing. Agricultural Total Factor Productivity (TFP) growth rates in India were negative prior to 1974 and have since grown at a stable but low rate - 0.3% between 1991 and 2006 for example (Nin-Pratt et al., 2010). Indian agriculture benefited from the Green Revolution but has continued to be plagued by low technical and production efficiency due to issues with land distribution, investment and infrastructure to such a degree that production efficiency in 2006 was similar to its 1960 levels (Nin-Pratt et al., 2010). Manufacturing growth has also been modest in India. The sector has expanded since 1993 but this has been substantially due to employment growth, as TFP growth languished at around 1% annually and manufacturing contributed less than 30% to output (Bosworth and Collins, 2008).

These three features - relatively low agricultural productivity, no large manufacturing sector and a substantial expansion in services - have led to India's growth trajectory 'bucking' many conventions. Growth models like the Solow model predict a key role for investment but India's physical capital accumulation has not stood out (Bosworth et al., 2007). Similarly, theoretical implications of the Lewis model are based around a transfer of labour from agriculture to industry but Indian growth has been underpinned by expansion in services, with evidence of persistence of surplus labour in agriculture (Gollin, 2014). India also doesn't fit neatly into other theories that predict growth in stages. For example, Rostow's stages of growth (Rostow, 1959) characterised the growth process as 'taking off' from increasingly mechanised agriculture and higher savings, eventually leading to the industrial sector completely dominating agriculture. India's services led growth has made it proximate the sectoral composition of a middle income economy without large scale manufacturing (Gordon and Gupta, 2005).[4] But do such peculiarities matter since high growth has been achieved anyway? The answer should be yes - because of the persistence of widespread poverty.

There are good reasons to believe that the persistence of widespread poverty and associated regional inequality are associated with the specific features of Indian growth discussed above. Low productivity in the agricultural sector is problematic because poverty reduction across the developing world has been driven strongly by growth in agricultural incomes (Anríquez and Stamoulis, 2007; Cervantes-Godoy and Dewbre, 2010; Ligon and Sadoulet, 2018). Growth in the Indian agricultural sector was the most important determinant of poverty reduction prior to 1990 and although that has changed with increasing importance of urban growth since, growth in agriculture continues to be a significant contributor to poverty reduction (Datt et al., 2018). In a pattern consistent with other developing countries, the importance of the primary sector in India is also underlined by the fact that around half of employment is still provided by this sector (Datt et al., 2018). Logically, this is where the role of manufacturing in providing employment comes in, and so do further concerns about the Indian development path. Many studies have highlighted both, the misallocation of labour across sectors in India and the need for India to broaden its base into manufacturing to provide greater employment (Bosworth et al., 2007; Hsieh and Klenow, 2009). There has also been concern that employment provided by the service sector in India is limited, biased against unskilled and semi-skilled labour (which restricts the potential to pull people out of agriculture), and that future scope for expansion may be limited (Acharya and Acharya, 2003; Panagariya, 2008).[5] One of the key factors driving service sector expansion - availability of a minority of highly skilled people - also reflects India's failure to keep up in the quantity and quality of primary and secondary schooling which would be required for broader based future economic growth (Bosworth et al., 2007).

The persistence of poverty in India has had a strong regional dimension. There is evidence that post-independence growth and poverty reduction in India differed significantly across states. The overall pattern of growth has not been pro-poor as there has been higher growth in states with lower output elasticities of poverty, and this pattern has been driven by initial conditions characterised by low farm productivity, poor literacy and health and unfavourable land distributions (Ravallion and Datt, 2002). The rapid economic growth achieved

[4] India is also ill at ease in fitting more contemporary frameworks. The *Global Competitiveness Reports* characterise stages of growth as factor driven, efficiency driven and innovation driven, and while India has moved beyond factor driven, it isn't characterised as having reached the second stage.

[5] Other work has come to a somewhat more optimistic conclusion that services can be viable source of employment alongside manufacturing (Eichengreen and Gupta, 2011).

in India starting in 1980s and 1990s while reducing overall poverty, was accompanied by rising inequality across almost every category. Inequality in incomes and expenditures rose across and within states, between rural and urban areas, and within urban areas (Deaton and Dreze, 2002; Banerjee and Piketty, 2005; Dhongde et al., 2007; Pieters, 2010).

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The historical focus of this thesis to analyse the patterns outlined above is targetted at discovering the fundamental determinants of growth. Apart from the potential in such an approach apparent from evidence on the historical origins of India's relative over performance in services and under-performance in agriculture (Gupta, 2019), there is indication that regional inequalities in late 20th century India were the result of pre-existing institutional and infrastructural capabilities across the different states (Kochhar et al., 2006; Ravallion and Datt, 2002). The use of data covering the subcontinent and different time periods in Chapters 1 and 3 permits an analysis of variations in economic development across time and space, while the use of village level data in Chapter 2 directs the focus on rural development specifically. Data from colonial India allows this thesis to explore important historical differences in institutions and geography. The start of the colonial period, in particular, saw substantial differences in land tenure emerge as administrators grappled with the best way to extract land revenues whilst familiarising themselves with newly acquired British territories. Understanding these critical differences and then tracing their impacts across history is one of the major preoccupations of this thesis.

The focus on outcomes beyond income and consumption, while being a by-product of data limitations to a certain degree, allows this thesis to address broader conceptions of economic development. One of the outcomes analysed in both Chapters 1 and 2 is literacy, which is a determinant of economic growth but also a measure of economic development and human development with widespread political, social and health related impacts. In the Indian context, human capital has been shown to be an important determinant of the success of the services sector (Broadberry, 2010). At the same time, the failure of India to expand basic literacy has been an impediment to transfer of labour from unskilled to semi-skilled occupations (Bosworth and Collins, 2008). Patterns of literacy across India therefore form a core element in explaining regional patterns of development. In addition to literacy, this thesis examines agricultural productivity directly through yields and acreage under High Yielding Varieties (HYVs) in Chapter 3, and also uses the critical input of irrigation as an outcome measure in Chapter 2. Finally, this thesis includes public good provision as an outcome in Chapter 2 reflecting availability of infrastructure and investment.

By creating and using new historical data, utilising appropriate econometric methods and gathering qualitative evidence, this research seeks to provide fresh insight into our understanding of economic development in general, and of India in particular. In three chapters, this thesis will explore how and when geography matters more than institutions, estimate the persistent impacts of historical institutions at the village level, and finally suggest how such long run persistence can be explained particularly in light of the land reforms and the Green Revolution in the second half of the 20th century. The rest of this introductory note will summarise the motivations, strategies and results of the chapters that follow.

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Cross country studies (see, for example, Rodrik, 2004) that illustrate the pre-eminence of institutions have spawned two interesting and interlinked responses. The first response has emphasised that geography can be shown to have significant effects on long run development if geographical conditions are measured more precisely or the analysis is conducted over wider samples. These types of analyses have, for example, demonstrated how the disease environment has direct and independent effects on current development outcomes (Sachs, 2003; Alsan, 2015). The second broad response has argued that there is more scope to uncover the role that geography plays in development by analysing the different geographical conditions within countries. Analysis of this kind has allowed a wider range of geographical measures to be incorporated, with evidence that the relative importance of geography vis-a-vis institutions is stronger at the subnational level.[6] The large variations in geographical conditions across the Indian subcontinent make an investigation along these lines promising.

Chapter 1 of this thesis prioritises such an analysis. In this chapter, one of the most apparent geographical features of the subcontinent - the monsoons or seasonal rain-carrying winds - is analysed to understand historical patterns of literacy. The uncertain nature of monsoon rainfall is captured by building a statistical profile for districts in colonial India, using historical rainfall data, that captures the degree of exposure to rainfall shocks and uncertainty. A range of evidence from developing country contexts that indicates the importance of ex-post and ex-ante costs of dealing with uncertain rainfall is presented along with an explanation of why such costs are likely to have been pertinent in the context of early 20th century colonial

[6] For example, Mitton (2016) finds that geography is more useful for explaining within-country differences in development compared to across country differences.

India. The analysis in Chapter 1 suggests that higher rainfall variability was associated with lower district level literacy in a statistically and economically significant manner. Further original data on primary enrolment rates and agricultural productivity is used to emphasise the important role played by income shocks in explaining the relationship discovered via the preceding analysis.

There are some other important concerns with the literature on institutions. One of the major critiques has been regarding the measurement of institutions. In cross-country studies data used to proxy 'good' versus 'bad' institutions often rely on indices measuring the quality of governance. Apart from the fact that such studies can end up being a bit vague in their definition of institutions, a number of data concerns have also been raised (Høyland et al., 2012; Donchev and Ujhelyi, 2014). Studies that either in conjunction, or instead, use historical data in their analysis have also been the subject of debate on data quality.[7] In colonial India, land revenue systems that were nominally the same, operated differently in different parts of the country. Re-classifications based on alternative interpretations in parts of the country have led to existing results on institutions no longer being robust.

Chapter 2 deals with these issues by utilising a new village level dataset from early 20th century India. Disagreements among administrators on how the land revenue system should operate in colonial India led to sharp discontinuities in land tenure type. The evolution of official policy bore its mark strongly on the province of Madras. Land revenue in one-third of the province was settled with landlords who made a fixed annual payment to the government and were left free to manage collections within their estates. In the rest of the province, revenue was settled directly with cultivators. Chapter 2 exploits this quasi-random assignment of villages in the 19th century to different revenue systems, and employs a Regression Discontinuity Design (RDD) framework to estimate the impact of villages being assigned to a landlord based revenue system as opposed to a cultivator based revenue system. Villages assigned to the former are shown to have significantly lower literacy, irrigation and public good provision in 2001 relative to the latter. Evidence regarding historical migration, public good provision and differential impact of railways is discussed as potential channels for the discovered effect.

Another significant issue with the institutions literature is that it often is not able to explain *how* institutions have persistent effects. Many innovative methodological approaches are able to identify a causal effect of historical institutions. But why don't subsequent shocks such as state policies and programmes nullify such an impact? Indeed, arguments that historical

[7] For example, Albouy (2008) provides a substantive critique of Acemoglu et al. (2001)'s data construction.

institutions, frequently attributed to colonial administrations, are the strongest determinants of long run development can be fairly critiqued for discounting role for local agency. This places scrutiny on the common explanations for the impacts over centuries - the persistence of *de facto* institutions despite changes in the formal *de jure* institutions, and the role of path dependence.

Chapter 3 takes up the challenge of exploring these concepts in the light of policy developments in independent India. Two of the biggest post-independence shocks to the rural agrarian structure - the land reforms and the Green Revolution - are analysed. It is argued that the uneven success of both the land reforms and Green Revolution was partly conditioned by historical institutions, with areas formerly under landlord based revenue systems falling behind. Evidence is presented that the level of state commitment to reforms, the power of the landlords and the available state capacity were all significant factors in differential success of the land reforms and were themselves conditioned by historical land revenue institutions. A similar pattern, it is argued, was even stronger in the case of the Green Revolution where the pre-existence of infrastructure, a rich class of cultivating peasants and the role of the state were all conditioned by historical institutions and also in turn determined the places where the Green Revolution was most successful.

Unlike the first two chapters, which are self-contained, Chapter 3 reflects on the findings of the previous two chapters in the light of the changing circumstances after Indian independence. The usual explanation for persistent institutional effects in the Indian context relies to a large degree on different levels of development expenditures at the state level. However, in light of results presented in preceding chapter, Chapter 3 suggests channels through which differential effects can persist at the village level. Specifically, it is argued that the role of the land reforms in creating a rural elite at the village level has so far been under-emphasised, and that this village elite then played a fundamental role in the spread of the Green Revolution. In the final section of Chapter 3, the role of rainfall variability is revisited in these changed circumstances. It is demonstrated that the impact of rainfall variability is more limited in post-independence India, with its relevance being restricted to districts with poor irrigation facilities.

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This thesis will argue that the importance attributed to historical land tenure systems in the story of Indian development is well founded - such institutions have significantly determined development trajectories of regions within India. At the same time, the research presented in the chapters to follow will underline the importance of appropriately accounting for the role of geography, defining institutions with care, and going beyond identifying persistence to actually explaining it.

Chapter 1

The Certainty of Uncertainty: Literacy in Colonial India in the presence of agricultural shocks

'Vanarakada, pranampokada, teliyadu.'
(When rain comes, or life goes, no one knows.)

Old Telugu Proverb

This chapter uses an original dataset on rainfall variability and shocks in colonial India to demonstrate that these had a significant impact on development at the end of the colonial period. The vagaries of the monsoons resulted in very differing patterns of rainfall volatility and shocks across the Indian subcontinent that forced farmers to adopt costly ex-ante and ex-post coping strategies. Results show that downside risk in particular is an important determinant of literacy across colonial India, and that the key mechanism in operation is the effect of monsoons on agricultural incomes.

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1 Introduction

Geographical factors have long been a part of debates on long run development, either as providing the initial conditions for institutional diversity or as having long run independent impacts (Sokoloff and Engerman, 2000; Sachs, 2003). In the Indian context, the role of colonial land tenure institutions in long run development is by now, well established: such institutions have been shown to have long run impacts on agricultural productivity and public good provision (Banerjee and Iyer, 2005; Kapur and Kim, 2006). However, analyses of Indian development have done less on incorporating the role of geography. This is particularly important since the sheer size of the Indian subcontinent necessarily includes a multitude of different geographical conditions, with recent literature drawing attention to the historical importance of deltas and floodplains (Roy, 2014).

One of the most prominent geographical features of the subcontinent, which has so far received scant attention in analysis of development in a historical context, is the annual monsoons. The onset and progress of the monsoons rely on wind currents and topographical features, so variations in the timing and quantity of rainfall received have always been considerable across agricultural seasons and the different regions. Quantitatively, this climatic attribute has been shown to be the predominant, if not exclusive, determinant of agricultural production and performance of the rural economy in the Indian subcontinent (Ray, 1971; Krishna Kumar et al., 2004). The vagaries of the monsoon are likely to have been even more important in colonial India, given the high reliance on agriculture, low levels of irrigation and low levels of income at the time. To the best of our knowledge, this is the first study to focus on rainfall variability and shocks to study historical patterns of development in colonial India.

The outcome measure used is literacy, an important developmental indicator, for which consistent and reliable data is available for all the major provinces. Existing literature has shown that the progress of Indian literacy from the 19th century to the present has been both slow and unequal, and has lagged behind other countries at comparable stages of development (Bosworth and Collins, 2008; Chaudhary, 2009; Agrawal, 2014). Research on this topic from a historical perspective has also identified a myriad of important factors such as the impact of land revenues and taxes, the influence of caste and that of the degree of caste heterogeneity, and the long run influence of expenditures in the colonial era (Chaudhary, 2009, 2010b; Chaudhary and Garg, 2015).

This study uses an original dataset consisting of rainfall patterns to extend this research and test whether rainfall variability and shocks can contribute to explaining regional variation in literacy levels. There is a varied body of work, most using micro level data, that finds that shocks and uncertainty, in the presence of incomplete credit markets, lead to adverse developmental outcomes in terms of agricultural productivity, child nutrition and heights, and human capital (Binswanger, 1980; Alderman et al., 2006; Jacoby and Skoufias, 1997; Poertner, 2008). In colonial India, public expenditure on education was very low (even compared to other developing countries at the time) and the school system was decentralised, which means explanations for regional inequalities in development are more likely to be found in differing characteristics across regions.

Theoretically, rainfall shocks can affect schooling through both an income effect, whereby shortfalls in rainfall affect agricultural incomes and thereby affect both the supply and the demand for education, but also a substitution effect that works in the presence of a market for child labour. The income effect can be caused by strategies adopted to cope with shocks both ex-post, whereby households sacrifice human capital investment to smooth consumption, and ex-ante, where households follow a low risk, low reward strategy that leaves them poorer (Christiaensen and Subbarao, 2005; Rosenzweig and Wolpin, 1993). The substitution effect works in the opposite direction to the income effect, as higher agricultural incomes can incentivise households to employ children in the field (Rosenzweig and Binswanger, 1992; Kruger, 2007). We find some evidence of the income effect in our setting.

We use rainfall data between the period 1901-1930 to estimate consistent patterns of rainfall variability for all districts in the five major provinces of British India. We also calculate a measure for downside risk in particular, as this is both more pertinent in the context of India and can be measured with higher precision. Our results indicate that rainfall variability is an important determinant of literacy - higher variability and more negative shocks are associated with lower literacy - with these results staying statistically and economically significant across a series of models. To gain a better understanding of the channels, we also build a panel model for the province of Madras to show that rainfall shocks significantly affect cropped area and agricultural incomes. To substantiate the link further, we show that such negative agricultural shocks have a significant impact on the growth of primary school enrollment in colonial Madras.

The rest of the chapter is structured as follows. Section 2 lays out the background in terms of the literature and historical context. Section 3 discusses the data and related issues. Section 4 sets up the empirical framework and Section 5 discusses the results as well as the mechanisms. Section 6 concludes.

2 Background

2.1 Shocks, uncertainty and human capital

Research on the effect of shocks and uncertainty on development has a long lineage. There is, for example, a consensus that high macroeconomic volatility is associated with lower growth, and that resultant welfare costs are likely to be large particularly in developing countries (Ramey and Ramey, 1995; Acemoglu et al., 2003; Loayza et al., 2007). In the presence of uncertainty and risk, households could rely on insurance and credit markets to smooth consumption, but such markets are often missing or severely incomplete in poor, developing countries such as India (Townsend, 1994).

Rainfall variability has been shown to have impacts on economic development in cross-country analyses (Brown and Lall, 2006), but there is an even bigger literature that investigates the impact of rainfall variability on household income, consumption and savings. There is, for example, a classic literature that uses data on rainfall and agricultural households from developing countries to measure permanent income and finds that rainfall variability explains income variability very well (Wolpin, 1982; Paxson, 1992).

A large associated literature uses household data from poor and developing countries to analyse the effects of shocks on health and education outcomes in the short and the long run (Dercon, 2005). This can roughly be split into two different strands. The first strand of research finds that there are strong short and long run effects of rainfall variability that arise when households try to cope with shocks *ex-post*. *Ex-post* coping strategies are focussed on reducing the consequences of a shock by reducing consumption and/or de-capitalising assets. Agricultural households in developing countries have been found to be more susceptible to weather shocks as these are covariant rather than idiosyncratic, i.e. they are likely to affect all households in a particular region. A study from Kenya found that rainfall shocks were the biggest contributor to risk in arid regions and that household assets were able to compensate in situations of idiosyncratic shocks but not in those of covariant shocks (Christiaensen and Subbarao, 2005). Given this, it is no surprise that evidence indicates that rainfall shocks lead to immediate reductions in consumption, and these reductions can also be persistent (Dercon, 2005).

Apart from consumption, the impact of such shocks has been shown to fall very heavily on long term human capital. There is overwhelming evidence that rainfall shocks reduce child nutrition and heights, increase child labour, lower school enrollment and long run literacy, and reduce long run work prospects; with the effects found generally larger for children if shocks occur either in-utero or in early childhood, or if the children belong to households that are poor or overly reliant on favourable rainfall (Hoddinott and Kinsey, 2001; Alderman et al., 2006; Beegle et al., 2006; Thai and Falaris, 2014; Carrillo et al., 2017). There is thus significant evidence that *ex-post* mechanisms to cope with shocks can be costly.

However, a second strand of literature finds that costs associated with *ex-ante* coping stragies can be substantial, and sometimes even larger (Elbers et al., 2007). *Ex-ante* strategies aim to smooth income and consumption via obtaining insurance, savings or diversification of income sources. In a classic paper Rosenzweig and Wolpin (1993) argued that when agricultural households are faced with uncertainty, capital stocks are used as both buffer stocks and as working capital, and it is important to understand consumption and savings decisions in this context. Unlike Wolpin (1982) their model assumed that in the presence of borrowing constraints income is not exogenously given, but rather endogenously determined by the capital stocks chosen. They verified their findings using data from India that showed that agricultural households were risk averse in the face of uncertainty, leading to under-investment in bullock carts (their working capital).

More recent studies have also come to similar conclusions. Dercon and Christiaensen (2011) study technology adoption in Ethiopian agriculture where, in a similar absence of insurance and credit markets, farmers are reluctant to increase their fertilizer intake when faced with the possibility of poor harvests that lower consumption. They argue that this can contribute to trapping households in a low risk, low reward permutation, thereby increasing long run poverty. Another *ex-ante* strategy that households can adopt is occupational diversification. A study looking at Bangladesh found that adults in households in areas with higher rainfall variability tend to diversify employment to a greater extent, and that such diversification comes with significant welfare costs in terms of consumption (Bandyopadhyay and Skoufias, 2015).

Taking stock of the literature summarised so far in this section, it seems clear that risk and uncertainty caused by rainfall shocks in agricultural and developing societies has been shown to affect income, schooling outcomes and literacy. However, it is important to stress that the final result of rainfall shocks on literacy should depend on the interaction between an income effect and a substitution effect. So while there is evidence that higher wages increase human capital investment (Jacoby and Skoufias, 1997; Maccini and Yang, 2009), it is also possible that an increase in income leads to a decrease in schooling as the opportunity cost of going to school increases. There is evidence to this end that finds that higher wages in the presence of a market for child labour can lead to children quitting school to join the workforce early (Rosenzweig and Binswanger, 1992; Kruger, 2007). A recent study from Colombia shows that long run adult incomes are lower for individuals who grew up when world coffee prices were higher, as that led them to complete fewer years of schooling (Carrillo, 2019).

Whether the substitution effect dominates the income effect or vice-versa may be an empirical question, but there are some potential indicators regarding the relative effect. Firstly, the substitution effect would rely on the the existence of an outside option to schooling and also on the returns to schooling. Some evidence from developing contexts shows that crop losses lead to an increase in child labour as low income households look to compensate for loss of income and assets (Beegle et al., 2006). Secondly, the income and substitution effects may dominate each other at different times. Research from post-independence India has shown that schooling outcomes are affected negatively by negative rainfall shocks for children in utero or in early age, but are positively influenced after that point (Shah and Steinberg, 2017).

In summary, the overwhelming evidence is that rainfall variability can have serious impacts on development. These impacts could result from the risk and uncertainty associated with variability or due to coping strategies associated with shocks. The evidence indicates effects on income and also directly on human capital. The effect of rainfall variability in colonial India is likely to depend on the specific characteristics of the economy and the education system, something we turn our attention to next.

2.2 Colonial India

2.2.1 Rainfall and agriculture

The word 'monsoon' is derived from the 16th century Arabic word for season, and the monsoon rains have marked the changing of seasons across the Indian subcontinent for centuries. The rain carrying winds blowing from the South-West and the North-East deliver the vast proportion of rainfall - the South-West monsoon between June and September alone accounts for almost two-thirds of the annual rainfall. The monsoons have been predominantly ascribed to temperature differences between landmasses and the sea, but the factors that lead to good and bad seasons are not completely understood. There is some research on the Indian monsoon that indicates poor seasons are correlated with the El-Nino effect, while others have stressed the importance of convection currents over the Bay of Bengal and of temperature gradients over land in determining the onset, progress and intensity of the monsoons (Gadgil, 2003; Turner and Annamalai, 2012). The causes for spatial variations in monsoon rainfall are similarly attributed to convective regions over land, that can change from season to season (Gadgil, 2003).

The inherent unpredictability of the monsoons is likely to have had a big impact in colonial India. This is due to the economy being overwhelmingly agricultural - at the turn of the 20th century almost 70% of the Indian workforce was employed in agriculture and this figure marginally increased in the next few decades (Roy, 2002). This reliance on the monsoons made subsistence easy but risk-prone, and reduced the levels of private investment in agriculture (Roy, 2007). However the impact of rainfall variability on the Indian economy in the early 20th century is also likely to have been high due to the very low levels of irrigation facilities. There was very little public investment in irrigation - 4% or less of gross expenditures - in colonial India (Chaudhary et al., 2015). At the turn of the century, ordinarily, around 20% of cropped area could be irrigated; this varied by province but also depended on the quality of the monsoons as many tanks, wells and even rivers would become redundant if rains failed.[1]

The evidence for the importance of adequate rainfall to colonial India is plentiful. Both official and unofficial reports of the time stress the prime role of rainfall. For example, one author summed it up thus: "Obviously, the most important single phenomenon in the climatic system of India which is of paramount importance to the agricultural population of the country is the Monsoon." (Ramaswamy, 1942, pg 5)

This reliance of agricultural life on monsoons, particularly to deficits in rainfall, is also reflected time and again in the *Season and Crop reports*. For example, in 1903-04 the Director of Agriculture of Bengal says:

> The *ante*-monsoon showers were seriously defective throughout the Province except in Ranchi; the defect continued till, in many districts, paddy was resown...The season was not altogether favourable for the crop; the defect in the early part of the season affected not only the area but also the growth of the plants.[2]

The Director for Agriculture for the Bengal province wrote in a similar vein in 1928:

> Field operations and the sowing of seedbeds, for transplanted paddy were done under good conditions in May, but scanty rainfall in June retarded further progress. The rainfall in July and August was generally defective and transplanting operations were greatly hampered, notably in some West and North Bengal districts. Over consid-

[1] Report of the Indian Irrigation Commission, 1901-03
[2] Season and Crop Report of Bengal, 1903-04, pg 3

erable tracts in these districts the total rainfall was so deficient that transplanting never took place at all. The barren area would have been larger than it was had not favourable rain in early September facilitated further transplantation.[3]

The story was similar for cash crops as well, as the Director for Bombay writes about cotton: “The diminution was large and general in the Deccan and Karnatak districts except in Dharwar owing to the want of early sowing rains.”[4] However, even positive rainfall shocks could have impacts on agricultural production, as noted by the Director of Agriculture for Bombay in 1913 for a decline in millets: “Maize, juar and bajra all showed considerable decreases. The season, as pointed out above, was unfavourable for the sowing of these crops and continuous rain rendered the sowing of bajra, even on light lands to which this crop is mainly confined, very speculative.” [5]

The lack of sufficient rainfall could affect not only the growth of crops but also agricultural capital. A study of the economy of the time noted:

> The loss of agricultural capital [is huge] during the frequent periods of entire disorganisation due to the caprices of the season. Famines sweep away the meagre capital at the disposal of the Indian peasant. In times of famine thousands of cattle die or are sold for a few rupees a head. In 1918 the Bombay Presidency alone lost one million cattle or one-ninth of its whole stock. (Mukherjee, 1926, pg 27)

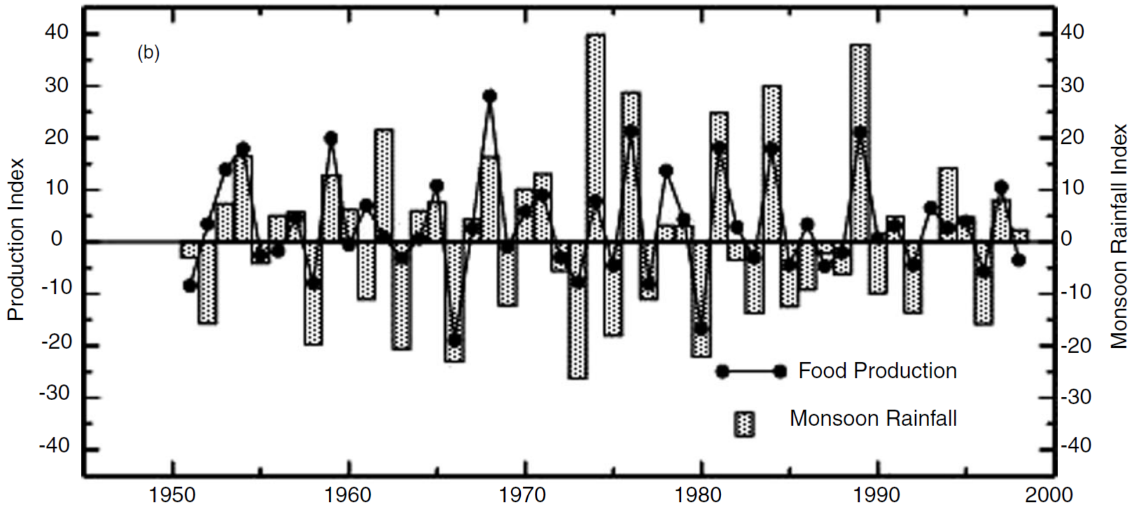
Shortfalls in rainfall also brought an increase in the incidence of disease, something noted by observers at the time. “I was an appalled witness of the dislocation of the social structure caused by a rainless year, and of the dreadful loss of human life from cholera and malaria.” (Gangulee, 1935, pg xxiv)

The quantitative evidence on the importance of rainfall in colonial India is equally convincing. In an India wide study looking at historical data, Ray (1971) found that annual variations in rainfall were sufficient to explain most of the fluctuations in agricultural output. The same study noted also the relative non-importance of factors such as temperature and of irrigation in affecting crop output in the Indian context. Other analyses set in colonial India have also found that rainfall had significant impacts on crop productivity and incomes (Donaldson, 2010; Burgess and Donaldson, 2010). The relationship between the monsoons and production was also systematically studied by Krishna Kumar et al. (2004) using post

[3] Season and Crop Report of Bengal, 1927-1928
[4] Season and Crop Report of Bombay, 1912-13, pg 4
[5] Season and Crop Report of Bombay, 1912-13, pg 5

independence data. The results of that study are reproduced in Figure 1.1, that shows both the consistent fluctuations in rainfall and their co-movement with agricultural output. In Section 5, we provide evidence from our original dataset that confirms such a relationship.

Figure 1.1: Food production and rainfall



Notes: Analysis by Krishna Kumar et al., 2004. The monsoon and food indices measure percentage deviations from the previous year's monsoon rainfall and food grain production respectively.

2.2.2 Education

The colonial education system set up in the 19th century almost completely replaced the indigenous system of schooling in British India. The colonial government was always reluctant to spend - government per capita expenditures on education were on average less than 0.01 pounds till 1912, lower than other developing countries at the time, and also lower than estimates from the princely states (Chaudhary, 2009). However, the first three decades of the 20th century did see considerable educational expansion. Overall enrollment rates increased from around 10% in 1902 to over 30% in 1932, while primary enrollment increased from 9% to almost 24% over the same period (Chaudhary, 2010a). This was mirrored by increased public expenditures on primary education - from 11 million rupees in 1897 to almost 70 million rupees in 1927 - although the bulk of public investment still went to secondary and higher education (Chaudhary, 2007). Literacy rates also increased, but not commensurately, from around 5% to 6.6% (Chaudhary, 2010a). There are three reasons a study of rainfall shocks and literacy in this context is particularly interesting.

Firstly, the Wood's Despatch in 1854 introduced a grant-in-aid system that made provisions for the government to partially support privately managed, tuition fee levying schools with public grants. Such aided schools formed the majority of primary schools across provinces. The most relevant result of this policy, for the purposes of the current study, is that this meant primary education was to a large extent decentralised, and the demand and supply of education across different regions was likely to be affected by local factors. More rainfall shocks are likely to have reduced demand for education, diverting resources away from school provision and also reducing enrollment in existing schools.

Secondly, while there were considerable differences in public spending across provinces in British India these differences have been shown to not be responsible for correspondingly large variations in educational outcomes. Instead, it was private spending that accounted for two-thirds of differences in total educational spending and a greater share of variation in enrollment and literacy (Chaudhary, 2010a). This suggests, again, that the private demand channel was an important one, and specifically the role of private investments to be key in the context of colonial India. Existing studies have shown that colonial public investments in education likely did have an impact despite being low (Chaudhary and Garg, 2015), but examining determinants of private investment in education is likely to be important.

Thirdly, one of the important issues in schooling in colonial times, which is remarked upon in almost every official report, was the issue of 'wastage' in primary education. This referred to the large drop in numbers in enrollment from the lower primary to the upper primary stages of education. Only about one-third of students would graduate from the first class to the second, and of those half or less would go on to finish class IV. Even colonial officials admitted that while the increases in enrollment were positive signs, a pupil who left before the primary stage of education was complete had little or no chance of becoming literate. This theme is repeated time and again in the Education Department reports. The Director for Education in Punjab writes in 1924,

> ...emphasis has been laid on the need to reduce stagnation, especially in the lowest class. In this matter it is the parent who requires to be educated, for in a large number of cases he has still to realize that the permanent advantage to his child of becoming literate is greater than his immediate economic value in tending cattle...That much remains to be done in this direction is, however, indicated by the fact that of the total number of pupils at the primary stage of instruction during the year under report about 55 per cent. were in the first class, and that of the pupils in this class in 1922-23 only about a third appear to have passed on to the second class last year.[6]

[6] Report on the Progress of Education in the Punjab, 1923-1924

Officials argued that four years of continuous schooling was necessary to acheive literacy. In this context, the role of agricultural shocks in disrupting education may have been an important part of the answer.

3 Data and Variables

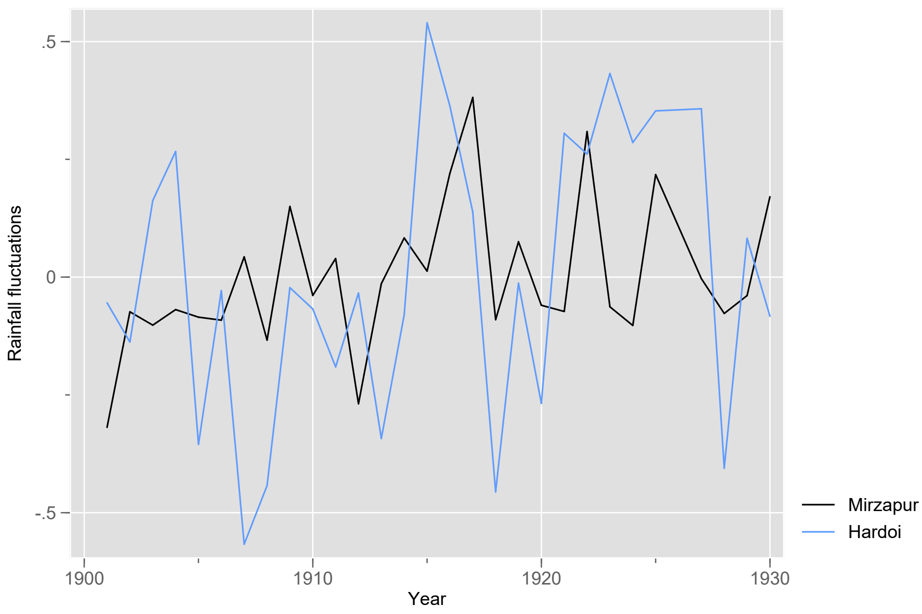
We use literacy as our outcome measure for two main reasons. Firstly, in the absence of income data, human capital is an important indicator of economic development. There is a established literature that finds human capital is an important determinant of long run economic growth, of technology adoption in agricultural settings, and of associated household level fertility decisions (Becker et al., 1990; Barro, 2001; Galor and Moav, 2004; Mittal and Kumar, 2000). Secondly, literacy is the most consistently available reliable indicator for human capital available from archival data from colonial India. Literacy figures in the colonial censuses post 1911 were constructed using a uniform test of literacy whereby individuals were recorded as literate if they could read and write a short letter to a friend (Chaudhary, 2010b). Our main specifications use 1931 literacy[7] as the dependent variable. Enrollment figures are consistently available only for a subset of provinces and tended to be overstated. However, we use these in a panel dataset for the Madras province, to provide evidence regarding the channels through which rainfall affects literacy.

We build an original dataset using under-explored data from the India Office Records collection housed in the British Library. We digitise annual rainfall data between 1901-1930 from the *Season and Crop Reports* series. These annual provincial reports aggregated station level data from the Meteorological department statistics to generate an accurate representation of rainfall at the district level. The annual rainfall is measured based on the year's agricultural season that runs from 1st June to 31st May, although the province of Punjab is an exception where the rainfall is measured for the season starting 1st March and ending 28th February. In the absence of digitised monsoon or month specific data, we prefer to use rainfall fluctuations over agricultural seasons to generate explanatory variables of interest.

Figure 1.2 plots the rainfall data for two districts in our sample - both districts were in the United Provinces and only a couple of hundred kilometres apart. They received rainfall from the same monsoons and both had the same quantity of average rainfall. However, from the figure it is clear that Hardoi received much more variable rainfall. Apart from the rainfall being more volatile, it is also apparent that Hardoi has much larger rainfall deficits in bad

[7]The 1931 census is used as the last complete colonial census - the 1941 census was disrupted by war.

Figure 1.2: Rainfall patterns: Hardoi and Mirzapur



Notes: Authors' calculations using rainfall data from the *Season and Crop Reports*. Data is plotted as deviations from average or normal rainfall.

seasons. In contrast, its favourable seasons are not always as good as the favourable seasons in Mirzapur. This suggests that the the negative and positive shocks need not be symmetric, or in other words, rainfall deficits may capture an important dimension in our data. Another reason negative shocks to rainfall might be a more precise measure is due to data limitations. A positive rainfall shock showing up in our data could reflect a favourable season but could also reflect excess rainfall at the wrong times, and without monthly or crop-specific data it is not possible to disentangle the two. On the other hand, a negative shock to rainfall is likely to always imply an inadequate monsoon.

While we use data for only approximately 30 years, we intend to capture long run rainfall patterns for a specific district. We begin by calculating the average rainfall variability in a district as the coefficient of variation or the relative standard deviation, calculated as the ratio of the standard deviation to the mean. This volatility measure captures the different risk profiles inherent in districts due to their differential exposure to the vagaries of the monsoons. We use this measure in our baseline models. This measure is plotted for the districts in our sample in Figure 1.3. It shows a concentration of high variability districts in the north west[8], but there is also variation within other provinces such as Bombay, Madras and Bengal.

[8]In the results section, we show our results are robust to the exclusion of these districts.

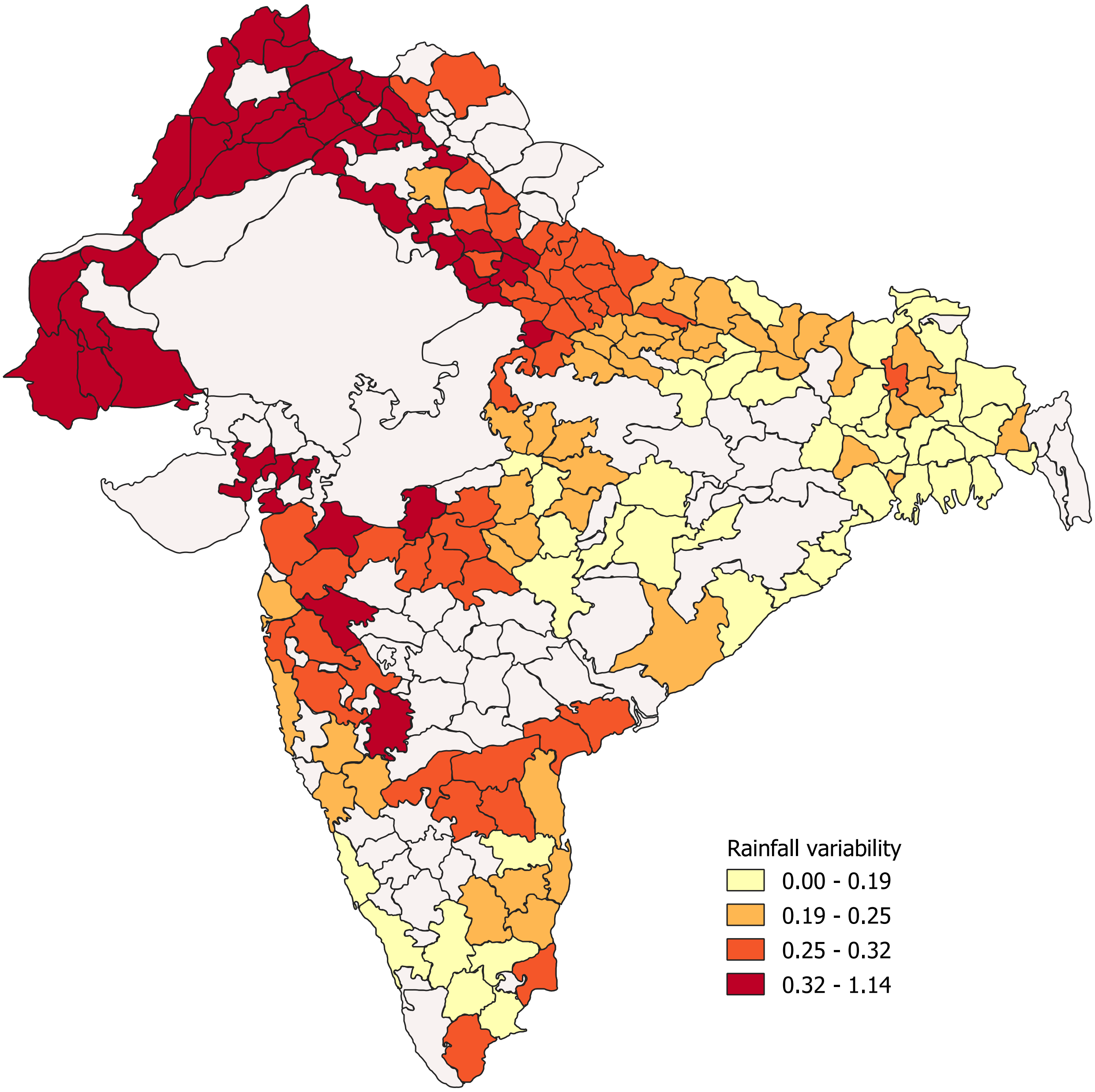
We also create additional measures of rainfall volatility. We have reason to believe that rainfall deficits could be a more precise measure and would capture a different dimension relating to downside risk in particular. Accordingly, we proceed to create variables for different segments of rainfall variability. We create a variable that measures the mean negative rainfall shock in a district over the 30 year period, where again the negative shock is defined as a deviation from the average or normal rainfall. In addition, we also create a variable that measures the number of 'dry' seasons experienced by the district in the 30 year period, as a complementary measure for downside risk. Finally, despite having conceptual and data related concerns with using annual positive rainfall shocks, we create two measures in parallel that capture the average positive rainfall shocks and the number of positive rainfall shocks experienced by a district.

Table 1.1: Summary statistics

	Mean	Std. Dev.
Literacy, 1931	6.55	3.20
Rainfall shocks	0.27	0.12
Occ Industry	0.04	0.02
Occ Professionals	0.01	0.00
Occ Trade	0.02	0.01
Prop Urban	0.11	0.08
Population density	0.66	0.44
Prop Muslim	0.25	0.27
Prop Brahmin	0.05	0.04
Prop Lower Caste	0.14	0.09
Prop Tribal	0.02	0.07
Prop Christian	0.01	0.02
Caste/Religious Fragmentation	0.75	0.19
Average rainfall	42.91	24.70
District board exp (pc)	0.06	0.04
Non-landlord proportion	0.49	0.42
Sample size	185	

In the construction of the rest of our dataset, we largely follow Chaudhary (2010b). We control for the occupational structure of different districts by controlling for the proportion of people employed in commerce, industry and services. We also control for population density and proportion of urban people by district to capture important differences in development across regions. Further, to control for differences in demand for education we also control for a number of social and religious characteristics: the proportion of Brahmins (the traditional higher caste priests who were more likely to be involved in teaching), the proportion of lower castes, tribal populations, Christians and Muslims. In addition, we include a caste and religious fragmentation index that has been shown to have an influence on the number of primary schools available (Chaudhary, 2009).

Figure 1.3: Rainfall variability in colonial India



Notes: Authors' calculations using rainfall data from the *Season and Crop Reports*. Data for each district is plotted as the mean deviation from average or normal rainfall over a 30 year period between 1901 and 1930. For presentation, the data is split into four quartiles.

Public spending on education took place via district boards that received resources from the provincial government and also from land cesses that were charged as a fraction of land revenue. We use two different variables to account for this. The first is the per capita district board expenditure on education in 1911 which is a relatively precise measure of public spending on education.[9] By controlling for these historical expenditures we capture the variation caused by differences in land revenue and income across districts. This variable also captures the impacts of differential public investments, thereby focussing our strategy more on clarifying the role of private investment. For robustness, we also run all our specifications with district per capita land revenues from 1931.

Finally, we also construct the standard geographical variables considered in the literature. Different soils types affected the type of agriculture which is likely to then have responded differently to risk in rainfall. We use the FAO classification to create a series of dummies for soil type to capture this variation. This is based on national soil surveys, reconnaissance surveys and interpolation based on climactic and geological data. The advantage of this map is that it follows a common nomenclature across national boundaries. We are thus able to create a range of soil variables that correspond to our dataset. To further test that it is not differences in quality of soil that are key, we create two principle components using data from the World Harmonized Soil Database that rate the quality of soil based on different criteria that influence plant growth. These include nutrient ability, nutrient retention capacity, rooting conditions and oxygen availability. We also create a dummy for coastal districts to capture different economic characteristics associated with coastal districts. Finally, in line with existing literature, we create variables for the 'normal' rainfall across districts measured as the long run average so that we can better disentangle the direct effects of variation in quantity of rainfall.

While time series data is scarce, we are able to build a small original panel dataset with primary school enrollment numbers, cropped area estimates and rainfall data for the Madras province. The enrollment data is taken from the *Report on Public Instruction* series, the rainfall data from the *Season and Crop Reports* and the cropped area estimates are digitised from the *Agricultural Statistics of India* series. Cropped area estimates are preferred as they are more reliable compared to outturn estimates. Outturn estimates provided in the *Season and Crop Reports* were produced using an estimated average yield for a crop and a seasonal factor based on the quality of the season. For a random sample of years across provinces

[9] We are grateful for Latika Chaudhary for sharing this and the caste and religious fragmentation index with us.

and major crops, we find a very high correlation (generally>.9) between the acreage and the estimated out-turn for a crop in a given year, making us believe using cropped area as a proxy for agricultural output is fair.

4 Model

The major aim of this chapter is to show that geography, which has so far been largely confined to the background of analyses in Indian history, influenced the progress of literacy through a specific, important channel, i.e. rainfall shocks and volatility. Some areas of the country had conditions that allowed for the practice of settled agriculture with very little year to year fluctuations, while other areas were reliant on marginal lands and timely rainfall.

The investigation will proceed in two major steps. First, we run a series of cross section OLS regressions with the literacy rate in 1931 as our dependent variable. We estimate variations of the following model:

$$Literacy_{ip} = \beta_0 + \beta_1 RainfallPattern_{ip} + \mathbf{X}\beta_{2ip} + \alpha_p + e_{ip} \qquad (1)$$

where our dependent variable of literacy measures the proportion of population in district i of province p, that could read and write based on the census data. Our main explanatory variables of interest capture patterns of rainfall volatility in different ways. We expect our measures to capture both, the effect of risk smoothing behaviour with the expectation of shocks and uncertainty as well as the influence of shocks i.e. both *ex-ante* and *ex-post* mechanisms. We use the coefficient of variation, which is defined as the standard deviation divided by the mean, as our measure of rainfall variability[10]. However, we also report results for the same model with different measures of rainfall volatility. In these OLS models, we control for a vector of variables **X** that includes the occupational, geographical, and structural variables described in the previous section.

In the second step of our analysis, we narrow our focus to identifying the channels through which rainfall may affect literacy. Specifically, we use a panel model for 23 districts of the Madras presidency where we have information on cropped area and rainfall for the period between 1909 and 1931. We then test to see whether current and lagged rainfall shocks have

[10]This is widely used as a measure of rainfall variability, risk and uncertainty across studies in the fields of meteorology and economics - see for eg. Shrestha (2000); Davis (2016); Skoufias et al. (2017); Antonio et al. (2018); Bellemare (2015); Menon (2009).

an impact on cropped area in line with the qualitative evidence discussed in Section 2.

$$Croppedarea_{it} = \beta_0 + \beta_1 RainShock_{it} + \alpha_i + \gamma_t + e_{it} \qquad (2)$$

We estimate Equation 2 including fixed effects for districts to capture time invariant characteristics and then also year fixed effects to capture trends over time. Finally, we further extend our panel data analysis to test whether changes in enrollment rates are associated with current or lagged changes in cropped area. The estimated model is presented in Equation 3.

$$Enrollment_{it} = \beta_0 + \beta_1 PositiveAgriShock_{it} + \beta_2 NegativeAgriShock_{it} + \alpha_i + \gamma_t + e_{it} \qquad (3)$$

5 Results and Discussion

Table 1.2 reports the results for the 1931 cross section. Literacy rate in 1931 is the dependent variable in all specifications. Since there was considerable variation across provinces who also had a great deal of policy power, we include a set of province fixed effects to account for province specific characteristics. In our preferred baseline specification (Column 1) we include the full set of controls described in Section 3, along with our measure of rainfall variability. Rainfall variability seems to have a negative and significant association with literacy. The coefficient implies that a 10% increase in the magnitude of rainfall shocks is associated with a 0.5 percentage points decrease in literacy. This is a sizeable impact given the mean literacy in our sample is only 6.5% and demonstrates that rainfall patterns are likely to have been an important determinant of development in colonial India. The specification in Column 1 of Table 1.2 is comparable to the model used by Chaudhary (2010b) with the addition of rainfall variability, although we also use 1931 literacy instead of 1921. The educational expenditure variable is still significant with a similar magnitude, but rainfall shocks seem to have an independent effect on literacy. We prefer to use district board educational expenditures in 1911 as a control for different income levels and of different public expenditures on education. However, to provide further reassurance, in Column 2, we use per capita land revenues in 1931 instead of board expenditures. The estimated effect of rainfall shocks remains identical in magnitude and significance.

Given the literature on the role of institutions in long run development, we next turn our attention to the variation in land tenure institutions. In the Banerjee and Iyer (2005) story, land revenue institutions had an impact on long run productivity and public good provision due to greater conflict between the elites and the masses in areas where colonial property rights were assigned to large landlords. In our study, controlling for different provincial characteristics by including province fixed effects already accounts for the majority of the variation in land tenure type, and including educational expenditure or per capita revenues is likely to be sufficient to control for direct implication of different resources available to the boards due to different land revenue systems. Nevertheless, in column 3, we include the key variable measuring the proportion of the district that was not under landlords from Banerjee and Iyer (2005)[11] which leaves our variable of interest intact despite the reduced sample size. We perform another simple test to rule out the role for institutions. The institutions literature argues that the fundamental differences were between the areas where landlords held property rights and the areas where property rights were held by individual cultivators. The vast majority of the landlord districts were in Eastern India in the provinces of Bengal, Bihar and Orissa. In Column 4, we estimate our model completely excluding these landlord areas. The continuing effect of rainfall shocks confirms that the result is driven by the geographical variation, and not by differences between different colonial land tenures. Finally, we perform an additional robustness check. As seen in Figure 1.3, there is a concentration of high variability districts in certain parts of the subcontinent, particularly in the north west. To test that our results aren't driven by the extreme volatility districts, we exclude the districts in the top 10th percentile and report the results in Column 5.

So far the rainfall measure used is the average volatility in rainfall between 1901 and 1930. We chose this to capture risk and volatility in rainfall. However, there are other valid ways to construct this measure. We turn to some of these in Table 1.3. First, we construct a variable that measures the mean value of negative deviations from normal rainfall in districts across the first three decades of the 20th century. With this alternative variable, the overall result is very similar. A 10% increase in downside risk related to rainfall is associated with around a 0.6 percentage points decrease in district level literacy (Column 2, Table 1.3). This indication finds further support when we isolate downside risk by creating a variable that measures the *number* of negative rainfall shocks experienced by a district over the 30 year period. We define a district as experiencing a negative shock if the annual rainfall is a 20% deviation from the normal rainfall for the district. This was the accepted definition of a dry season as per reports of the time (Government of India, 1905). The estimated coefficient (Column 3, Table 1.3) indicates a significant impact with similar magnitudes. A district that experiences three

[11] Apart from merging present day Indian districts, we also code all districts in present day Bangladesh as landlord districts to get a larger sample.

Table 1.2: Literacy and rainfall shocks in colonial India

	(1)	(2)	(3)	(4)	(5)
Rainfall variability	-5.402***	-6.055***	-4.506***	-4.842**	-7.197*
	(1.394)	(1.605)	(1.692)	(2.295)	(3.993)
Education expenditure (pc)	30.788***		33.637***	31.848***	34.198***
	(7.587)		(7.730)	(7.356)	(6.908)
Land Revenue (pc)		1.033***			
		(0.316)			
Prop Non-Landlord			-0.092		
			(0.537)		
Observations	177	180	141	154	159
R^2	0.78	0.76	0.78	0.71	0.80
Controls					
Province FE	Yes	Yes	Yes	Yes	Yes
Occupational Controls	Yes	Yes	Yes	Yes	Yes
Social controls	Yes	Yes	Yes	Yes	Yes
Geographical Controls	Yes	Yes	Yes	Yes	Yes

Notes: Robust standard errors in parantheses. *, ** and *** denote significance at 10, 5 and 1 per cent respectively. The dependent variable is the literacy rate in 1931. Rainfall shocks is an average measure of negative rainfall shocks over the period 1901-1930 from the annual *Season and Crop Reports*. Educational expenditure measures district level board expenditures on education in 1911. Per capita land revenues are calculated using revenue data from the *Agricultural Statistics of India* series from 1931. All specifications control for province fixed effects. Occupational controls include the proportion of people employed in trade, industry and in professional services, and the population density. Social controls include the proportion of Brahmins, lower castes, Muslims, Christians, tribes, and urban population. Geographical controls includes average rainfall, a dummy for coastal districts and controls for the major soil type.

Table 1.3: Other shock measures

	(1)	(2)	(3)	(4)	(5)
Rainfall variability	-5.402***				
	(1.394)				
Rainfall shocks (mean)		-5.871**			
		(2.901)			
Rainfall shocks (number)			-0.214***		
			(0.079)		
Rainfall shocks (mean, +tive)				-0.271	
				(0.209)	
Rainfall shocks (number, +tive)					-0.055
					(0.081)
Observations	177	176	177	176	176
R^2	0.78	0.77	0.78	0.77	0.76
Controls					
Province FE	Yes	Yes	Yes	Yes	Yes
Occupational Controls	Yes	Yes	Yes	Yes	Yes
Social controls	Yes	Yes	Yes	Yes	Yes
Geographical Controls	Yes	Yes	Yes	Yes	Yes

Notes: Robust standard errors in parantheses. *, ** and *** denote significance at 10, 5 and 1 per cent respectively. The dependent variable is the literacy rate in 1931. Rainfall shocks is a average measure of negative rainfall shocks over the period 1901-1930 from the annual *Season and Crop Reports*. The rest of the controls are the same as those in Table 2, column 1. All specifications control for province fixed effects. Occupational controls include the proportion of people employed in trade, industry and in professional services, and the population density. Social controls include the proportion of Brahmins, lower castes, Muslims, Christians, tribes, and urban population. Geographical controls includes average rainfall, a dummy for coastal districts and controls for the major soil type.

additional dry seasons (which equates to a one standard deviation increase) is associated with around 0.6 percentage points lower literacy. The estimated impact and significance is very stable across these models.

In Columns 4 and 5 of Table 1.3, we create parallel rainfall shock measures for the average upward rainfall volatility and the number of positive rainfall shocks over the 30 year period in our sample. Both coefficients are negative but do not come close to being statistically significant. This suggests that it is the downside risk associated with rainfall that affects literacy, not the upward volatility. There are studies that have shown that positive rainfall shocks do have a positive effect on agricultural productivity and agricultural incomes, but these can be lower in magnitude than the effect of negative rainfall shocks in a developing country context (Amare et al., 2018; Damania et al., 2017). This effect is likely to have been strong in the colonial India due to the widespread prevalence of subsistence agriculture following a low risk, low reward strategy which would be less responsive to positive shocks. One other important factor to consider is that the substitution effect may be stronger in the case of positive shocks. With a market for child labour, favourable weather conditions could lead to children dropping out of school earlier, and there is evidence for long run impacts of this in developing countries (Shah and Steinberg, 2017; Carrillo, 2019). The Education Department reports did often mention the outside option for children to be employed in the field or in tending cattle (as seen in Section 2) so such an effect could have been reasonably important in colonial India. Finally, as mentioned in Section 3, the aggregated nature of the rainfall data in our study could be doing a relatively poor job of disentangling favourable seasons from seasons with plentiful but untimely rainfall.

One of the important debates regarding colonial India concerns the implications of the commercialisation of agriculture which increased rapidly in the 2nd half of the 19th century with the expansion of railways and other transport infrastructure. To measure commercial agriculture in our data we use the proportion of area in a district that was used to grow non-food crops. This is not as precise as we would like as in some regions wheat and rice was also grown commercially, but we believe it is a fair measure of the relative levels of commercialisation in different regions. When we interact this new measure with our rainfall shocks variable in our baseline specification, the results indicate that the negative effect of downside risk is felt by districts that are least commercialised, with districts in the 4th quartile actually being completely immune to rainfall shocks (Table 1.4). These results should be treated as suggestive, but do support the idea that on average commercialised wasn't 'forced' leading to increased vulnerability, but rather was pursued in areas where infrastructural and technological innovations made conditions favourable to do so. On the other hand, areas with less potential for commercial agriculture were the same places that bore the brunt of risk associated with volatile rainfall.

Table 1.4: Heterogeneity analysis: commercial agriculture

	(1)
Rainfall variability	-7.334***
	(2.555)
Commercial Agriculture (quartiles)=2 × Rainfall variability	2.228
	(2.499)
Commercial Agriculture (quartiles)=3 × Rainfall variability	3.729
	(2.383)
Commercial Agriculture (quartiles)=4 × Rainfall variability	9.931***
	(3.497)
Observations	177
R^2	0.80
Controls	
Province FE	Yes
Occupational Controls	Yes
Social controls	Yes
Geographical Controls	Yes

Notes: Robust standard errors in parantheses. *, ** and *** denote significance at 10, 5 and 1 per cent respectively. The dependent variable is the literacy rate in 1931. This specifications includes four quartiles, based on the proportion of non-food crops, included as control variables along with their interaction with our baseline measure of average rainfall variability.

Next, we present an analysis concentrated on identifying the mechanisms. The existing literature states long run effects of rainfall on human capital are often felt due to an income effect. Lower agricultural income is likely to reduce investment in children at crucial stages in their lives. In the Indian context, the qualitative evidence indicates rainfall was, in large parts of the country, the biggest determinant of agricultural income. We identify this mechanism using a panel dataset on the Madras province with data on cropped area and rainfall shocks (as specified in equation 2). The results of this model are shown in Table 1.5.

Controlling for district and year fixed effects, contemporaneous rainfall is, as expected, a significant determinant of fluctuations in annual cropped area. In column 1, there is a strong positive correlation between annual rainfall fluctuations and annual changes in cropped area, while the lagged rainfall fluctuations have no effect. In column 2, we analyse negative and positive shocks separately where there is defined to be a rainfall shock in a particular year is the rainfall if below the 20th or above the 80th percentile of a district's rainfall distribution. The estimates indicate that a negative shock reduces the year's cropped area by around 5% after accounting for district specific characteristics and trends over time. Based on the average

Table 1.5: Panel model, rainfall and agricultural volatility

	(1)	(2)	(3)
Rainfall variation	0.100***		
	(0.024)		
Rainfall variation (t-1)	0.002		
	(0.024)		
-tive rainfall shock		-0.054***	
		(0.012)	
+tive rainfall shock		0.011	
		(0.011)	
-tive rainfall deviation			-0.258***
			(0.050)
+tive rainfall deviation			-0.010
			(0.039)
Observations	527	527	527
Controls			
District FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes

Notes: Robust standard errors in parantheses. *, ** and *** denote significance at 10, 5 and 1 per cent respectively. The dependent variable is the annual fluctuation in total cropped area in district i in year t. Explanatory variables include different measures for annual rainfall fluctuations. District and year fixed effects are included.

Table 1.6: Panel model, Madras primary enrollment

	(1)	(2)
+tive agri shock	-0.040	-0.069
	(0.151)	(0.131)
+tive agri shock (t-1)		0.106
		(0.085)
-tive agri shock	0.082	0.121
	(0.095)	(0.109)
-tive agri shock (t-1)		-0.121*
		(0.063)
Observations	501	500
Controls		
District FE	Yes	Yes
Year FE	Yes	Yes

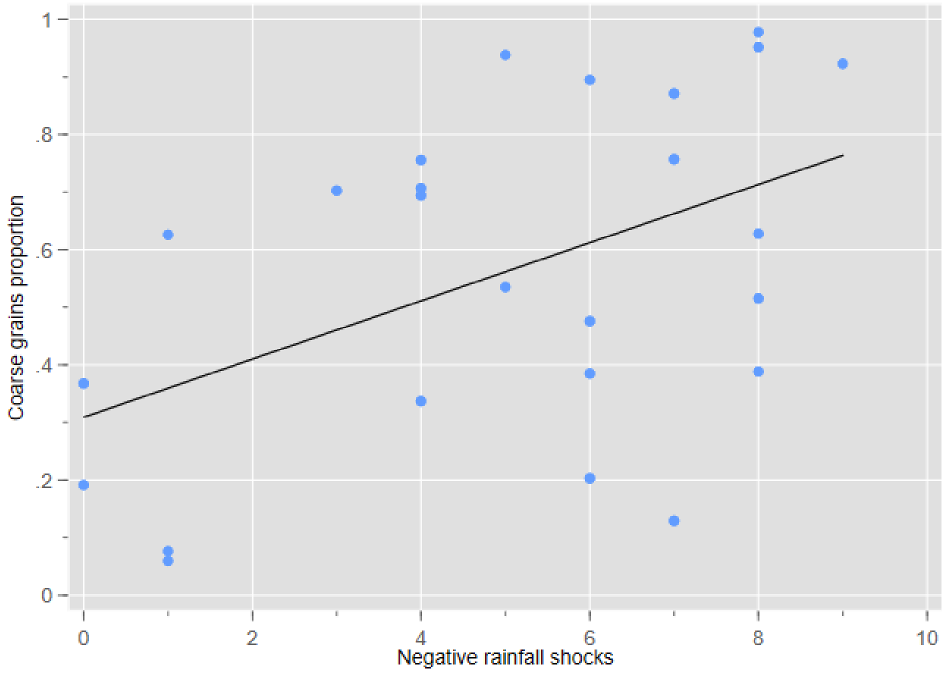
Notes: Robust standard errors in parantheses. *, ** and *** denote significance at 10, 5 and 1 per cent respectively. The dependent variable is the growth rate of primary school enrollment in district i in year t. Explanatory variables include a measure for negative and positive agricultural shocks (calculated based on cropped area) in year t,t-1 and t-2. District and year fixed effects are included.

cropped area in this region during this period, this amounts to over 75,000 acres of land that is left fallow in such a year. It is important to remember that this result reflects only a small proportion of the lost income as rainfall deficits are also likely to have substantially reduced plant growth and output, while also leading to substitution of higher productivity crops with lower productivity ones. In contrast, positive rainfall shocks do not seem to be systematically associated with fluctuations in cropped area. This suggests rainfall had asymmetric effects on cropped area in colonial India, and confirms again that downside risk was a key contributor to the risk associated with agriculture. Column 3 repeats the exercise with absolute values of negative and positive deviations from normal rainfall with results of similar significance and magnitude.

In the next step, we try to estimate whether these fluctuations in cropped area and agricultural output had an effect on fluctuations in primary school enrollment (equation 3). Primary school enrollment increased from 10% of the school age population in 1891 to 35% in 1941 (Chaudhary, 2012). These increases were largely driven on the extensive margin: increases in numbers of schools led to increasing primary enrollment but report after report emphasised that proportionate increases were largely felt only in the lower classes. This problem of 'wastage' concerned colonial officials, something we discussed in Section 2. Results in Table 1.6 provide tentative evidence for an effect of lagged negative agricultural shocks. In particular, they suggest that a bad agricultural season led to a reduction (or a slow down) in primary school enrollment with a lag. Enrollment was measured on 31st March which was the end of the academic year but this statistics recorded those on the rolls, not attendance. Due to this fact, only the previous year's rainfall could theoretically have an impact on enrollment. We confirm this in Column 1 where contemporaneous shocks show no significant relationship with enrollment, as expected. What the results do suggest is that negative agricultural shocks have an adverse impact on growth in enrollment in the next year. There are two possible interpretations to this. Firstly, a bad season could lead to a depletion of household assets which would have an impact on parental investments in education. This could be the reason why students dropped out earlier in some districts, before they achieved literacy. Secondly, this could be a mechanical impact of a bad season reducing land revenues and the availability of funds and thereby slowing down the construction or opening of new schools. Due to data limitations, we are not able to investigate this further, however these results do reassert the role played by negative rainfall and agricultural shocks by showing that they had an impact on another educational outcome during that time.

Finally, we investigate whether there is any evidence for ex-ante coping strategies. Districts in the colonial province of Madras were split between districts that grew cheaper, coarse grains such as ragi, cholum or cumbu and districts that had suitable conditions to grow rice. Of course, the quantity of rainfall and the market conditions were important determinants of this, but we perform a simple test for whether such a risk adverse strategy also fits with *ex-ante* coping mechanisms to deal with risk and uncertainty. In Figure 1.4, we plot the average area devoted to coarse grains as a proportion of the total area set aside for foodgrain production for every district in the Madras province against the number of serious negative

Figure 1.4: Coarse grains and rainfall shocks



Notes: Authors' own calculations using data from the *Agricultural Statistics of India* and the *Season and Crop Reports*. The graph shows the positive relationship between the number of significant negative rainfall shocks over our 30 year sample and the proportion of food cropped area that is devoted to the production of coarse grains such as cholum, ragi and cumbu.

(greater than 20% from average) rainfall shocks experienced by the district. There is a strong positive correlation which could suggest that districts that were more vulnerable to weather shocks were forced to stick to cultivating low productivity foodgrains in a low risk, low reward strategy. If this is the case, the associated costs could have been substantial. However, the very small sample size available does not allow us to perform more powerful statistical tests required so these results should be interpreted with caution.

6 Conclusion

This chapter set out with the aim of substantiating a greater influence of geographical factors in the long run development of India. Using an original dataset on district level rainfall patterns and an original panel dataset for the Madras province, the results showed significant impacts of negative rainfall shocks on district level colonial era literacy. The impact of adverse weather shocks on agricultural income is shown to have been an important channel. Despite the reliance of Indian farmers to this date on monsoon rains, this has nonetheless not featured prominently in debates on Indian long run development so far.

Literacy rates in India rose from less than 20% prior to independence to over 70% according to the 2011 census. This rise in literacy has been impressive and has been carried out on the back of a series of mass literacy programmes at both the central and the state level. While compulsory primary schooling was not introduced till 2009, starting with the National Policy on Education in 1968, there was a greater focus on the universal provision of rural schools. Despite this, India's literacy has lagged behind countries such as China, and also displays comparatively higher regional, rural-urban and gender based disparities (Dreze and Loh, 1995). The results in this chapter suggest there is merit in looking at geographical and historical factors to understand regional patterns that lie beneath India's failures in basic education.

There are several useful extensions of this research that can be made. Our results on the resistance of commercialised districts to the impacts of rainfall variability suggest that an analysis of how irrigation facilities were built and how they interacted with rainfall risk would have definite utility. A more disaggregated dataset on rainfall and cropped area would permit a better understanding of the vulnerability of different regions to rainfall variability, and potentially also clarify some of the mechanisms further. Finally, it would also be interesting to analyse other developmental outcomes, such as health, and see how they fit in this milieu.

Chapter 2

Persistent Impacts of Colonial Land Tenure Systems: Evidence on Development in Rural India

This chapter uses a geographical Regression Discontinuity Design (RDD) on a new village level data set from colonial India to estimate the causal impact of land revenue institutions on long run rural development. An early 19th century historical quirk meant that villages in close geographical proximity were assigned to different property rights systems - some falling under landlords and others under the government. Villages that were assigned to landlords in the colonial era are shown to have lower literacy and irrigation at the turn of the 21st century. Historical evidence on legal confusion, higher revenues and greater conflict in landlord villages is highlighted, and it is argued that migration, public good provision and the differential impact of the railways are some of the channels for the observed persistence.

***

1 Introduction

The effect of institutions, particularly those originating in colonial periods, has been the subject of much debate. Studies on the topic broadly agree that such historical institutions can have long run impacts - both across and within countries - on current levels of income as well as developmental indicators such as literacy (Acemoglu et al., 2001; Gallego, 2010; Engerman and Sokoloff, 2012). However, concerns persist about the measurement of institutions in this field of research. The big geographical scope of most of these studies amplifies the problem whereby institutional labels disguise a large variety of institutional configurations and their interdependencies (Ogilvie and Carus, 2014).

This research focusses on a single district in the state of Andhra Pradesh in India, where villages were assigned to different land tenure systems at the beginning of the 19th century. This happened due to an exogenous quirk around a historical boundary: villages on the western side of this boundary were handed over to a pre-existing landlord for revenue administration as per colonial policy in 1801, thus becoming *zamindari* or 'landlord' villages, but the administrator on the eastern side went against official policy to settle villages under his control directly with cultivators, thus creating *raiyatwari* or 'government' villages. This historical accident had dramatic consequences: landlord villages had higher revenue extraction, greater legal confusion and higher conflict and inequality compared to government villages. This chapter argues that this exogenous assignment of villages to different land tenure systems had significant and persistent impacts, with landlord villages remaining worse off into the 21st century.

To provide empirical evidence, this chapter builds a new dataset that links colonial era village level records to a geo-referenced 2001 census. Using this unique data and a geographical regression discontinuity design (GRD), the long run impact of historical land tenure institutions on long run rural development is estimated. Villages that were historically on the landlord side of the boundary are shown to have substantially lower literacy, irrigation and public good provision in 2001 compared to villages that were on the government side. Additionally, the impact of the railways expansion in the late 19th century is also analysed.[1] The current study finds that access to the railways benefited government villages only, and as such, it is likely to have contributed to further divergence between the two sets of villages.

[1] There have been concerns about the impact of railways construction in colonial India on the spread of disease and the environment, but recent work has suggested potentially positive impacts on market integration, agricultural productivity and famine relief (Kerr, 1995; Donaldson, 2010; Burgess and Donaldson, 2010). Research on Africa has indicated that historical investments in transport infrastructure are likely to have substantial impacts on the intensity and distribution of economic activity, with later investments showing diminishing returns (Jedwab and Moradi, 2016).

This study makes some important contributions to the existing literature. The first of these is that, by taking the village as a unit of observation, it is able to address criticisms regarding the definitions of institutions. In the Indian context, Banerjee and Iyer (2005) show that districts that fell under a landlord-based revenue system had lower agricultural productivity and public goods provision in post-Independence India. However, there has been a debate on their classification of districts as ‘landlord’ or ‘non-landlord’, with some implications for their results (Iversen et al., 2013; Banerjee and Iyer, 2013). It is very likely that institutional labels did not represent identical land tenure arrangements across the Indian subcontinent and in fact substantial differences in agrarian structure could exist within a given type of land revenue system (Roy, 2014; Verghese, 2018). This study is able to more clearly identify different institutions by focussing on villages in a small geographical area in the colonial province of Madras. The second contribution this study makes is methodological. The most popular way to overcome the endogeneity of institutions in the literature has been the Instrumental Variables (IV) approach, often by using the quasi-random assignment of institutions based on historical or geographical conditions in the past. Such approaches leave themselves open to critiques as it is not possible to rule out other channels through which historical or geographical conditions could affect current economic performance. This chapter follows an alternative method - a Regression Discontinuity design - to estimate the impact of historical land tenure assignment in colonial India on present day development at the village level. Finally, the creation of a village level dataset allows this study to provide insights on rural development in particular.

The rest of this chapter is structured as follows. Section 2 briefly summarises the historical circumstances leading up to the establishment of different land tenure systems, and discusses how this led to divergent developmental paths. Section 3 explains the data and empirical strategy. Section 4 discusses the results and Section 5 concludes.

2 Historical background

The purpose of this section is two-fold. Firstly, to lay out how the circumstances around late 18th and early 19th century leading up to the ‘historical accident’ because of which similar villages within a few kilometres of each other were assigned to completely different land tenure systems. Secondly, to summarise the historical evidence regarding the consequences of this institutional divergence.

2.1 The makings of a historical accident

Surveying their spoils after the tumultuous 18th century, the British had to decide the best way to manage land revenue arrangements in the newly extended Madras province. In 1793, the Permanent Settlement had been introduced in the province of Bengal. This meant that big landlords or local chiefs were stripped of their military and judicial powers but were given permanent property rights in their estates. Such landlords (or *zamindars*) could administer the villages in these estates as they saw fit, and any revenue over and above what was due to the government could be retained by them. The rationale for this system was that it would lead to assured revenue, incentivise landlords to invest and increase productivity in the long run, and respect pre-existing agrarian relations. The official position of the Board of Directors was that the Bengal Permanent Settlement or *zamindari* system should be extended into the territories acquired in Madras in the late 18th and early 19th century.

This official position did not gain acceptance among all the administrators in the Madras province. The most important figure in this opposition was Thomas Munro, a military man turned administrator who had been experimenting with a different type of revenue administration. Around the same time as the Permanent Settlement was being rolled out in Bengal, Munro was articulating the need to get rid of not just pre-existing big landlords but also smaller landlords who controlled only a few villages. The revenue system proposed by Munro was one where every peasant (or *ryot*) had a direct contract with the government. Instead of giving over estates in perpetuity to pre-exisiting landlords, Munro was advocating a system where individual cultivators paid rent to the government based on an annual settlement. Ironically, the arguments made for this cultivator based system - incentives for productivity, concern for small peasants, and reference to pre-existing structures - were very similar to those made for the landlord based one.[2]

These conflicting policies came to a head at the turn of the 19th century. The lands comprising the districts of Cuddapah and Nellore were acquired from Mughal governors almost simultanouesly, Cuddapah in 1800 and Nellore in 1801. Both districts were populated by small kings (known as *poligars*) who had legal and revenue authority in villages under their control. The Madras government was instructed by the Governor-General in 1799 to extend the Bengal system across *poligar* territories.[3] Mr. Travers was the Collector of Nellore in 1801 and he dutifully oversaw the implementatation of this policy. By 1802, the major *poligars* in Nellore,

[2] Such arguments were made possible partly because pre-colonial land revenue arrangements varied significantly across the country, and proponents could pick and choose examples that provided legitimacy to their preferred system.

[3] *The Fifth Report, v. 3, pg 336* as cited in Stein (1989)

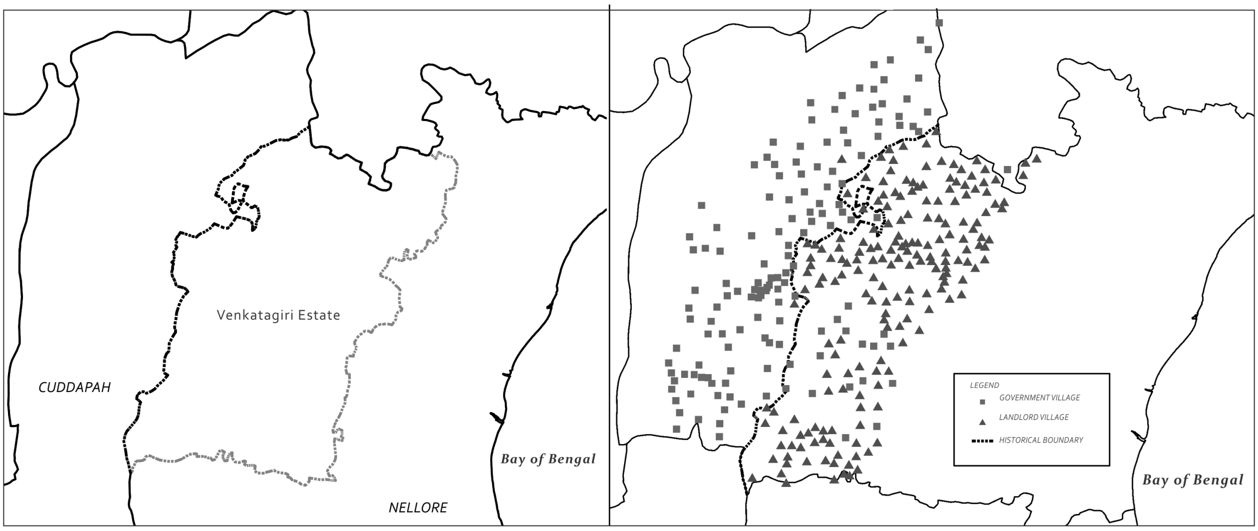
including the King of Venkatagiri (the area bordering Cuddapah), were by decree of the Madras governor relieved of their military obligations and effectively transformed from kings to landlords.[4] They were left to administer the villages under their control as long as they paid an annual rent fixed in perpetuity. The *zamindari* system had successfully been exported from Bengal into Madras. The official policy was the same a few kilometres across the border in Cuddapah, but the Collector appointed to implement this was Thomas Munro.

Munro arrived in Cuddapah off the back of a successful stint further west in the province, with a burgeoning authority and reputation, and friends in high places. He believed in the alternate revenue system he had devised and successfully experimented with but he didn't want to be seen to be disobeying direct orders. The solution he devised was ingenious, if somewhat cruel to the *poligars*, some of whom he admitted himself had proof of authority going back centuries. Munro raised the revenue demanded of the *poligars* to the theoretical maximum based on previous records. When a *poligar* invariably failed to pay he was ordered to present himself in Munro's court - in itself an insult to these kings. The absconding kings were then efficiently hunted down and pensioned off. At the start of this process Munro stated, "I am convinced that it is possible to expel them all and to hang the great part of them."[5] He was true to his word. By the time he left Cuddapah for Britain in 1807, "there was not a single... unpensioned, unimprisoned, or unhanged Poligar in the district".[6] Instead of landlords, Munro assigned property rights to over 200,000 cultivators during his stint. This was a huge success in terms of the revenue collected, which helped subside initial anger towards Munro, and laid the foundation for the *raiyatwari* system to be extended further in the future.

This combination of historical and political circumstances meant that villages within a few kilometres of one another were assigned to completely different land revenue arrangements (Figure 2.1). Villages under the landlord based *zamindari* system became 'landlord' villages and those under the cultivator based *raiyatwari* system became 'government' villages. These villages were otherwise very similar. It is hard to find historical records at this level of disaggregation but there is some evidence from the *Imperial Gazetteer of India*[7] published in 1908 and 1909 that the geographical conditions on both sides of this historical boundary were almost identical. The gazetteer reports rocky hills, red and gravelly soil, small and seasonal rivers, and around 25 inches of rainfall annually in the vicinity of the border. Villages

[4] *Manual of the Nellore District in the Presidency of Madras, 1873*
[5] Wellesley papers as cited in (Stein, 1989, pg 88)
[6] *Manual of the Cuddapah District in the Presidency of Madras, 1873, pg 136*
[7] Available in digital form at https://dsal.uchicago.edu/reference/gazetteer/

Figure 2.1: Historical boundaries and land tenures around the discontinuity



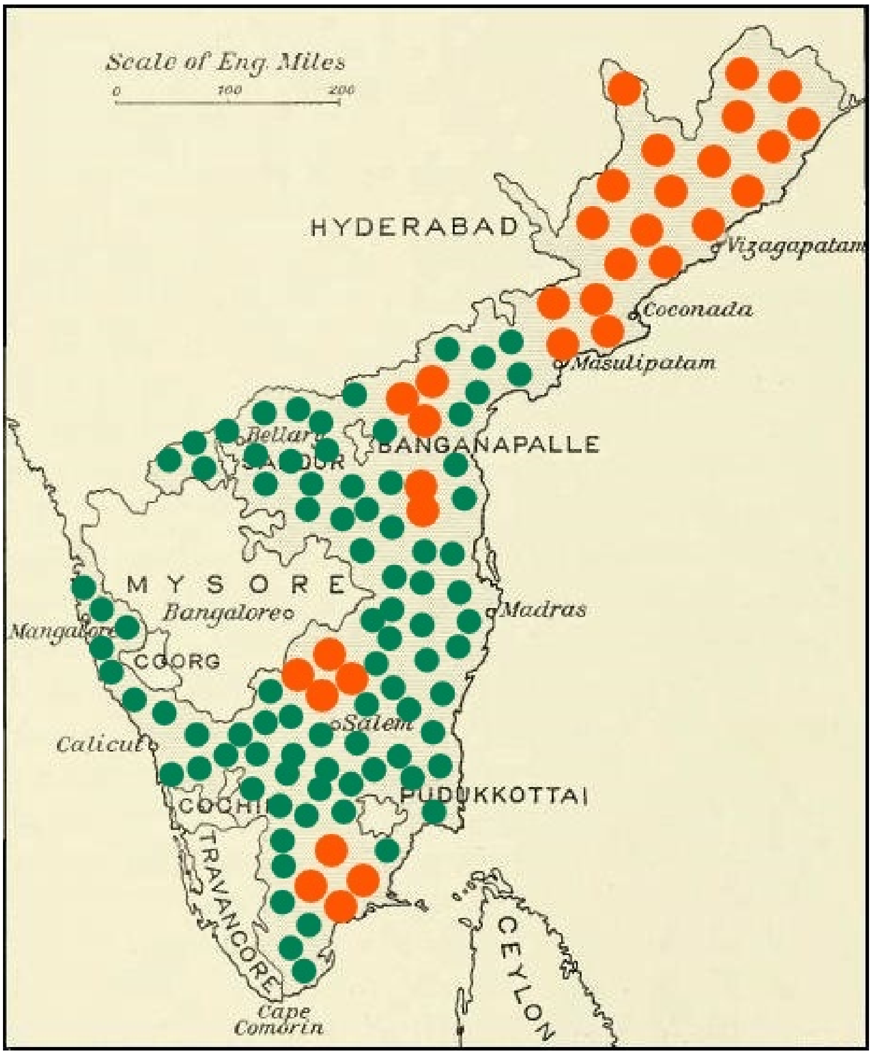
Notes: The panel on the left shows the study area prior to 1801 and the panel on the right shows how government villages on the left and landlord villages on the right of the discontinuity.

on both sides were relatively isolated and far from cities of any importance. In terms of previous history, the Nellore side witnessed less warfare and depopulation. The Nellore manual states "... the districts of Nellore and Ongole... entirely escaped the effects of the last two wars, the population has suffered no violent decrease, and the population have not been deprived of means of cultivation" (*Nellore manual, pg. 471*). In contrast, it is remarked that the neighbouring areas of Cuddapah suffered depopulation and the country was in "poor condition" (*Kurnool manual, pg. 53)*.[8]

What happened in this region happened across the province in similar, if not identical ways; one-third of the province of Madras was settled permanently under the landlords by 1802, in a manner that was legally irreversible. But the rest of the province was to be settled in a cultivator based system that was continuously refined over the 19th century (Figure 2.2). The latter process was much speeded along by the return of Munro in 1821, this time as the Governor of Madras. With the ideological tide decidedly in his favour, almost unrestricted authority, and a cohort of very loyal civil servants, Munro set in motion the process to finish what he had himself started.

[8] For the purposes of the empirical strategy employed here, it is important to show that conditions were similar prior to the arrival of the British. It is reassuring that differences in prior history imply that future government villages started from being worse off in terms of population, which would be a bias against our finding a result in favour of their future success.

Figure 2.2: Land tenures in Madras province



Notes: The map shows the approximate spread of landlord (orange) and government (green) land revenue systems in the Madras province.

2.2 The impacts

The effects of different land tenures on the villages were dramatic and began to be felt almost immediately. In this section, I will highlight the three key differences that arose between landlord and government villages. These are (i) higher revenue demands, (ii) more legal confusion and (iii) a higher incidence of conflict in landlord villages.

2.2.1 Higher revenue demands

One of the first things that often took place in government villages was a lowering of revenue demand. In Cuddapah for example, Munro recommended a 25% decrease in the revenue demanded to encourage cultivation in what was a depopulated area. This was implemented in 1821. However, in landlord villages the story was different. When the revenue demand due from landlords was fixed permanently in 1801, the amount the landlords could demand of their tenants was not, leading to the possibility of severe over-extraction of revenue. Historical evidence suggests that the rate of revenue on comparable pieces of land could be 4 to 5 times higher in landlord villages compared to government ones (Sayana, 1949, pg 106). While the tenants suffered under these harsher conditions, the presence of a class of sub-tenants meant that the actual cultivators often worked under almost impossible conditions (Driver, 1949, pg 66).

To make matters worse, revenue remissions in case of bad weather were much harder to get in landlord villages. In government villages, cultivators paid only for the land cultivated in a given year. Additionally, in bad seasons the District Collector would consider revenue remissions as part of the annual revenue assessment process. No such systematic process existed in landlord villages.

Although the landlords were liable for persecution if there was 'undue exaction', in practice this rarely ever happened for two major reasons. Firstly, the diversity in collection methods (cash or kind) and the plethora of additional customary charges imposed, made it impossible for the government to accurately measure the levels of exaction (Raychaudhuri et al., 1983, pg 218). For example, in various estates (including Venkatagiri), a traditional system continued to be used, which meant that revenue was to be paid on a crop by crop basis. Higher rates were charged for more productive crops, and cultivators were forced to cultivate inferior lands alongside higher quality ones (Sayana, 1949). Secondly, the village headmen and accountants were appointed by the landlord and they were able to modify revenue arrangements from village to village in a variety of ways, often to the advantage of the village elite (Baker, 1984, pg 431). Weaker tenants were more heavily assessed but could not get legal recourse given the lack of proper accounts and their generally disadvantaged position within the village.

2.2.2 Legal confusion

In government villages, the *raiyatwari* system meant that individual cultivators were given a title deed to a piece of land laying out their revenue obligations. Cultivators were free to buy or sell land based on these deeds, and to take up more land for cultivation, creating a market in land.

In contrast, in landlord villages properly rights were badly defined and hard to enforce. In theory, tenants and sub-tenants had certain property rights in land. However, the settlements made around 1801 failed to lay out what these rights were and hence "left the courts the impossible task of discovering them" (Washbrook, 1981, pg 656). The lack of an estate bureaucracy and accompanying land records meant that even if these rights were defined, it was pretty much impossible for the courts to help. The same problem manifested itself on the side of the landlord as well. If a tenant did not pay the due rent, the landlord found it hard to "convince the court that a particular ryot occupied a certain tract of land, was supposed to pay a certain rent, and indeed had not paid it" (Baker, 1984, pg 430).

Landlords resorted to forcing greater revenue out of their estates, using the legal uncertainty to their advantage. In the early years, they auctioned off large chunks of land to temporary landlords who used force to squeeze as much rent as possible from the land. The tenants on these lands were doubly disadvantaged. The landlords continually raised their rents higher and higher, and at the same time, they began to ignore their customary obligations, and give away common village lands to richer cultivators.

Landlords had legally defined responsibilities to provide irrigation facilities in the estates, but the government had no way to force them to fulfil these. Even worse, the government discovered through a series of legal cases starting 1880s onwards, that it couldn't make landlords pay for water from government irrigation canals passing through landlord tracts. These legal difficulties extended to the construction of railways which meant they often navigated around the estates (Baker, 1984).

2.2.3 Conflict

It shouldn't come as a surprise that arbitrary rent demands, decreasing customary rights and no legal recourse led to a higher level of conflict on landlord estates. The peasants complained about the sorry state of irrigation works but a lot of the more severe conflict revolved around the historical rights of peasants to use forests that the landlords had chipped away at. Where things got really bad, the dispute was "conducted with greater bitterness and in some estates ryots and estate officials murdered one another with monotonous regularity" (Baker, 1984, pg 436). The violence was strongest in the Telugu areas around Venkatagiri estate, and in the estate itself, peasants launched a protest in the 1930s to restore traditional rights to fodder and timber (Sarkar, 1989).

The conflict between landlords and peasants was sustained also by the economic and political developments in the early 20th century. As the railways were built and commercialisation of agriculture proceeded at pace, landlords found their traditional role in the centre of the economy was being diluted. They resented the shift of trade from traditional towns to new emerging market towns that had railway access. Many tried to maintain their economic and social power by discouraging the production of cash crops. Many also attempted to expand their power to the political stage. In the Venkatagiri estate, there is some evidence that cultivators were classified into 'obedient' and 'disobedient' categories based on their political inclinations (Sayana, 1949).

2.3 Summary

The first half of this section set out to show how an exogenous shock resulted in villages in close geographical proximity being assigned to different land tenure systems. Evidence presented in the second half suggests that the historical quirk of villages a few kilometres apart falling under entirely different property rights regimes had dramatic impacts. These can be summarised thus:

First, over-extraction of revenue left the peasants in landlord villages poorer than their counterparts in government villages. Those who could afford to migrate to government areas did, leading to a considerable exodus from landlord areas. In Venkatagari, there were reports that "villages were being deserted" because it was "impossible to eke out a living out of farming under the Zamindars" (Sayana, 1949, pg 117). This historical migration changed the structure of these villages, such that landlord villages were smaller and had greater inequality. Government villages grew more cash crops and had higher productivity, with a bigger mass of small to medium cultivators. This is likely to have had significant demand side effects, with lower demand for new technology and for education in landlord villages.

Second, there was likely to be an under-provision of public goods, including schools. Research has shown that inequality and the presence of an elite reduced primary schooling enrollment (Galor et al., 2009; Chaudhary, 2009), and this mechanism is likely to have been strong in landlord villages. Given low colonial government expenditures, the provision of services in colonial India depended on local boards. These local boards, in landlord areas, would be dominated by landlord interests who would determine how and where to spend the funds available. The higher inequality and conflict in these villages is likely to have led, potentially through capture of local democratic institutions, to lower public goods provision in the long run, à la Banerjee and Iyer (2005).

3 Data and Methodology

3.1 Data

I use historical and modern data for my analysis. In terms of data, my main contribution in this research is the digitization of the 1901 village census for the province of Madras. This means that, unlike most other studies, I am able to conduct my analysis at the village level.

One of the biggest challenges in the process of creating the dataset was to match villages from the historical 1901 census to the geo-referenced 2001 census. This section will outline the challenges faced and the methodology used in the matching.

In the raw historical data villages are listed alongside a generic serial number, identified only by their name and the names of the sub-district and district in which they fell. Given the absence of an ID to link these datasets, and the fact that the way these villages were spelt changed considerably over time, the biggest challenge faced was to accurately link the same village to the modern census. The first part of the process was automated using an approximate string matching technique implemented in R. This meant that village names were matched with different distances[9] . For example, perfect matches, where the village names were identical across the two censuses, would match with a distance of 0, villages with one letter different would match with a distance of 1, and so on. Dealing with perfect matches was trivial, and in practice, even villages matches with a distance of 1 proved to be straightforward to verify. These were villages where often one letter had changed (for example, *Ayyavaripalli* became *Ayyavaripalle*) or a letter had been added (*Chintodu* became *Chinthodu*). But it remained clear that these were the same village names.

[9]This technique counted addition of letters, removal of letters or changes in letters as creating a one unit distance between the names

Names matched with a distance of 2 consisted of a mixture of villages that were (i) likely the same - for example *Mailavaram* became *Mylavaram*, *Bhimavaram* became *Bheemavaram*, (ii) were clearly different – *Koturupadu* vs *Kollurupadu*, *Munagapadu* vs *Mundlapadu*, or (iii) where there was some uncertainty – *Revuru* and *Ravur*, *Kolagotla* and *Kalagatla*. Dealing with the first two categories was straightforward, but all villages in the third category were dealt with on a case by case basis. For such villages, the historical sub-district was matched to the modern sub-district to confirm whether they were in the same geographical area. If this test was successful, the next criteria adopted was village size. The overall trend in the data was that villages that were more highly populated historically continued to be so today. If the population figures for a village across the historical and modern census were widely inconsistent – for instance, a large village historically being a small hamlet in the present, or vice versa – then such villages were excluded. The process was similar for villages matched with a distance of 3, although most villages in this case clearly were case of being wrongly matched. However, there were still some names that seemed to be referring to the same village – for example, *Kondamidi Konduru* and *Kondameeda Konduru*, *Gollakandukuru* and *Golla Kandakur*. Such villages were extracted from this set of matches and included in the sample.

There were some additional challenges in the merging process. It is reasonably common for villages to have the same names in a given area. This meant that for some villages in the sample, the decision about which of the identically named villages should be matched across the censuses to each other needed to be made manually. This process was carried out using additional information on sub-districts and on the relative populations. Where both these parameters did not clearly allow a match, such villages were not included in the sample.

One final concern regarding the data matching process, partly the result of the inherent difficulty, was that there were many villages from the historical census that couldn't be matched at all. This would be particularly concerning if there was a systematic bias in the villages dropping out of the sample. To confirm this was not the case, I compare the distributions of the matched and unmatched villages (Figure 2.4 in the Appendix). There were a slightly larger number of unmatched village in the lowest population, but broadly the unmatched villages seem to be evenly spread across the distribution, which is reassuring. Section 4.2 will take up a discussion of how robust the results are to varying the matching criteria discussed in this section.

The historical census gives me information on the land tenure type, population and religion in 1901. The modern 2001 census gives me information on literacy, irrigation and other variables based on caste and occupational categories. Finally, I also link the 2001 Village Amenities Survey that provides information on village public good availability.

I supplement this census data with altitude and ruggedness/slope variables created using satellite data from the National Remote Sensing Centre, through their open data portal *Bhuvan*[10]. To create measures of soil quality, I use the Harmonized World Soil database that rates soils based on their quality affecting plant growth across 6 criteria. I calculate two principal components from these six measures as indicators of soil quality. Since each village is geo-referenced, it is straightforward to create various distance measures. I plot historically important towns and calculate the distance to the nearest town from each village. The railway line that passed through the study area is plotted and I use colonial military records to identify railway stations in the 19th century.

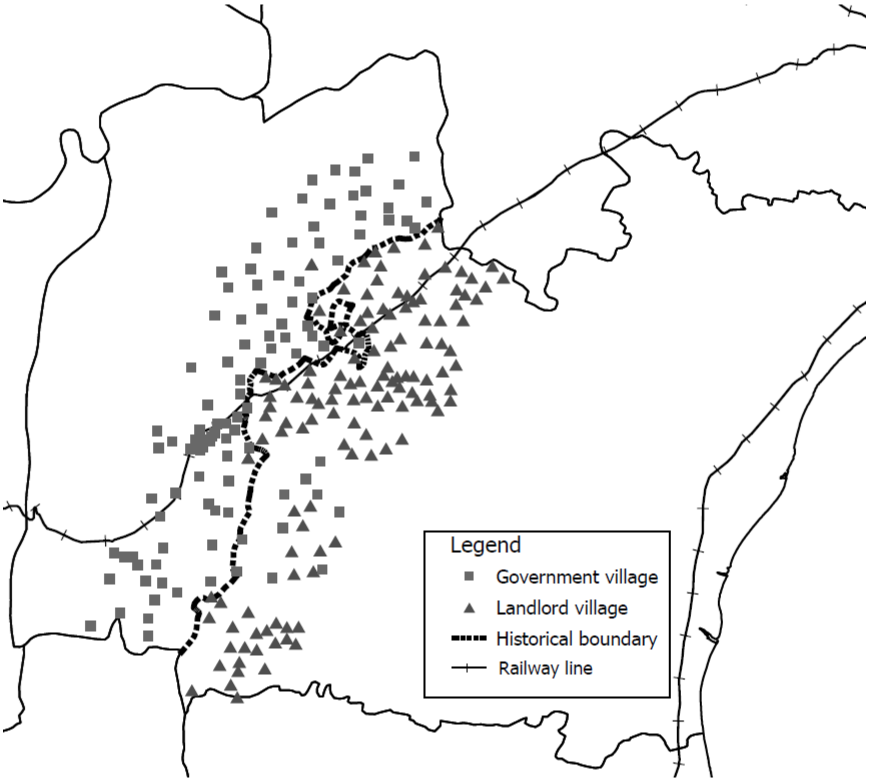
3.2 Empirical strategy

Across the province, the assignment of land tenure type is likely to be correlated with unobservables, thereby biasing results from a normal OLS regression. It is not possible to accurately control for geographical characteristics such as rainfall or soil quality, or for the location and quality of roads and markets. However, the presence of sharp discontinuities in land revenue systems suggests the potential utility of a Regression Discontinuity Design (RDD). The particular discontinuity chosen is the historical, north-western boundary of the Venkatagiri kingdom, which falls in present day Prakasam district (Figure 2.3).

I use only the north-western boundary of the Venkatagiri kingdom for a few reasons. Firstly, this is the cleanest discontinuity in land tenure. Villages that had been 'gifted' by past kings to various entities were brought under government control, and such villages were concentrated in the eastern and central part of new estate. Secondly, the headquarters of the Nellore district were located beyond the south-east of the kingdom and the city of Madras, capital of the province, was situated a bit further down the same coast. In contrast, the major towns in the chosen study area lay along the boundary. Thirdly and finally, historical evidence suggested that construction of railways could be endogenous to land tenure type. The line passing through the the study area cuts diagonally across, covering both landlord and government villages. In addition, this line was nominally built as a famine relief line, so can be treated as a somewhat more exogenous shock to the area.

[10] Available at https://bhuvan-app3.nrsc.gov.in/data/download/index.php

Figure 2.3: Study area with railway line



Notes: Map shows study area around historical boundary as before with the addition of the railway line that traverses the region.

In the case of this particular RDD setting, a sharp discontinuity where assignment to treatment is based on historical boundaries, the strategy resembles a randomized experiment such that distance to the boundary does not change probability of treatment. Table 2.1 summarises the different variables across the boundary. The first section of the table analyses the differences in altitude, slope and soil quality. The second section of Table 2.1 considers the placement of these villages in relation to towns and railway lines. In the third section of the table, I include some other variables from the 1901 and 2001 census data. This is not ideal since the land tenure assignment happened a century prior, which implies that only geographical variables in this study can be considered pre-determined since all others could in theory be affected by the initial tenure assignment. Nevertheless, I include these variables in the analysis for completeness. I calculate the proportion of agricultural labourers and the proportion of lower castes (Scheduled Castes) in 2001 as these are variables that would indicate lower demand for education across these sets of villages. From the limited information available from the 1901 census, the proportion of Muslims in the village is calculated. This is expected to be lower in the villages that were historically ruled by the Hindu kings of Venkatagiri, and this is what the data reflects.

Table 2.1: Summary statistics

	<5 km			<10 km		
	Landlord	Government	s.e.	Landlord	Government	s.e.
Geographical variables						
Altitude	116.47	93.29	34.26	119.65	91.71	20.98
Slope	88.03	87.51	.33	88.11	87.58	.25**
Soil 1	-.58	-.42	.08*	-.48	-.43	.07
Soil 2	-1.08	-1.00	.04*	-.90	-.96	.08
Distance measures						
Nearest station distance	9.62	10.06	1.69	12.65	11.20	1.65
Nearest town distance	20.19	15.43	2.69*	23.02	15.49	2.22***
Other variables						
Proportion lower castes, 2001	.21	.21	.03	.26	.20	.03
Proportion labourers, 2001	.25	.27	0.02	.23	.25	0.02
Proportion Muslim, 1901	.02	.02	.01	.02	.05	.02
Observations	24	26	-	29	37	-
	<15 km			<20 km		
	Landlord	Government	s.e.	Landlord	Government	s.e.
Geographical variables						
Altitude	109.99	95.12	14.24	100.89	96.34	11.47
Slope	88.00	87.59	.20**	87.88	87.32	.37
Soil 1	-.41	-.35	.06	-.28	-.40	.05**
Soil 2	-.59	-.92	.10***	-.43	-.89	.10***
Distance measures						
Nearest station distance	16.69	12.58	1.67**	18.82	13.44	1.55***
Nearest town distance	26.27	17.04	1.75***	26.65	17.79	1.48***
Other variables						
Proportion lower castes, 2001	.23	.20	.02	.24	.20	.02
Proportion labourers, 2001	.23	.26	.01	.24	.27	.01
Proportion Muslim, 1901	.03	.05	.01	.03	.05	.01
Observations	52	65	-	78	82	-

Reported standard errors of difference in means, and *, ** and *** signify a T-test for difference in means at the 10, 5 and 1 % level.

The model estimated is:

$$Outcome_i = \alpha + \tau Z_i + \mathbf{G}\gamma + \mathbf{X}\beta + f(location)_i + u_i \qquad for\ i \in b$$

where outcome in village i is our developmental indicator of interest, Z indicates a village is a landlord village, G is a selection of geographical controls and X is a set of other covariates. b defines different samples based on distance to historical boundary. With a binary treatment variable, τ will measure the treatment effect.

Formally, there are two common challenges to such an empirical strategy. The first is that of random assignment: it needs to be shown that villages are randomly assigned to either side of the boundary. Unlike other RDDs that use household data, this is less of a problem here. None of the villages in the area were able to self-select to one or the other side of the boundary. The second challenge is that of compound treatment. If there are multiple treatments across the discontinuity then τ no longer measures the treatment of interest. While all the villages in our sample currently fall in the same district, historically district boundaries were drawn around this discontinuity. There are a few points to be made on this issue. Firstly, overall per capita spending in colonial India was low, particularly with regards to education. Spending on primary education continued to be low after independence in 1947, with mass rural literacy programmes only taking off around the 1980s. Secondly, colonial education was decentralised such that the establishment of schools was largely financed by local revenues. On top of this, in *zamindari* areas the local boards were more often than not under the control of the *zamindar*. So insofar as there were differences in public good provision across historical districts in this area, these are likely to have themselves been a function of the different land tenure types. Thirdly, since 1970, all of these villages have been in the same district so have been treated to exactly the same state and district level policy interventions.[11]

4 Results

4.1 Discussion

Table 2.2 reports the baseline results for literacy for villages within 5, 10, 15 and 20 km of the discontinuity. In columns (1) I include no controls and in columns (2) I include geographical controls for altitude, slope and soil quality. Villages that were historically landlord villages have significantly lower literacy in 2001, compared to their counterparts across the disconti-

[11] In the next section, a more formal test is attempted to rule out the threat of a compound effect.

nuity that were historically government villages. These impacts are substantial - historical assignment to a landlord leads to 10 percentage points lower literacy. The mean literacy in my sample is around 40 percent and the estimated impact lies between half and a full standard deviation impact. This is quite a remarkable result given the geographical proximity of these set of villages.

It is possible that distance to towns and railway stations, religious populations, proportion of agricultural labourers, and proportion of lower castes could all be endogenous to the assignment of land tenure in 1801, so would qualify as bad controls. Despite this, I include these in columns 3 and 4, to show robustness of the main results. The results stay significant across specifications and across different distances. This implies that these are not major channels through which these colonial era institutions have impacts on 21st century outcomes.

So far I have used the naive distance to the boundary as the running variable in my regressions. However, in a geographical setting distance to the boundary may not be sufficient. Accordingly, I also use different polynomials capturing the geographical location of various villages. In Tables 2.3 and 2.4 (baseline I and baseline II respectively), I follow best practice in literature to show that results are robust to including linear and quadratic polynomials in distance, linear polynomial in distance along with a treatment interaction term, and linear and quadratic polynomials in latitude and longitude (Dell, 2010; Becker et al., 2016).[12]

Next, I investigate the provision of public goods in these sets of villages. Using the Village Amenities dataset, I find that landlord villages have a lower probability of having a middle school and a high school (Table 2.5, columns 1 and 2). I do not use data on primary schools due to a lack of variation in the sample. However, the result as it stands is interesting. While wide-scale educational programmes have expanded the supply of primary schools across villages, the number of secondary schools and secondary enrollment has lagged behind in India (Kingdon, 2007). The poor quality of primary schooling often means that completing primary schooling is no guarantee of functional literacy (Carron and Chau, 1996). The absence of middle and high schools in formerly landlord villages perhaps indicates an important channel through which they lag behind in literacy. In Table 2.5, I further show that formerly landlord villages are significantly less likely to have a medical facility, a bus route and a post office.

Data is available on the type of irrigation in each village so I use this to disentangle the type of irrigation that drives the difference between landlord and government villages. These results are presented in Table 2.6. There is no river irrigation in the study area, so

[12] As an alternative outcome, I use the the proportion of irrigated land in the village interpreted as a measure of agricultural productivity and development. Results are similar in magnitude and significance. To conserve space, these results are in the Data Appendix at the end of this chapter.

Table 2.2: Literacy: main results

	(1)	(2)	(3)	(4)
Within 5 km of boundary:				
Landlord village	-13.115***	-10.404***	-9.335**	-11.477***
	(3.131)	(3.355)	(3.619)	(3.254)
Observations	47	47	47	47
R^2	0.29	0.42	0.54	0.62
Within 10 km of boundary:				
Landlord village	-10.689***	-10.773***	-8.869***	-8.970***
	(2.367)	(2.680)	(3.049)	(2.815)
Observations	88	88	88	83
R^2	0.19	0.25	0.46	0.55
Within 15 km of boundary:				
Landlord village	-6.683***	-7.647***	-8.601***	-8.705***
	(2.044)	(2.332)	(2.407)	(2.470)
Observations	138	138	138	120
R^2	0.07	0.13	0.36	0.53
Within 20 km of boundary:				
Landlord village	-6.299***	-7.081***	-7.087***	-8.104***
	(1.709)	(1.980)	(2.003)	(2.258)
Observations	177	177	177	141
R^2	0.07	0.15	0.32	0.49
Controls				
Geographical controls	No	Yes	Yes	Yes
Distance controls	No	No	Yes	Yes
Other controls	No	No	No	Yes

Notes: The dependent variable in all regressions is percentage of literate people in the village in 2001. Geographical controls include village altitude, village ruggedness and two principal components to capture soil quality. Distance controls include distance to nearest railway station and distance to nearest town, and squared terms for both. Other controls include proportion of Muslims in 1901, proportion of Scheduled Castes in 2001 and proportion of agricultural labourers in 2001. Panels report results of villages within 5, 10, 15 and 20 km of of historical Venkatagiri boundary, and landlord village indicates the effect on treated villages. Robust standard errors reported in parantheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 2.3: Literacy: baseline I specifications

	Linear-distance	Quadratic-distance	Linear-interaction	Linear-coordinates	Quadratic-coordinates
Within 5 km of boundary:					
Landlord village	-10.401***	-10.150***	-8.841	-6.140*	-6.800*
	(3.389)	(3.453)	(6.594)	(3.219)	(3.795)
Observations	47	47	47	47	47
R^2	0.42	0.43	0.42	0.63	0.64
Within 10 km of boundary:					
Landlord village	-10.125***	-10.125***	-13.943***	-5.620*	-5.774*
	(2.500)	(2.513)	(4.718)	(3.095)	(3.344)
Observations	88	88	88	88	88
R^2	0.29	0.29	0.30	0.58	0.59
Within 15 km of boundary:					
Landlord village	-7.521***	-7.321***	-14.979***	-5.239*	-4.997*
	(2.328)	(2.264)	(3.771)	(2.713)	(2.886)
Observations	138	138	138	138	138
R^2	0.14	0.16	0.16	0.39	0.43
Within 20 km of boundary:					
Landlord village	-6.999***	-6.972***	-12.116***	-4.783**	-4.690*
	(1.966)	(1.940)	(2.991)	(2.349)	(2.399)
Observations	177	177	177	177	177
R^2	0.15	0.17	0.17	0.43	0.46
Controls					
Geographical controls	Yes	Yes	Yes	Yes	Yes
Distance controls	No	No	No	No	No
Other controls	No	No	No	No	No

Notes: Columns report baseline specification I with variations of location polynomial. The dependent variable in all regressions is percentage of literate people in the village in 2001. Geographical controls include village altitude, village ruggedness and two principal components to capture soil quality. Panels report results of villages within 5, 10, 15 and 20 km of of historical Venkatagiri boundary, and landlord village indicates the effect on treated villages. Robust standard errors reported in parantheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 2.4: Literacy: baseline II specifications

	Linear-distance	Quadratic-distance	Linear-interaction	Linear-coordinates	Quadratic-coordinates
Within 5 km of boundary:					
Landlord village	-11.277***	-11.210***	-4.074	-7.530**	-6.422
	(3.304)	(3.370)	(8.133)	(3.408)	(4.168)
Observations	47	47	47	47	47
R^2	0.63	0.63	0.64	0.71	0.71
Within 10 km of boundary:					
Landlord village	-8.715***	-8.719***	-12.549***	-7.998***	-7.200**
	(2.813)	(2.837)	(4.460)	(2.922)	(3.414)
Observations	83	83	83	83	83
R^2	0.56	0.56	0.57	0.66	0.66
Within 15 km of boundary:					
Landlord village	-7.434***	-7.790***	-12.524***	-7.601***	-7.067**
	(2.359)	(2.437)	(3.882)	(2.747)	(3.259)
Observations	120	120	120	120	120
R^2	0.55	0.55	0.57	0.63	0.63
Within 20 km of boundary:					
Landlord village	-6.263***	-7.316***	-12.762***	-6.889***	-6.017*
	(2.216)	(2.274)	(3.413)	(2.593)	(3.177)
Observations	141	141	141	141	141
R^2	0.50	0.52	0.53	0.62	0.63
Controls					
Geographical controls	Yes	Yes	Yes	Yes	Yes
Distance controls	Yes	Yes	Yes	Yes	Yes
Other controls	Yes	Yes	Yes	Yes	Yes

Notes: Columns report baseline specification II with variations of location polynomial. The dependent variable in all regressions is percentage of literate people in the village in 2001. Geographical controls include village altitude, village ruggedness and two principal components to capture soil quality. Distance controls include distance to nearest railway station and distance to nearest town, and squared terms for both. Other controls include proportion of Muslims in 1901, proportion of Scheduled Castes in 2001 and proportion of agricultural labourers in 2001. Panels report results of villages within 5, 10, 15 and 20 km of of historical Venkatagiri boundary, and landlord village indicates the effect on treated villages. Robust standard errors reported in parantheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 2.5: Public good provision

	Middle school	High school	Medical facility	Bus route	Post office
Landlord village	-2.195***	-2.140***	-1.223***	-1.086**	-2.243***
	(0.446)	(0.535)	(0.362)	(0.446)	(0.443)
Observations	118	118	120	120	120
Pseudo R^2	0.28	0.29	0.18	0.28	0.32
Controls					
Geographical controls	Yes	Yes	Yes	Yes	Yes
Distance controls	Yes	Yes	Yes	Yes	Yes
Other controls	Yes	Yes	Yes	Yes	Yes

Notes: Each column reports results from a probit model where the dependent variable is the presence or absence of the specific public good. The preferred specification used includes villages that fall within 15 km of the historical Venkatagiri boundary, and uses the full set of controls as defined before. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

we don't have to consider that. Of the other sources, it seems that there is no significant difference in access to government canals between the sets of villages - the coefficient on canals is negative but not significant. The headline result here is that the biggest portion of the differences in irrigation between the villages is driven by tube-wells. Tube-wells, generally run on electricity, are signs of richer cultivators growing higher productivity crops. So in this case, it seems like the channel may be a demand side one. The boom in productivity during the Green Revolution of the 1960s was accompanied by a rise in irrigation using tube-wells. But there is strong evidence that this was unevenly spread. Areas that had a mass of medium cultivators were more conducive to capitalist development, particularly in the adoption of new technologies (Das, 1999).[13] These results provide quantitative evidence for this at the village level. Landlord villages also have access to fewer tanks which could be an indication of more historical under-provision of irrigation.

In Table 2.7, I investigate the impact of railways on literacy. As a general rule, the distance to the nearest station significantly affects literacy, being 5 km closer to a railway station increases literacy by between half to a full standard deviation. However, when looking at the interaction between distance to nearest station and the treated villages, the positive impact of the proximity of railways on literacy either substantially diminishes or completely vanishes for landlord villages. The literature on the impact of railways on India has found important impacts of trade costs and quantity, but the impacts on growth and development, and the precise channels are still unclear (Bogart and Chaudhary, 2015). The results here perhaps give one indication as to why the railways did not have clear cut positive impacts on development. Another interesting possibility is that the presence of a nearby railway station actually facilitated further rounds of successive migration out of the landlord villages that explains lower literacy among the stayers in the sample. These results indicate that instead of ameliorating the conditions of landlord villages, railways can be seen as a channel for further divergence.

In Table 2.8, I provide a tentative test for the migration. So far I avoided using village population data because the historical assignment of land tenures in 1801 clearly caused villages to have different structures. However, I now add village population in 1901 as an explanatory variable to my model. Column 1 and 3 of Table 2.8 show the original results for Basline I and II, and columns 2 and 4 show the new coefficients once I control for village population in 1901. The results are weaker once population is controlled for, particularly for

[13]In Chapter 3, the reasons due to which such divergence was possible during the Green Revolution are laid out.

Table 2.6: Irrigation, by source

	Tube-well	Wells	Tanks	Govt Canals
Landlord village	-9.762***	1.161	-5.058*	-3.091
	(2.084)	(0.981)	(2.567)	(2.199)
Observations	116	116	91	116
R^2	0.45	0.20	0.57	0.26
Controls				
Geographical controls	Yes	Yes	Yes	Yes
Distance controls	Yes	Yes	Yes	Yes
Other controls	Yes	Yes	Yes	Yes

Notes: This table breaks down the main results on irrigation into different sub-categories. 'Tube-well' is the percentage of village land irrigated using tube-wells, 'wells' is the percentage of land irrigated using wells and so on. Villages within 15 km of the historical Venkatagiri boundary are included in the regressions. Geographical, distance and other controls as defined before. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 2.7: Railways and literacy

	(1)	(2)	(3)	(4)
Within 10 km of boundary:				
Landlord village	-19.966***	-19.566***	-8.985	-15.331***
	(4.107)	(4.409)	(5.676)	(4.587)
Distance from station	-0.719**	-0.774**	-1.351**	-1.402**
	(0.280)	(0.307)	(0.586)	(0.648)
Landlord village=1 × Distance from station	0.824**	0.823**	0.010	0.573
	(0.376)	(0.371)	(0.475)	(0.365)
Observations	88	88	88	83
R^2	0.28	0.35	0.46	0.56
Within 15 km of boundary:				
Landlord village	-20.777***	-21.116***	-14.597***	-15.923***
	(3.441)	(4.200)	(5.042)	(4.358)
Distance from station	-0.863***	-0.876***	-1.740***	-2.082***
	(0.165)	(0.177)	(0.589)	(0.514)
Landlord village=1 × Distance from station	1.051***	1.031***	0.427	0.544**
	(0.218)	(0.251)	(0.315)	(0.263)
Observations	138	138	138	120
R^2	0.23	0.27	0.37	0.55
Within 20 km of boundary:				
Landlord village	-21.067***	-21.088***	-17.434***	-18.060***
	(2.888)	(3.820)	(4.102)	(3.749)
Distance from station	-0.767***	-0.744***	-1.550***	-1.544***
	(0.118)	(0.126)	(0.379)	(0.411)
Landlord village=1 × Distance from station	0.998***	0.957***	0.645***	0.704***
	(0.157)	(0.189)	(0.210)	(0.196)
Observations	177	177	177	141
R^2	0.26	0.30	0.36	0.53
Controls				
Geographical controls	No	Yes	Yes	Yes
Distance controls	No	No	Yes	Yes
Other controls	No	No	No	Yes

Notes: Same as Table 2, but with the inclusion of distance to nearest rail station and an interaction term between distance to nearest rail station and landlord village included in every specification. The 5 km sample is excluded as there are no variation in access to station amongst this group of villages. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 2.8: Literacy: population as a channel

	(1)	(2)	(3)	(4)
Within 5 km of boundary:				
Landlord village	-10.401***	-9.836*	-11.277***	-11.955***
	(3.389)	(5.340)	(3.304)	(4.340)
Observations	47	47	47	47
R^2	0.42	0.42	0.63	0.63
Within 10 km of boundary:				
Landlord village	-10.125***	-10.890***	-8.715***	-6.745*
	(2.500)	(3.042)	(2.813)	(3.420)
Observations	88	88	83	83
R^2	0.29	0.29	0.56	0.57
Within 15 km of boundary:				
Landlord village	-7.521***	-7.705***	-7.434***	-5.549*
	(2.328)	(2.939)	(2.359)	(3.059)
Observations	138	138	120	120
R^2	0.14	0.14	0.55	0.55
Within 20 km of boundary:				
Landlord village	-6.999***	-6.501***	-6.263***	-4.449
	(1.966)	(2.437)	(2.216)	(2.709)
Observations	177	177	141	141
R^2	0.15	0.15	0.50	0.50
Controls				
Geographical controls	Yes	Yes	Yes	Yes
Distance controls	No	No	Yes	Yes
Other controls	No	No	Yes	Yes

Notes: Columns (1) and (3) show baseline specifications with literacy as before, while Columns (2) and (4) additionally include the village population in 1901 as an explanatory variable. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

the less parsimonious specification, which indicates some role for village size and structure. But the fact that they don't disappear altogether indicates that the persistence of adverse developmental outcomes in landlord villages is not a function of this alone.

4.2 Robustness

I put the results through a series of robustness tests. Firstly, I perform 'donut' RDDs where I exclude the villages that lie very close to the boundary. It could be, for instance, that medieval wars around the boundary altered the nature of the area such that it is boundary specific characteristics that are driving my results. Column 1 of Table 2.9 shows that the results are robust to excluding villages closest to the boundary.

Secondly, I run alternative specifications with different population bandwidths to ensure it isn't just large or very small villages driving the results. In Table 2.9, column 2, I exclude

Table 2.9: Literacy: robustness

	(1)	(2)	(3)	(4)
Within 5 km of boundary:				
Landlord village	-23.333**	-6.074*	-9.001***	-13.425***
	(7.725)	(3.229)	(3.198)	(4.332)
Observations	26	37	45	34
R^2	0.81	0.65	0.61	0.72
Within 10 km of boundary:				
Landlord village	-11.529**	-5.799*	-6.892**	-8.392**
	(4.626)	(3.244)	(2.730)	(3.620)
Observations	62	70	81	58
R^2	0.59	0.59	0.56	0.50
Within 15 km of boundary:				
Landlord village	-8.849**	-6.053**	-6.380***	-7.765**
	(3.364)	(2.752)	(2.256)	(3.170)
Observations	99	99	116	75
R^2	0.56	0.55	0.58	0.47
Within 20 km of boundary:				
Landlord village	-6.457**	-4.891**	-5.369**	-8.264***
	(2.935)	(2.334)	(2.086)	(2.993)
Observations	120	113	137	82
R^2	0.50	0.48	0.52	0.49
Controls				
Geographical controls	Yes	Yes	Yes	Yes
Distance controls	Yes	Yes	Yes	Yes
Other controls	Yes	Yes	Yes	Yes

Notes: Robustness checks with literacy as the dependent variable and all explanatory variables included. Column (1) runs a 'donut RDD' that excludes villages nearest to the boundary to rule out any features of the boundary itself that drive the results, Column (2) excludes villages with a population above 1500 and Column (3) excludes villages with a population below 50 to check whether preceding results are driven by either set of villages, and finally column (4) excludes all villages wither side of the hill range on the southern side of the study area. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

villages with a 1901 population greater than 1500 to show that the results hold even when we compare small landlord villages to small government villages. In a parallel manner, I exclude villages that had populations lower than 50 (Table 2.9, column 3) to show that it isn't the case that very small villages are driving the results. The estimated coefficients are reasonably stable through these checks.

Finally, a sub-sample of the villages to the south of my study area lie either side of a hill range. I run my baseline specifications with all these villages excluded to show that these do not drive the results. (Table 2.9, column 4).

I also run a test specifically to allay fears about the possibility of significant compound treatment across the study boundary (Table 2.10). *Inam* villages were villages gifted by the

Table 2.10: Compound treatment test

	(1)	(2)	(3)	(4)
Left side inam	5.220	0.126	-1.499	7.520
	(3.865)	(5.325)	(5.433)	(7.081)
Observations	39	39	39	31
R^2	0.05	0.27	0.36	0.60
Controls				
Geographical controls	No	Yes	Yes	Yes
Distance controls	No	No	Yes	Yes
Other controls	No	No	No	Yes

Notes: In this table, villages from the two sides of the boundary that were neither landlord nor government but belonged to a third type of tenure - *inam* - are compared. Literacy rate in 2001 is the dependent variable and all controls are as defined previously. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

landlord or the government to charitable organisations or loyal officers on favourable terms. So far I excluded this third different type of land tenure, but now I use such villages on both sides of the border. If there are other treatments across this historical boundary that are driving the results, we should expect to see *inam* villages in the government area do better than the *inam* villages in the landlord area. The results in Table 2.10 of this test indicate, albeit with a very small sample size, that this is not the case. There is no significant difference between these sets of villages across the boundary, although the sign of the coefficient could indicate potential spillover effects.

Given the data matching process outlined in Section 3.1, additional tests are conducted to test the robustness of results to varying the matching criteria. The automated string matching algorithm matched village names across the the historical and modern census with different *distances*. In Table 2.15 and 2.16 (presented in the Data Appendix at the end of the this chapter) I run the Baseline II regressions for both literacy and irrigation, with all controls and a linear polynomial in distance. In column 2, I run the same regression but with all villages that were matched with a distance of 3 excluded. In column 3, I additionally exclude all villages that were matched with a distance of 2. Reducing the sample in this way accounts for potential errors in matching villages based on sub-districts and populations. The results for literacy are unchanged in magnitude and significance. With the reduced sample, the results for irrigation for the smallest bandwidth (within 5 km) are no longer significant, but the rest of the results are comparable. In column (4) I show that excluding villages which shared a name with another village is not a major concern as there were few such villages and excluding them does not affect the results.

5 Conclusion

This chapter makes use of a sharp, random discontinuity in the colonial assignment of property rights at the beginning of the 19th century to explain why villages in close geographical proximity to each other have very different developmental outcomes in the long run. Estimates suggest that having been a landlord village reduces literacy and irrigation by about one standard deviation across the different specifications. Estimates of the impacts of railways suggest the potential to ameliorate the condition of the landlord villages is not realised as the benefits are largely felt by government villages.

While it has been shown institutions do matter, it is often hard to define exactly the nature of inclusive versus extractive institutions, the manner in which they come to exist side by side, and the channels through which their effects persist in the long run. The present study suggests the utility of approaches that focus on a smaller geographical areas. The natural extension of this study is to explain in detail how such effects continue to be visible so many years after the formal colonial institutions were dismantled just after India became independent in 1947.

6 Data Appendix

Table 2.11: Main results, irrigation

	(1)	(2)	(3)	(4)
Within 5 km of boundary:				
Landlord village	-15.219***	-13.032**	-9.132*	-9.120*
	(4.730)	(5.796)	(4.845)	(4.514)
Observations	47	47	47	46
R^2	0.18	0.29	0.48	0.52
Within 10 km of boundary:				
Landlord village	-21.809***	-22.221***	-19.240***	-15.968**
	(3.580)	(4.589)	(5.251)	(6.039)
Observations	89	89	89	82
R^2	0.26	0.33	0.39	0.44
Within 15 km of boundary:				
Landlord village	-21.188***	-21.731***	-20.209***	-19.507***
	(3.009)	(3.403)	(3.923)	(4.722)
Observations	136	136	136	118
R^2	0.26	0.29	0.32	0.36
Within 20 km of boundary:				
Landlord village	-19.670***	-20.191***	-17.624***	-16.580***
	(2.546)	(2.733)	(2.667)	(3.338)
Observations	173	173	173	139
R^2	0.25	0.28	0.33	0.34
Controls				
Geographical controls	No	Yes	Yes	Yes
Distance controls	No	No	Yes	Yes
Other controls	No	No	No	Yes

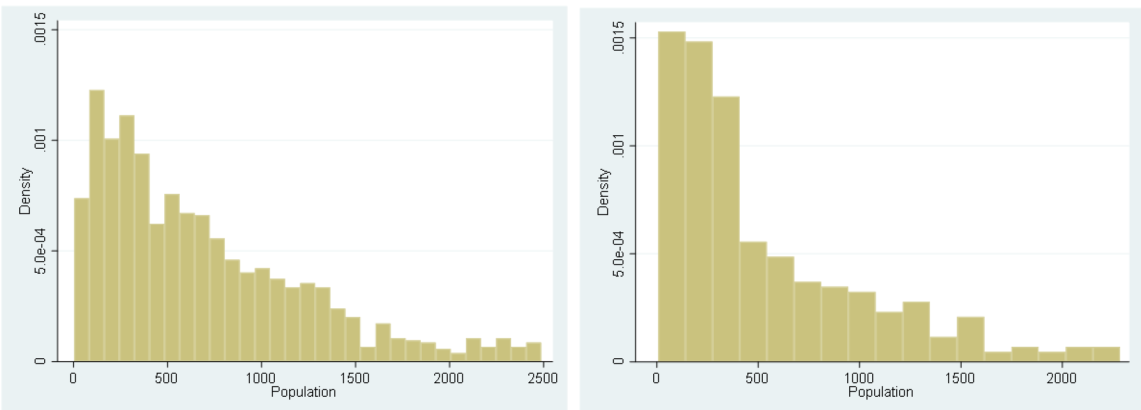
Notes: The dependent variable in all regressions is percentage of land irrigated in the village in 2001. Geographical controls include village altitude, village ruggedness and two principal components to capture soil quality. Distance controls include distance to nearest railway station and distance to nearest town, and squared terms for both. Other controls include proportion of Muslims in 1901, proportion of Scheduled Castes in 2001 and proportion of agricultural labourers in 2001. Panels report results of villages within 5, 10, 15 and 20 km of of historical Venkatagiri boundary, and landlord village indicates the effect on treated villages. Robust standard errors reported in parantheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 2.12: Irrigation: baseline I specifications

	Linear-distance	Quadratic-distance	Linear-interaction	Linear-coordinates	Quadratic-coordinates
Within 5 km of boundary:					
Landlord village	-12.770**	-13.139**	10.654	-12.233	-2.619
	(5.621)	(5.846)	(9.953)	(7.463)	(5.404)
Observations	47	47	47	47	47
R^2	0.30	0.31	0.41	0.34	0.55
Within 10 km of boundary:					
Landlord village	-21.401***	-21.402***	-4.748	-14.699**	-10.883**
	(4.299)	(4.319)	(7.265)	(6.259)	(5.363)
Observations	89	89	89	89	89
R^2	0.34	0.34	0.39	0.36	0.45
Within 15 km of boundary:					
Landlord village	-21.504***	-21.438***	-15.320**	-14.651***	-11.718***
	(3.346)	(3.322)	(6.042)	(4.792)	(4.141)
Observations	136	136	136	136	136
R^2	0.30	0.30	0.30	0.32	0.36
Within 20 km of boundary:					
Landlord village	-20.389***	-20.298***	-19.035***	-14.990***	-13.524***
	(2.750)	(2.726)	(4.937)	(3.889)	(3.490)
Observations	173	173	173	173	173
R^2	0.29	0.30	0.29	0.30	0.31
Controls					
Geographical controls	Yes	Yes	Yes	Yes	Yes
Distance controls	No	No	No	No	No
Other controls	No	No	No	No	No

Notes: Columns report baseline specification I with variations of location polynomial. The dependent variable in all regressions is the proportion of irrigated area in the village in 2001. Geographical controls include village altitude, village ruggedness and two principal components to capture soil quality. Panels report results of villages within 5, 10, 15 and 20 km of of historical Venkatagiri boundary, and landlord village indicates the effect on treated villages. Robust standard errors reported in parantheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Figure 2.4: Distribution of matched and unmatched villages



Notes: Distribution of historical matched villages on the left, and unmatched villages on the right

Table 2.13: Irrigation: baseline II specifications

	Linear-distance	Quadratic-distance	Linear-interaction	Linear-coordinates	Quadratic-coordinates
Within 5 km of boundary:					
Landlord village	-9.066*	-9.221*	8.142	-4.766	0.127
	(4.485)	(4.629)	(10.365)	(8.463)	(5.875)
Observations	46	46	46	46	46
R^2	0.52	0.52	0.56	0.54	0.58
Within 10 km of boundary:					
Landlord village	-15.384**	-15.427**	-2.173	-12.305	-5.400
	(5.874)	(5.909)	(8.971)	(8.764)	(7.402)
Observations	82	82	82	82	82
R^2	0.46	0.46	0.49	0.45	0.55
Within 15 km of boundary:					
Landlord village	-17.634***	-17.998***	-10.315	-17.226**	-9.375
	(4.721)	(5.140)	(7.348)	(7.391)	(6.228)
Observations	118	118	118	118	118
R^2	0.37	0.37	0.38	0.36	0.43
Within 20 km of boundary:					
Landlord village	-16.160***	-17.572***	-12.801**	-17.935***	-9.987*
	(3.782)	(4.093)	(5.545)	(6.238)	(5.356)
Observations	139	139	139	139	139
R^2	0.34	0.35	0.34	0.34	0.40
Controls					
Geographical controls	Yes	Yes	Yes	Yes	Yes
Distance controls	Yes	Yes	Yes	Yes	Yes
Other controls	Yes	Yes	Yes	Yes	Yes

Notes: Columns report baseline specification II with variations of location polynomial. The dependent variable in all regressions is the proportion of irrigated in the village in 2001. Geographical controls include village altitude, village ruggedness and two principal components to capture soil quality. Panels report results of villages within 5, 10, 15 and 20 km of of historical Venkatagiri boundary, and landlord village indicates the effect on treated villages. Robust standard errors reported in parantheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 2.14: Irrigation: robustness

	(1)	(2)	(3)	(4)
Within 5 km of boundary:				
Landlord village	-25.372***	-14.487**	-13.614**	-14.953**
	(7.621)	(5.994)	(6.132)	(6.318)
Observations	26	37	45	35
R^2	0.56	0.29	0.28	0.26
Within 10 km of boundary:				
Landlord village	-29.692***	-23.641***	-21.707***	-23.867***
	(4.761)	(4.526)	(4.339)	(4.533)
Observations	68	76	87	74
R^2	0.46	0.39	0.33	0.38
Within 15 km of boundary:				
Landlord village	-26.659***	-23.554***	-21.820***	-23.777***
	(3.626)	(3.806)	(3.391)	(3.804)
Observations	115	116	132	112
R^2	0.36	0.33	0.29	0.32
Within 20 km of boundary:				
Landlord village	-24.265***	-22.239***	-20.607***	-22.433***
	(2.970)	(3.205)	(2.793)	(3.208)
Observations	152	145	169	141
R^2	0.34	0.33	0.28	0.32
Controls				
Geographical controls	Yes	Yes	Yes	Yes
Distance controls	No	No	No	No
Other controls	No	No	No	No

Notes: Robustness checks with irrigation as the dependent variable and all explanatory variables included. Column (1) runs a 'donut RDD' that excludes villages nearest to the boundary to rule out any features of the boundary itself that drive the results, Column (2) excludes villages with a population above 1500 and Column (3) excludes villages with a population below 50 to check whether preceding results are driven by either set of villages, and finally column(4) excludes all villages wither side of the hill range on the southern side of the study area. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 2.15: Literacy: Matching robustness

	(1)	(2)	(3)	(4)
Within 5 km of boundary:				
Landlord village	-11.277***	-8.671**	-9.357**	-11.315***
	(3.304)	(3.299)	(3.451)	(3.326)
Observations	47	42	37	46
R^2	0.63	0.64	0.64	0.63
Within 10 km of boundary:				
Landlord village	-8.715***	-6.597**	-7.427**	-8.355***
	(2.813)	(3.010)	(3.126)	(2.814)
Observations	83	72	63	81
R^2	0.56	0.56	0.59	0.55
Within 15 km of boundary:				
Landlord village	-7.434***	-5.466**	-6.098**	-7.013***
	(2.359)	(2.402)	(2.626)	(2.354)
Observations	120	105	85	117
R^2	0.55	0.56	0.59	0.55
Within 20 km of boundary:				
Landlord village	-6.263***	-4.096*	-5.821**	-5.856***
	(2.216)	(2.100)	(2.492)	(2.185)
Observations	141	121	99	137
R^2	0.50	0.56	0.61	0.52
Controls				
Geographical controls	Yes	Yes	Yes	Yes
Distance controls	Yes	Yes	Yes	Yes
Other controls	Yes	Yes	Yes	Yes

Notes: Robustness checks with literacy as the dependent variable and all controls included. Column (1) runs the baseline II specification with a linear polynomial in distance and all controls. Column (2) excludes all villages that were matched with a distance of 3, Column (3) excludes all villages matched with a distance of 3 and 2, while Column (4) excludes villages that had a common name with at least one other village. See Section 3.1 for a fuller description of the data.

Table 2.16: Irrigation: Matching robustness

	(1)	(2)	(3)	(4)
Within 5 km of boundary:				
Landlord village	-9.066*	-5.185	-2.052	-9.174**
	(4.485)	(4.032)	(4.409)	(4.482)
Observations	46	41	36	45
R^2	0.52	0.54	0.50	0.52
Within 10 km of boundary:				
Landlord village	-15.384**	-10.373**	-8.156	-15.461**
	(5.874)	(4.996)	(5.430)	(5.858)
Observations	82	71	62	80
R^2	0.46	0.50	0.50	0.46
Within 15 km of boundary:				
Landlord village	-17.634***	-14.552***	-11.887**	-17.350***
	(4.721)	(4.332)	(4.908)	(4.766)
Observations	118	103	83	115
R^2	0.37	0.37	0.40	0.37
Within 20 km of boundary:				
Landlord village	-16.160***	-13.332***	-11.322***	-16.119***
	(3.782)	(3.586)	(4.107)	(3.847)
Observations	139	119	97	135
R^2	0.34	0.36	0.38	0.34
Controls				
Geographical controls	Yes	Yes	Yes	Yes
Distance controls	Yes	Yes	Yes	Yes
Other controls	Yes	Yes	Yes	Yes

Notes: Robustness checks with irrigation as the dependent variable and all controls included. Column (1) runs the baseline II specification with a linear polynomial in distance and all controls. Column (2) excludes all villages that were matched with a distance of 3, Column (3) excludes all villages matched with a distance of 3 and 2, while Column (4) excludes villages that had a common name with at least one other village. See section 3.1 for a fuller description of the data.

Chapter 3

Reforms and Revolution in Independent India

This chapter summarises the significant impacts of the land reforms and the Green Revolution in post-independence India and analyses the reasons for their success varying greatly across the different states. It is proposed that commitment to reforms, power of the landlords and state capacity were important determinants of land reform success, and the pre-existence of infrastructure, a rich class of rural cultivators and the role of the state were all crucial for the spread of the Green Revolution. Evidence is presented that each of these factors was to a degree conditioned by colonial land tenure systems, underlining the importance of historical institutions. The importance of historical institutions is estimated quantitatively using data on agricultural productivity, and alongside it is demonstrated that rainfall variability in this period has a significant impact only on districts with bad irrigation infrastructure.

***

1 Introduction

This thesis has argued strongly for the existence of long run, persistent impacts of historical institutions on long run growth and development, as in Chapter 2. Although such persistence may be interesting, it raises important questions. Why did no public or private policy in the intervening centuries break this persistence? Influential hypotheses suggest that the presence of strong forces of path dependence or lock-in can keep certain economic systems in a sub-optimal equilibrium (see for example Acemoglu 1995; Nunn 2007). That sounds reasonable, but there is a need to go beyond to examine how and why large exogenous shocks are unable to alter the existing economic configurations. This chapter will attempt to examine Indian economic growth and development in the context of two such external shocks, the land reforms and the Green Revolution, both in isolation and in their interaction with historical institutions.

The literature on long run persistence generally relies on econometric methods to regress modern day outcomes on historical data. Much research has been devoted to designing models to infer causation, often through the use of an Instrumental Variable (IV) approach. When such an approach is used within the New Institutional Economics (NIE) literature to highlight persistent impacts of historical institutions, the use of historical data allows scholars to argue that methodological concerns such as those of reverse causation have been overcome.[1] As such, there is a large body of literature in this tradition that has identified strong and persistent effects of historical institutions and thereby advanced our understanding of economic development in general, and the economic history of specific parts of the world (Acemoglu et al., 2001; Banerjee and Iyer, 2005; Nunn, 2008).

While the use of modern economic tools has revitalised many fascinating debates[2], significant concerns remain. In essence, no matter the precise methodology, most studies of this type are cross section analyses in that they search for associations between data from two points in time. More often than not, this means that these studies omit discussion of historical developments in the intervening years. This is natural as economics has always relied on certain abstractions or simplifications to capture key principles. However, the use of such abstraction in economic history can be problematic.

The obvious cost is that we may lose much of the historical detail and contextualisation surrounding the topic of interest. This can be a concern for various reasons. Firstly, this can

[1] This is related to the concern that while better institutions may cause higher growth, higher growth is also likely to lead to better institutions. Using historical data to measure institutions allows us to rule out the latter.

[2] One prominent example is the debate on long run African development, see for example, Hopkins (2009) and Fenske (2010).

prevent us from understanding the mechanisms through which we can observe a persistent impact. NIE has told us that history matters but can be less forthcoming on stating the precise channels through which history matters (Nunn, 2009). Research in the field has attempted to overcome this by using additional data to delineate such channels[3]. Secondly, by losing the historical details and using, often sparse, historical data regardless, the data itself can come under scrutiny. The landmark contribution by Acemoglu et al. (2001) that sparked the NIE literature has itself been heavily criticised for using data that are poorly sourced and of low quality (Albouy, 2008). Similarly, institutional literature from both Africa and the Indian subcontinent has been criticised for using data that misrepresents the historical reality 'on the ground' (Jerven et al., 2016; Iversen et al., 2013).

The third problem is more inherent to the econometric approaches of this type. The abstraction from historical detail necessarily entails a certain 'compression of history' or a 'leapfrogging of legacies' whereby some historical periods and trajectories are omitted from discussion (Austin, 2008; Jerven, 2011). An interesting example from the Indian subcontinent is proposed by Roy (2014) who argued that the process of specialisation and trade based on favourable geographical conditions was very important in colonial India but had exhausted itself by the time of independence. Nevertheless, it would be important to include such regional differentiation in analyses if we are to understand patterns of regional inequality and their origins in India.

A consequence of this final issue is that the institutions literature often is not able to show path dependence or lock-in, which are the common explanations put forward for the persistence. Path dependence reflects the idea that economic processes and structures can not shake off their own past - external shocks are not able to disrupt the existing relationship between different agents (David, 2001). An important assumption here is that there are multiple equilibria, since if there was a universal equilibrium to converge to, historical shocks could only have temporary effects (Nunn, 2009). Institutions themselves have been shown to be very persistent (Acemoglu and Robinson, 2006). Formal changes in governance can dismantle *de jure* institutions but leave *de facto* institutions, those that rely on underlying agent relationships, intact. Studies have highlighted the importance of making this distinction. They have shown, for example, that the impact of property rights reforms that change the formal rules is conditional on the judicial capability to enforce them and thereby to make them credible (Voigt and Gutmann, 2013).

[3] e.g. Dell (2010)

This thesis has previously argued that the historical assignment of different land tenures, whereby in some regions tax liabilities were settled with landlords (in landlord or *zamindari* regions) and in others directly with cultivators (non-landlord or *raiyatwari* regions), had long lasting impacts. Chapter 2 showed that villages historically assigned to landlords in 1801 had lower public good provision, lower literacy and lower irrigation two centuries later compared to neighbouring villages where a cultivator based land revenue system was put in place. The argument was that historically higher extraction, conflict and out-migration in landlord villages permanently changed the structure of such villages to make them more unequal and impoverished. The landlords often attempted to stop peasants in their villages from participating in increasing commercialisation to preserve their economic and social status. This meant that infrastructure such as the railways only benefited non-landlord villages, and thus became a channel for further divergence. However, these land tenure systems were abolished after independence in 1947. This raises some important questions. Why did the government policies and projects after independence not compensate for historical inequalities? Why did the extensive programme of land reforms initiated after independence not redistribute land effectively? Why did increasing possibilities for higher agricultural productivity not lead to the adoption of new technologies and better practices in landlord villages?

This chapter sets out to show how path dependence and lock-in can work in practice. To do so it analyses two of the biggest shocks to rural Indian society in the decades following Indian independence in 1947 - the land reforms and the Green Revolution. The former was an ambitious attempt to change the rural power structures to make them more equal, and the latter entailed the introduction of modern high yielding varieties of cereals into Indian agriculture. Both were successful only to an extent and both exhibited large variations across the country. This chapter will argue, with the aid of existing literature, that the consequences of historical institutions were significantly responsible for the limited and uneven success of both the land reforms and the Green Revolution. It will argue that the success of the land reforms relied on political will or commitment at the state level, the power of the landlords and state capacity, and the spatial variation in the success of the Green Revolution can be explained by differential access to critical infrastructure, the presence of a rich class of cultivators and the role of state. Some of these factors appear in existing literature, but this chapter tries to bring them together in a coherent manner.

This chapter builds on the findings of Chapter 2 as well as Chapter 1. In a quantitative analysis using data on productivity and the area under High Yielding Varieties (HYVs), it reconfirms the importance of historical land tenures but also incorporates ideas from Chapter

1. Chapter 1 argued that traditional analyses of development on the Indian subcontinent often fail to account for the deep heterogeneity in geographical conditions present within such a large landmass. The original analysis in that chapter showed that the inherent risk associated with the vagaries of the monsoon had a significant impact on historical patterns of educational attainment. This chapter builds on those results by introducing the risks associated with rainfall variability into a more modern setting. It makes the case for the continuing relevance of geography and infrastructure access, alongside institutional factors. The results indicate that rainfall variability continued to be associated with low agricultural productivity districts, but the effect is driven by a minority of districts with low irrigation infrastructure that were particularly exposed to such weather risk.

Finally, this chapter also aims to provide a more general summary of the different literatures in both these fields. To the best of the author's knowledge, no research has brought together in one place disparate qualitative and quantitative studies on the topics of the land reforms and the Green Revolution. One of the objectives of the following sections is to summarise the key features, impacts and determinants relating to both topics.

The chapter is structured as follows. Section 2 deals with the land reforms and Section 3 covers the Green Revolution; Section 4 concludes.

2 Land Reforms

The land reforms enacted in India in the immediate years after the country achieved independence in 1947 comprised the 'largest body of agrarian legislation to have been passed in so brief a span of years in any country' (Thorner, 1976), and even that was dwarfed by the sum total of the eventual legislation passed in the next few decades. These reforms were meant to address concerns of economic efficiency as well as distributive justice (Herring, 1983). To do this, the land reforms had to address well established agrarian relations that existed from colonial or even pre-colonial times. The purpose of this section is to demonstrate that the extent to which the aims of these policies were achieved was very limited, varied across the country, and depended on the very agrarian relations that they set out to change. After laying out the nature of the land reforms in section 2.1, providing a general account of their success in section 2.2, bringing together the existing evidence on their impacts in section 2.3, and discussing the exceptions of West Bengal and Kerala in section 2.4, section 2.5 will concentrate on identifying the precise reasons for the overall failure of the reforms and how these relate to historical institutions. Section 2.6 will offer some concluding thoughts.

2.1 Background

There were four distinct, but complementary, sets of land reform legislation (Mearns, 1999).[4] The rationale and the guidelines for these reforms were laid out in the first two Five Year Plans launched by the Central Government in 1951 and 1956. However, the actual design and implementation of the laws was left to the various State governments in India's federal structure. This section will bring together the major rationale of the different reforms and highlight some of the provisions created.

The *first* branch of land reforms targeted the top layer of intermediaries, rentier classes who had an obligation to collect revenue from their lands and pay a fixed amount to the state. These intermediaries included *zamindars* appointed by the colonial administration, but also *jagirdars* who had been granted estates by various Indian kings in return for military service. While rural agrarian society often consisted of multiple intermediaries between the state and the actual cultivator, these reforms set out to remove only the top layer. These reforms were considered the logical first step by the government because such intermediaries had been singled out even prior to Indian independence as the root cause of poor condition of the peasantry leading to significant political momentum against them (Herring, 1983).

The various Acts legislated for in the different states of India between 1948 and 1954 all shared some common characteristics. Most fundamentally, they legislated for the abolition and acquisition of all permanently settled estates, and sought to transfer these permanent rights to the erstwhile tenants. However, there were two other important provisions. Firstly, almost every state laid out the basis for compensation for the ex-intermediaries, with the amount of compensation being inversely proportional to the size of the intermediary's holding (Appu et al., 1997). Secondly, every state legislated for different amounts of land that the ex-intermediary could retain, or in some cases resume, for 'personal cultivation'.

The *second* branch of land reforms were focused on addressing tenant security in the country, irrespective of the type of land tenure prevalent in colonial times. In former landlord (*zamindari*), but also non-landlord (*raiyatwari*) areas, land was leased to tenants who could lease it out even further. The scope of the tenancy reforms laid out in the course of the first Five Year Plan was to reduce and regulate rents, confer permanent rights to tenants, and where possible convert tenants to owners (Appu, 1975).

Most states incorporated all these elements into their laws. Before the reforms, the tenant generally had to cover the cost of cultivation and pay 50 per cent of the gross produce as

[4] A full list of land reform legislation by state can be found in the Appendix.

rent to the landlord, with this figure sometimes as high as 75 per cent (Dantwala, 1957). The planning documents recommended that this should be reduced to around one-fourth or one-fifth of gross produce based on irrigation conditions. All states enacted laws for this purpose but with some variation in the details. To confer permanent rights, the different states enacted laws to stipulate a minimum period for a lease which varied between 5 to 12 years with landlords allowed to take over land either for personal cultivation or if the tenant signed over the land voluntarily. Finally, the majority of the states enacted laws to convert tenants to owners. In some states (e.g. Bihar), however, such laws were missing, and in others (e.g. West Bengal) sharecroppers and newly registered tenants were precluded from these benefits (Patel, 1954). These laws were passed simultaneously with the laws concerning intermediaries, with all states enacting some tenancy laws by 1953.

The *third* set of land reforms related to land ceilings that stipulated a maximum amount of land an individual or a family could hold. These were slower to get off the ground due to disagreements as to whether they were needed, and their potential adverse effects on food-grain availability.[5] Apart from the surplus land distributed after the abolition of intermediaries, the Second Five Year plan (1956-1961) recommended that states imposed ceilings on agricultural holdings, allowing for surplus land to be distributed easing the incidence of landlessness. When the progress seemed to be slow, fresh directives were issued in 1959 which led to all states enacting ceiling laws by 1961. However, the progress under these was unsatisfactory, and in 1971, there was another central directive to enact laws with much stricter ceilings (Herring, 1983). The variations in how these laws varied across different states included the height of the land ceilings themselves, but also the definitions of a 'family holding' based on the size of the family, and on the quality of land and irrigation. There were also a series of exceptions included in the various state laws that ranged from plantations, orchards, dairy farms, forest land, hill land and tank fisheries (Appu, 1997).

The *fourth* set of land reforms formulated in the 1950s and early 1960s concerned land consolidation. There is a debate on whether these should be characterised as land reforms (Oldenburg, 1990), and they were smaller in scope relative to the other reforms, but are nevertheless included here for the sake of completeness. The purpose of land consolidation was to rearrange fragmented holdings among different tenure holders to create more compact plots with an equivalent value to the fragmented plots. Most states passed some laws to this

[5] The case for land ceilings was made primarily on moral and ethical grounds - that they would fulfil constitutional aims of equality. Although the Congress Agrarians Reform Committee argued in 1949 that large holdings were inefficient, this was challenged by the Agriculture department that argued such ceilings would penalise, at a high administrative cost, the few large farmers who were operating on a modern capitalist basis (Herring, 1983).

effect - making provisions for land valuation, land for public facilities, procedures for cash compensation and village consultation - between 1948 and 1972.

2.2 Were the reforms successful?

An official judgement on the Indian land reform programme termed it as the "greatest hiatus between promise and performance" (Herring, 1990, pg 52). This section will summarise reports on the relative success with which different types of land reforms were formulated and implemented. The aim of this section is to provide a broad overview of the relative success of the different branches of land reform, before the next section delineates the precise impacts.

The abolition of intermediaries is considered one of the more successful reforms. The Fifth Five Year Plan stated that "the laws for the abolition of intermediaries have been implemented fairly efficiently" (Fifth Five-Year Plan, 1974, pg 43). This official stance is shared by many other studies that refer to these sets of reforms as "highly successful" (Deininger et al., 2009, pg. 501), "implemented more efficiently than the other programmes" (Appu, 1997, pg *xx*), and "agreed to be one component of reforms that was relatively successful" (Basu and Maertens, 2012). The main reason for this optimistic viewpoint seems to be the official figures that stated the abolition of intermediaries had brought 20 million tenants into a direct relationship with the state (Third Five-Year Plan, 1961). Broad judgements of the reform have also suggested the potential for these to have change the power structures in rural areas (Myrdal, 1986). At the same time, this largely positive picture of these sets of reforms has to be balanced against some substantial limitations. Due to the provision made in different states for 'personal cultivation' most intermediaries were able to keep much of their land legally and were able to evict existing tenants leading to large scale evictions (Appu et al., 1997; Besley et al., 2016). In addition, the scope of the laws meant that they usually provided no protection to under-tenants and share-croppers.

On tenancy reforms, an official report of the government in 1973 expressed dissatisfaction: "In several States in the matter of tenancy reform legislation falls short of accepted policy. And what is even worse, the implementation of enacted laws has been half-hearted, halting and unsatisfactory in large parts of the country. The legal protection given to tenants has been ineffective (Report of the Planning Commission Task Force, 1973)". The effects of tenancy reforms were perverse in many ways as it gave landlords an incentive to prevent tenants from obtaining occupancy rights. Landlords could achieve this by exploiting the two provisions in the legislations that allowed for resumption of land for personal cultivation and for the voluntary surrender of land by tenants. Nevertheless, some studies argue that tenancy reform was among the best implemented reforms with “more limited manipulation and fewer administrative bottlenecks” (Besley et al., 2016, pg. 73). In some states, the reforms did cover large areas - 27% of arable land in Maharashtra and 15% each in Gujarat and Karnataka (Deininger et al., 2009). Finally, the two states most successful in implementing land reforms - West Bengal and Kerala - did so via tenancy reforms.

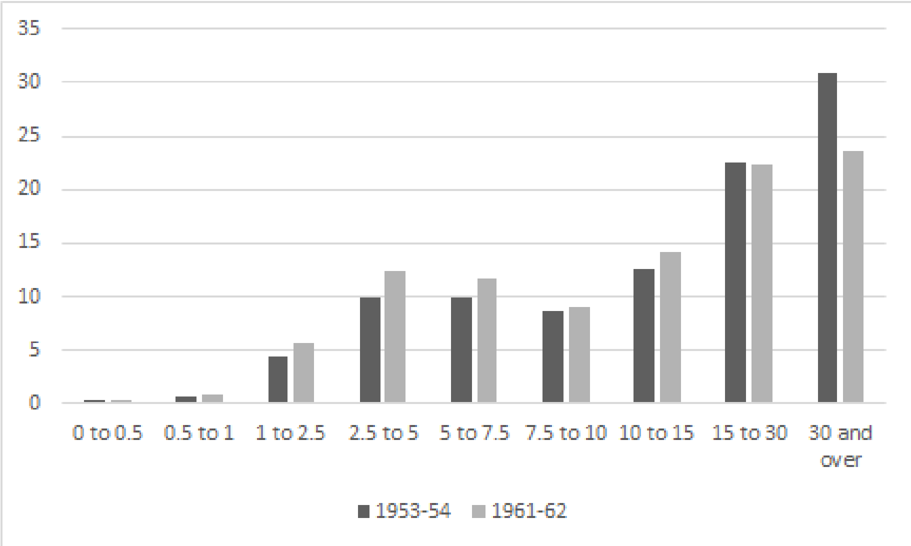
Unlike the other previous two sets of reforms, where reports show considerable disagreement as to the success of the reforms, the judgement on the land ceiling acts is almost unanimously negative. This was partially because there was considerably less clarity in policy terms even from the Central Government regarding the normative benefits of such ceilings or the recommended provisions, and this translated into lax implementation in the various states (Dantwala, 1957; Herring, 1983). The aggregate impacts were disappointing: it was estimated that over 35 years the redistribution achieved through ceilings affected less than 2 per cent of the total operated area (Ray, 1996). In addition, the redistributed land generally comprised small plots of poor quality which would require investment that was infeasibly high (Prosterman et al., 1990; Besley et al., 2016).

There is less research on the effect of land consolidation reforms - partly because its implementation was limited to only a few parts of the country. The initiative for land consolidation being almost entirely at the state level, almost all of the land consolidation took place in a few states in the north and centre of the country (Mearns, 1999).

2.3 Impact of land reforms

Broad judgements aside, the evidence for the impact of reforms is scattered across a range of qualitative and quantitative studies. There is no study that succinctly brings together this evidence. This section will attempt to highlight the commonalities and the discrepancies across this literature. Some of the impacts of land reforms debated in the literature are the impacts on land distribution, income and poverty, and agricultural productivity. Each will be considered in turn. While individual studies may indicate the presence of an equity-efficiency trade off, i.e. lower land inequality came at the cost of lower productivity, it will be demonstrated that on the whole the literature does not support such an hypothesis. This section will further explore two Indian states that were important exceptions to the generally dismal picture - West Bengal and Kerala - and explore whether these have implications for our overall understanding of the effects of the reforms.

Figure 3.1: Distribution of operational holdings, 1953-54 and 1961-62



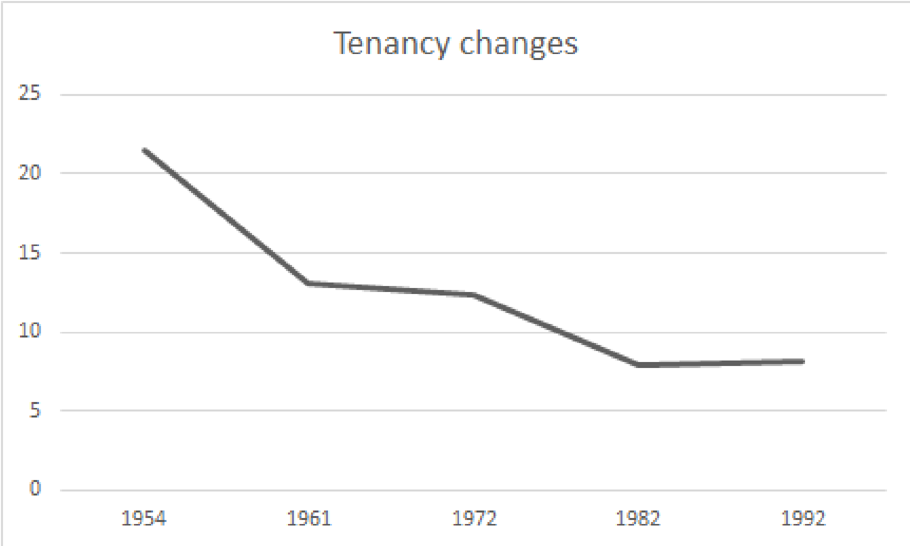
Notes: Authors' calculations of percentage of area across different thresholds of operational holdings, in acres, using National Sample Survey Organisation (NSSO) data.

2.3.1 Distribution of land

The initial round of land reforms, concentrated on the abolition of intermediaries, did have some visible impacts on the distribution of land, in line with reports of their success. There is limited data available, but using National Sample Survey Organisation (NSSO) data some broad characterisations of these reforms can be made. These provide a mixed picture as seen in Figure 3.1. The initial set of reforms seem to have had some impact on the highest category of operational holdings with the area under holdings above 30 acres declining from 31% to 24%, but even by 1962 about half of the total agricultural land was operated in holdings above 15 acres (Figure 3.1). Additionally, the biggest gainers from these reforms seem to have been in the middle of the distribution, with land operated by small farmers in holdings up to 1 acre remaining at around 1 per cent of the total. Crude exercises that categorise states into high reform and low reform states show that those with higher numbers of all land reform legislation saw slightly greater decreases in the land operated Gini (0.017 relative to 0.010) and in the proportion of landless (2.94% relative to 1.49%) (Besley and Burgess, 2000).

Disentangling the results of the tenancy reforms on land inequality is more problematic. The debate hinges on the aggregate impact on tenancy via the abolition of intermediaries and the tenancy reform themselves. The reported tenancies are plotted in Figure 3.2 and display a sharp downward trend in the decades after independence. There are three possible explanations for such a decline in reported tenancy (Ghatak and Roy, 2007). The first is that there could be under-reporting of tenancies. This could be due to a switch to tenancies

Figure 3.2: Decline in reported tenancy



Notes: Percentage of land under tenancy in India from National Sample Survey Organisation (NSSO) data reported in Conning and Robinson (2007).

that were informal or shorter (Ray, 1996). The second could be due to wide scale eviction of tenants, both after legislation and in anticipation of reform legislation. As discussed in the previous section, the first category of land reforms made provisions for former intermediaries to retain land for 'personal cultivation' and the latter category relating to tenancy reforms additionally allowed for 'voluntary surrenders' of land. There is also a large literature on landlords evicting tenants in anticipation of reforms in Latin America (De Janvry, 1981; Pelupessy, 1997). Evidence from India shows that something similar took place: every additional expected tenancy reform reduced reported tenancy by 1.4 percentage points (Conning and Robinson, 2007). The third and final explanation for a reduction in tenancy rates could be the transfer of land from landowners to erstwhile tenants. In states that were successful in implementing tenancy reforms, many tenants became landowners (Appu, 1975). These three explanations would imply different results for land inequality: the eviction of tenants would definitely increase operational land concentration while having indeterminate impacts on owned land concentration, while the transfer of land to tenants would decrease owned land concentration with probably little impact on the distribution of operated land.

Despite these possibilities, state level analyses find little support for any of these channels at the aggregate level. Ghatak and Roy (2007) used a panel dataset of 15 Indian states derived from National Sample Survey (NSS) data and found that the tenancy reform legislation had no significant impact on the distribution of ownership holdings or on the distribution of operational holdings. Research that has used household and village level data and a better methodology, has identified more nuanced and illuminating results. An important study utilised changes in state boundaries and heterogeneity in state level reform, and found that tenancy reforms led to persistent decreases in overall land inequality (Besley et al., 2016). The authors explain their results based on tenancy reforms increasing the productivity of the marginal tenant relative to the marginal owner-occupier due to a decrease in the sanctions available to the owner to extract greater effort from the tenant. However, the results are different for upper and lower castes. While the upper caste households were significantly more likely to own land after tenancy reforms, Scheduled Caste and Scheduled Tribe households were less likely to own land. This is in line with earlier evidence that indicated benefits of land reforms were disproportionately felt by the middle of the distribution, with the worst off not gaining.

Unlike tenancy reforms, there is no systematic evidence of the aggregate impacts of land ceilings and land consolidation on land inequality. The impacts of land ceilings were much derided due to large scale evasion but Lipton (1985) argued that the impacts achieved were reasonable for a non-revolutionary setting. The direct effects of the land ceiling were the seemingly modest redistribution of 4 million acres of land, but studies suggest that the indirect effects were larger (Vyas, 1979). These indirect effects included the disposal of large amounts of land by landowners in anticipation of the implementation of the land ceilings, and although a substantial quantity of this was simply transferred to relatives or clients, the net effect was one of decreasing concentration of land ownership with benefits to small landowners (Lipton, 1985). With regards to the effects of land consolidation, a study set in the state of Uttar Pradesh found that these reforms increased the presence of independent farmers due to increased economic viability of their farms leading to potentially lower tenancy agreements and absentee owners (Oldenburg, 1990).

To summarise, the various land reforms are likely to have had significant impacts on the distribution of land with two important caveats. First, these impacts do not show up strongly in the aggregate data due to significant regional variations (a discussion of which will follow); and second, the change in distribution benefited the middle of the distribution the most, sometimes even at the expense of lower castes and classes.

2.3.2 Agricultural productivity

The evidence of the impacts of land reforms on agricultural productivity at the aggregate level mostly supports a view of insignificant or negative impacts. The approach employed by

Besley and Burgess (2000), using state level panel data, showed that cumulative land reforms had a negative and significant impact on agricultural productivity. In terms of types of land reforms, their analysis indicates that tenancy reform had a negative impact on agricultural productivity, the impact of land consolidation was positive, and both other types of reforms did not have significant impacts. Ghatak and Roy (2007) ran the same analysis with an alternative yield measure. The older study used the ratio of real agricultural state domestic product to net sown area. The later study argued that since the state domestic product defined in this way included livestock, it is likely to lead to measurement error. The alternative proposed was to use crop yield data on 6 major crops to generate measures for average agricultural productivity at the state level. With this alternative variable, tenancy reforms have a positive but insignificant impact on agricultural productivity, while land ceilings and land consolidation legislations have a negative and significant impact.

What could explain any permutation of these results? The negative or null effect of the tenancy reforms is hypothesised to be either due to poor implementation, or due to the relatively strong negative impacts of tenant evictions compared to the improvement in tenant incentives (Ghatak and Roy, 2007). The negative impacts of land consolidation are not explained, but are likely to be a result of their very limited and poor implementation (Niroula and Thapa, 2005). The potentially negative impacts of the land ceiling legislation on agricultural productivity could stem from fragmentation of land into inefficient holdings (Sharma, 1994; Ghatak and Roy, 2007).

As with their impacts on land inequality, a better understanding of the impacts of land reforms on productivity is likely to be found in more micro level studies since the implementation of such reforms varied strongly across the country. An important study by Banerjee et al. (2002) analysed variations in implementation within a better performing state (West Bengal) and found that tenancy reforms increased agricultural productivity where the they were implemented more strongly. A study from the same state found that villages with higher tenancy registrations had significantly higher rice yields, stemming from higher incentives for tenants, but also from a wider package of accompanying reforms implemented at the village level (Bardhan et al., 2007).

To summarise, the best available evidence of land reform legislation supports a somewhat pessimistic view of their impact on productivity at the aggregate level. But evidence from regional studies suggests that tenancy reform, if implemented well, had positive impacts on agricultural productivity.

2.3.3 Poverty and income

Despite the various limitations in the reforms, there is evidence that land reforms had favourable impacts on poverty, wages, income and human capital.

Higher intensity of land reform as measured by the number of reform legislation across states has been shown to have been negatively associated with state level poverty and positively associated with agricultural wages. State level analysis showed that such a result was driven by the abolition of intermediary and tenancy reform legislation, and these reforms were correlated with reductions in rural poverty in particular (Besley and Burgess, 2000). The significant positive impact of tenancy reform on agricultural wages, and by extension the welfare of the landless, has also been verified using household level data (Besley et al., 2016). One of the major limitations of these studies is that they only measure the intent to reform, not the implementation.

Deininger et al. (2009) used a household data set and actual implementation measures - the share of rural population that received land due to tenancy reforms or the amount of land redistributed due to ceiling laws - and showed that both tenancy and land ceiling reforms were positively associated with increases in income, consumption and total assets. In addition, their work indicates that the benefits of both these reforms were felt by all sections of society, but the beneficial impact on the poorer sections was stronger. Finally, this analysis concluded that tenancy reform was directly associated with higher years of schooling, although this was not the case for ceiling reforms, which suggests in the latter the indirect effects may have been more important.

To summarise, there is a consensus that land reforms did have beneficial growth and income impacts, despite their perceived success being limited. The most robust evidence for positive impacts relates to tenancy reforms, but there is also some suggestion that the abolition of intermediaries and ceiling acts led to favourable outcomes.

2.4 The exceptions - West Bengal and Kerala

The evidence examined so far, seems to suggest that while there were clearly some significant shortcomings in the scope and implementation of the different reforms, important benefits did accrue from them. In this context, the states of West Bengal and Kerala are particularly relevant as they are known to have made considerable progress in land reforms. These states passed high numbers of reform legislation but also implemented the reforms more thoroughly. In West Bengal and Kerala, tenancy legislation affected a relatively large percentage of the area

(6.41 and 8.47 respectively) and the area transferred as a result was to over 10 percent of their respective populations - indicating a more pro-poor bias relative to other states (Deininger et al., 2009). For ceiling legislation, West Bengal was an even bigger outlier as these reforms affected 15 per cent of the area and almost 20 per cent of the population when no other state even hit two-digit figures (Deininger et al., 2009). The remainder of this section will consider the experiences of these two states in particular, and their implications for our understanding of the aggregate results.

The positive results from West Bengal, a former *zamindari* province, stem largely from reforms implemented after the election of a communist government in 1977. Prior to this, legislation was passed, but no significant progress seems to have been made. After 1977, the state distributed a large quantity of land to landless households and also launched *Operation Barga* which led to the registration of over 1.3 million sharecroppers between 1979 and 1985 (Bardhan and Mookherjee, 2010; Appu et al., 1997). When Ghatak and Roy (2007) re-ran the analysis of Besley and Burgess (2000) but included an interaction dummy for the state of West Bengal, they found that the effects on land reforms in West Bengal were significantly different, in the positive direction, relative to the rest of the country. Even more dramatically, these same authors found that while analysis for all of India shows that land reforms had no overall impact on the Gini coefficient for land, if West Bengal was excluded, higher tenancy reform *increased* land inequality. This suggests that landlords were able to evict tenants in most of the country, but not in West Bengal.

Tenancy reforms in Kerala are also acknowledged to have been both radically framed, and well implemented (Appu et al., 1997). Herring (1990) studied Kerala as an anomaly in the Indian land reform narrative and highlighted profound social and economic transformations via the implementation of tenancy reform. The numbers back up this claim. The Kerala Land Reforms (Amendment) Act began to be implemented in 1970 and it clearly stipulated that all tenanted lands would henceforth belong in the government. Upon a payment of a nominal price, the tenants could obtain ownership rights over this land. This Act addressed tenants across different tiers - both superior tenants but also inferior tenants ('homestead tenants') - and led to the transferring of land rights to around 1.25 million tenants (Radhakrishnan, 1981). Land ceiling elements of this reform enjoyed significantly more modest success, due to the fact that the gap between their announcement in 1950s and implementation in the 1970s gave landlords the opportunity to take anticipatory steps by rearranging their lands across individuals (Herring, 1990). The exceptionalism of Kerala has not so far been analysed in replications of country wide analyses, but evidence suggests it is likely to be important.

2.5 Explaining regional variation in land reforms

The previous sections have provided detail on the types of land reforms, and their perceived and actual successes. The fact that there was regional variation has been emphasised, not least in the discussion of West Bengal and Kerala, but this section will focus on attempting to understand the major causes for the failure of land reforms in some places, and its success in others. It will make the argument that the level of commitment to reforms in state politics, the power of landlords in the countryside and state capacity were all important determinants of reform.

The regional variation in the success of land reforms shows some correlation with historical land tenures. There is little evidence that the number of legislative acts passed in formerly landlord states was significantly different compared to non-landlord states, either overall or within categories of reform such as tenancy reform (Besley and Burgess, 2000). There is strong evidence that there was significant variation in the actual scope and impact of the reforms, however. Tenancy reform, which had the most robust positive impacts where implemented, identifies this difference very strongly. Using data from Deininger et al. (2009) and state classification as per Banerjee and Iyer (2005), tenancy reforms affected 1.45% of the area and 2.16% of the population in formerly landlord states compared to 9.42% and 5.4% in formerly non-landlord states. If we exclude West Bengal, the performance of formerly landlord states gets even worse as, on average, less than 0.5% of the population and area was affected by tenancy reforms. The impact of land ceiling legislation was felt by a larger proportion of area and people in landlord areas but this is to be expected, given the higher historical inequalities. The abolition of intermediaries and the land ceiling laws did equalise the largest landholdings across landlord and non-landlord states, but even up till 1990 landlords areas had 8 percentage points higher marginal landholdings (Banerjee and Iyer, 2005).

The rest of this section will delve into the proposed causes for the success or failure of reforms - varying political will, landlord power in the countryside, and differential state capacity - and where appropriate highlight how these related to historical land tenure institutions.

2.5.1 Political will

Political will, or the extent of commitment of policymakers to a given set of policies, has repeatedly been highlighted as one of the key fundamental reasons for the success or failure of reforms in different contexts (Otsuka, 1991; McCourt, 2003). This theme occurs repeatedly in the discussion of Indian land reforms where the federal nature of the state gives scope for political lethargy at different levels. The lack of political will manifests itself in the inclusion of the various caveats and loopholes in the reform legislation. Many of these have already been discussed. For instance, the biggest limitation in the scope of the intermediary abolition Acts enacted in different states, was that they all made allowances for intermediaries to retain land for 'personal cultivation'. As a consequence, contemporary observers found that in Bihar, an ex-*zamindari* state, it was "not difficult to come across estates of 500, 700 or even 1000 acres" (Thorner, 1955, pg. 33-34). The various laws also made provisions for generous compensation to be given to ex-intermediaries thereby enriching them, and enabling them to acquire new land (Mearns, 1999). In tenancy reforms, allowances for 'personal cultivation' and 'voluntary surrenders' had perverse effects. Ceiling laws, apart from setting the ceiling too high, also allowed partition of land to escape the effects of the laws. Even after this problem came to light many states were slow to act, some like Bihar still permitted transfers to family members within 12 months, and some like Orissa did not act at all (Januzzi, 1974; Appu et al., 1997).

The implementation of the these laws was poor due to factors discussed in the next few sections, but political will would have gone a long way in overcoming these. Indeed, in the exceptional cases of West Bengal and Kerala, it is the strong political commitment to reform that is most apparent. In West Bengal, the aforementioned Operation Barga was initiated in 1977 with the new left wing government, closing prior loopholes specifically related to the clauses for 'personal cultivation'. In addition, there was huge commitment to implementation - government officials would tour villages and attempt to register as many sharecroppers as possible (Bardhan and Mookherjee, 2002). This led to Bengal being an outlier where around 1.5 million share tenants were registered by 1993, and redistribution of land amounted to 6.72 per cent of operated area (Bardhan and Mookherjee, 2002; Appu, 1997). Similarly in Kerala, strong political will, complemented by agrarian mobilization, resulted in the 2.8 million tenants acquiring ownership rights by 1992 (Appu, 1997, pg 115) making tenancy reforms a success in the state.

What determined the presence of political will in a particular region? The evidence suggests that the presence of the Congress party and other 'soft left' parties in the state legislature reduced the probability of enacting land reform legislation, with the negative influence of the Congress party significant for all types of reforms, but stronger for tenancy reforms and abolition of intermediaries (Besley and Burgess, 2000). The presence of hard left parties increased the probability of land reform legislation, and there is also evidence in particular that the presence of elected left wing representatives *along* with higher political competition increased the enactment and implementation of reform legislation (Besley and Burgess, 2000; Conning and Robinson, 2007; Bardhan and Mookherjee, 2010). A study using village level data from West Bengal found that the share of left seats in the local Gram Panchayat had an 'inverted U' shaped relationship with land redistribution, and that reform activity was stronger just prior to elections (Bardhan and Mookherjee, 2010).

This empirical evidence makes it important to better understand why exactly the Congress and the soft left deterred progress in land reforms. One explanation is that landed interests were particularly dominant in such parties which led to a decrease in political will; the Congress party for example, often included many landholders, including ex-intermediaries in its ranks (Brass, 1984). Many of the elected representatives from the Congress also had landed interests. In a survey of five Indian states, Chopra (1994) found that over half of the elected Congress legislative assembly members had an occupational background in agricultural where they were generally absentee landlords (Chopra, 1994, pg 93). In contrast, only 11 per cent of Communist Party (CPIM) members were employed in agriculture (Chopra, 1994). This contrast was also reflected in the background of the legislators: the majority of the Congress legislators lived in urban or semi-urban areas and the majority of Communist legislators lived in rural areas. Even more interestingly, a quarter of Congress legislators surveyed reported being born in rural areas but having moved to urban areas, thus giving credence to the presence of absentee landlords amongst the Congress (Chopra, 1994). An analysis on the basis of caste in the state of Karnataka found that the majority of the legislature was dominated by the traditional landowning castes, the same castes that also comprised the majority of large landlords in the state (Thimmaiah and Aziz, 1983). The study further argued that the re-organisation of political parties in the state, and the subsequent election of backward communities to the legislature directly led to the enactment of more radical land reforms in 1974.

Even if the majority of politicians or members belonging to a particular party did not have landed interests themselves, the presence of multi-class interests in the overall party or ruling coalition would lead to ideological incoherence and failure to reform (Kohli et al., 1987). This is relevant as evidence from the state of Uttar Pradesh indicates that ex-*zamindars* were very successful in retaining considerable power in the new democratic and economic institutions, and the presence of fragmented interests within state governments led directly to ideological and practical reticence in the matter of land reforms (Metcalf, 1967; Kohli et al., 1987). The role of political fragmentation was also important at the state level in reducing the number of reform laws enacted (Conning and Robinson, 2007). In this sense, greater conflict and ideological heterogeneity in formerly landlord states could have played a role in preventing a radical reform programme from being implemented.[6]

To summarise, the lack of political will was a critical impediment to the success of the reforms. This lack of will was related to the presence of strong landed interests in major political parties such as the Congress, while greater political fragmentation arising from even minority landed interests adversely affected the commitment to reform.

2.5.2 Power of the landlords

Apart from influencing reform legislation through their power in state legislatures, landlords also held a great degree of economic and social power across India. This section will consider the many ways in which this power was exerted to stymie the progress of land reforms.

In the years immediately after independence, landlords often challenged the legality of reform legislation leading to significant delays. This is illustrated most starkly in the experience of the intermediary abolition laws in the formerly landlord state of Bihar. The first land reform act in Bihar - the Bihar Abolition of Zamindari Bill - was published in 1947 as per the national priorities of targeting ex-*zamindars* but the powerful landlords immediately lodged legal objections. They sought injunctions from the court and argued that such acts violated the constitutional right that guaranteed people equal rights and protection under the law, and also fought over the compensation amounts. Their efforts led to the court striking down the Bihar Act. The Central Government responded to this by passing the first amendment to the Indian constitution which validated the various intermediary abolition laws by explicitly providing exceptions to the fundamental rights and vesting power in the state governments to acquire estates (Gae, 1973). Having failed to stop the passage of this amendment the landlords challenged its validity in the Supreme Court, which in 1952 upheld the constitutional amendment and thereby validated the Bihar Land Reforms Act (Merillat, 1960). The five years of delay before the law even began to be implemented allowed landlords to rearrange their holdings to minimise any eventual impacts of the reforms (Januzzi, 1974).

Apart from the legal channel, landlord power also manifested in lobbying in state legislatures. An apt example of this comes again from Bihar. In 1954, the state government tried to devise tenancy reforms to protect the sub-tenants against dispossession of their land and limit the produce they had to pay to 35 per cent. This came under significant opposition from

[6] The exception of West Bengal where the peasant organisation was strong has been partly attributed to widespread peasant mobilisation under communist leaders after the Bengal famine of 1943, that laid the basis for future electoral successes in the state (Huizer, 1999).

landowners with much of the anger directed against the provision that allowed the sub-tenant to claim a summary inquiry for restoration of their land. The opposition from landed interests was pressed through prominent members of the Congress party, local Bar associations and even government employees (Thorner, 1976, pg 34). In response to the opposition, the proposals were shelved for the time being and the bill was sent back for revision. Provisions regarding sub-tenants were subsequently included in the Bihar Land Reforms Act of 1961 but the previously controversial clauses were dropped. This example is particularly revelatory as in this case, both the Chief Minister and the Revenue Minister of Bihar, were fully supportive of the 1954 proposal, but it was still not possible to implement it.

Landlord power over the rural countryside could be even more complete. The lax laws enacted for the tenancy reforms similarly gave scope for abuse by landlords. Recall that the tenancy laws permitted landlords to resume land for 'personal cultivation' and that this led to a wide-scale eviction of tenants across the country. The power of the landlords was also visible in the 'voluntary' surrenders of property by tenants, that were far from voluntary and often pushed through by threats (Appu, 1997, pg 101). Data from Hyderabad shows that in areas of greater historical landlord power (*jagirdars*) compared to non-landlords areas, there were a higher percentage of legal evictions (2.56 to 0.79) and illegal evictions (22.14 to 6.65) of tenants, and also a substantially higher percentage of 'voluntary' surrenders (17.83 to 6.39) (Eashvariah, 1985).

Landlord control over land records was also an important roadblock in reform implementation. In the laws dealing with abolition of intermediaries, after the government overcame the legal hurdles, ex-intermediaries in many parts simply refused to share land records that were essential for calculating the compensation due and hence for implementation. The government was forced to go to court to force the landlords to share the records, leading to further crucial delays (Appu, 1997). The availability of the land records aside, evidence suggests that these were manipulated by the landlords. This was of concern for ceiling laws in particular, as despite overly generous ceilings and plentiful exceptions, there is wide scale evidence that landlords were able to bribe or influence the village accountants and divided their land into multiple holdings across near and distant relatives (Ladejinsky, 1972). The processes set in place to correctly dispose of ceiling or tenancy applications themselves were also not immune to landlord pressures that could often slow down the pace of such disposals (Thimmaiah and Aziz, 1983).

This section shows there is clear evidence that landlords used their economic and social power to subvert land reforms, from using the judiciary to delay implementation and preserving key loopholes in legislation via lobbying to using their control over rural India to evict tenants or manipulate land records.

2.5.3 State capacity

From the literature, the final set of reasons for the ineffectiveness of land reforms can broadly be placed under the umbrella of inadequate state capacity. These reflect the idea that even if there was political commitment, and the landlords could somehow be brought on board, the lack of state infrastructure at the village level would still remain a serious impediment to the swift implementation of land reforms. This is relevant as policies or programmes designed to alter existing economic and social configurations relied themselves on available state capacity.

Large parts of the country had minimal state presence in rural India. This was particularly true of areas where the land revenue in colonial times had been permanently settled i.e. the *zamindari* areas. Lee (2019) has documented that the local bureaucracy was smaller and tax raising capacity was significantly lower in landlord areas compared to non-landlord areas. This historical divergence had two important implications for post-independence land reforms. Firstly, it lowered state capacity through fewer state bureaucrats and worse land records. In states that were predominantly non-landlord there was a well established revenue hierarchy going down to the village level, but in states like Bihar, West Bengal and Orissa that had historically been in landlord provinces, organisations had to be set up essentially from scratch (Appu, 1997, pg 68). The result was that “progress was comparatively easy in temporarily settled areas... where adequate records and machinery existed” but not in landlord areas where “land records and revenue administration had to be built up almost from the beginning” (Govt of India, 1956).

Secondly, the state infrastructure in formerly landlord provinces was more pro-landlord and more corrupt. The potential of manipulated land records to entangle cultivators in costly legal proceedings meant the accountants had huge leverage, and it was found that village accountants tended to side with the wealthiest landlord class against the cultivators (Appu, 1997, pg 69). A study by Pandey (2010) found that villages that were historically under landlord control had persistently less functional and more corrupt local governments compared to villages without the historical presence of an elite class of local landlords.

2.6 Conclusion

The land reforms enacted in post independence India had noble aims to ultimately give land back to the tiller. However, the impact of the body of land reform legislation fell well short of this. But as the first major effort to tackle historical land ownership structures in Independent India, analysing the reforms gives us an idea of how and what they were able to change in rural India. The abolition of intermediaries, for instance, was relatively successful but where it succeeded the land was transferred from the large colonial landlords to the richer peasants. The tenancy reforms also had some success, with evidence for impacts on poverty and inequality, but these reforms also led to the mass evictions of tenants to the benefit of richer owner-occupiers who gained in strength. Land reforms to implement ceilings were crippled from the start from lack of will although they did achieve limited success, while the overall impact of land consolidation was constrained by being severely limited in geographical scope.

Apart from bringing together a swathe of literature on the impact of land reforms (qualitative and quantitative, old and new), Section 2 proposed three key reasons for the nature of the impacts of the land reforms. All of these - the lack of political will, the power of the landlords, and state capacity - are related to different degrees to the historical land tenure institutions and illustrate some degree of lock-in. The first two reflect the power of the landlord class at different levels: in the political sphere, in their ability to litigate, and in their potential to subvert the intent of land records due to their control over village life. This power was exercised to limit the change in the *de jure* institutions via the inclusion of various loopholes, but more broadly this power reflected the relatively steady nature of the *de facto* institutions that prevented the state from credibly committing to changes in the rules (Voigt and Gutmann, 2013).

One of the most important elements that emerges from the analysis here is that any discussion on the impacts of land reforms needs to incorporate states like West Bengal and Kerala carefully, as these states are strong exceptions that were able to enact and implement strong land reforms, overcoming obstacles on the back of a strong political will and backing from the peasantry. The strong political commitment stemmed mainly from the election of left wing parties with fewer landed interests that then actively closed loopholes and implemented reforms thoroughly.

The uneven implementation and the intended and unintended impacts of the reforms deserve a more prominent place in conversations about long run Indian development, for their role in maintaining the status quo while also in making key changes in rural Indian society that would be of relevance in the following decades.

3 Green Revolution

The Green Revolution refers to the development of modern High Yielding Varieties (HYVs), initially for wheat and rice but then for a number of other crops such as sorghum, millet and barley, that saw substantial increases in agricultural productivity across the developing countries focussed but not limited to the years between 1965 and 1990. It is best described as “an increase in the rate of growth of agricultural productivity, based on the application of modern crop breeding techniques to agricultural challenges of the developing world” (Gollin et al., 2018, pg 2). The first modern varieties emerged from two agricultural research centres - the International Center for Wheat and Maize Improvement in Mexico (CIMMYT) and the International Rice Research Institute (IRRI) in the Phillipines. These were joint initiatives between the governments and philanthropic organisations such as the Rockefeller Foundation and the Ford Foundation. Eventually, 16 such centres were opened up worldwide (Evenson and Gollin, 2003).

The HYVs developed had broadly three defining characteristics. The first was that the new cereal varieties were ‘dwarf’ varieties that had shorter stalks. This meant the plants spent less energy on producing grain or straw material and more on producing grain but crucially also meant that the plants could support the additional grain without falling over (Evenson and Gollin, 2003; D’Agostino, 2017). The second key characteristic of particular HYVs was that they could mature faster, and the resultant decrease in time to harvest allowed farmers to cultivate more crops around the year (Pingali, 2012; D’Agostino, 2017). The third important feature of all HYVs was that they were much more responsive to the use of chemical fertilizers (Evenson and Gollin, 2003). Additionally, such varieties were also more reliant on the availability of a constant supply of water. The trends in agriculture that accompanied these modern varieties included therefore, an expansion in irrigation and the use of agricultural machinery to support large scale farming, along with increases in infrastructure supported by government intervention (Hazell, 2009).

The spread of HYVs was rapid in all developing countries and also in India. This was most apparent for HYV wheat which comprised 70% of all wheat grown in India within a decade of its introduction in 1966 (Parayil, 1992). In contrast, HYV rice suffered from multiple issues that slowed its expansion. These varieties were more vulnerable to diseases, went against local preferences in that they were sticky or chalky, and had lower profit margins relative to wheat (Swaminathan, 1969; Chakravarti, 1973; Roy, 1971). Nevertheless, 50% of rice grown in India was of the modern varieties within two decades (D'Agostino, 2017). The progress with regards to other crops was slower still. For many of the crops suitable to dryer climates such as sorghum, millet and barley the first HYVs only emerged in the 1980s resulting in late adoption (Evenson and Gollin, 2003).

3.1 Summary of impacts

This section will summarise the various impacts of the Green Revolution with specific reference to India. As outlined below, the Green Revolution increased agricultural production, lowered prices, increased nutrition and health, increased demand for education and had significant impacts on the economy as a whole. While these substantial benefits are well established, there is also research on potentially adverse consequences in relation to inequality and the environment.

The most visible direct effects of the Green Revolution were felt on agricultural yields and productivity. The average annual growth rate of agricultural yields in Asia was 3.12% between 1961 and 1980 and 2.09% between 1981 and 2000, resulting from the adoption of HYVs and associated inputs such as fertilizer and irrigation (Evenson and Gollin, 2003). According to counter-factual simulations crop yields in developing countries would have been 19.5-23.5% lower if HYVs had not been introduced (Evenson and Gollin, 2003). Cereal production grew 3.57% annualy in Asia between 1967 and 1982, with the highest impacts on wheat (Hazell, 2009). In India, between 1970 and 1995, cereal yield increased from 0.925 t/ha in 1970 to 1.743 t/ha in 1995 and cereal production increased from 92.8 million metric tonnes to 174.6 million metric tonnes (Hazell, 2009). The Green Revolution in India was timely in that in the mid-1960s India was witnessing low incomes, rising unemployment and was heavily dependent on foreign aid to satisfy its food requirements (Dasgupta, 1977; Parayil, 1992).

The immediate results of significantly higher food production was lower food prices and higher nutrition intake across deveoping countries. According to the estimates of Evenson and Gollin (2003) prices were 35-66% lower, calorific intake 13-14% higher and the Green Revolution managed to raise the health status of 32-42 million preschool children. This proved particularly important for poor people (Rosegrant and Hazell, 2000; Fan, 2002). There is also plenty of research in the Indian context. For example, Pinstrup-Andersen and Jaramillo (1991) studied villages in the district of North Arcot in South India and found that the introduction of HYVs led to an increase in rice production which in turn led to household calorie intake increasing by up to a two-thirds and protein intake doubling between 1974 and 1984. Smaller farmers continued to have lower levels of consumption but saw bigger increases during this period. Similarly, Ryan and Asokan (1977) found that there was a net increase in the consumption of both calories and proteins in 6 wheat growing states on India, despite some evidence of pulses being substituted for HYV wheat.

The extended impacts were felt on fertility, mortality and human capital investments. Evidence from India has indicated that the Green Revolution decreased fertility by increasing female wages and by inducing higher human capital investment in children, while there is also independent evidence of positive effects of HYV adoption on the demand and supply of schooling (Foster and Rosenzweig, 2007, 2004). At the same time, there is also evidence that adoption of HYVs substantially reduced infant mortality and these effects were felt most strongly for rural and poorer mothers. The effect on infant mortality is hypothesised to be a combination of an income effect, a decrease in distress labour market participation and a reduction in exposure to negative income shocks (Bharadwaj et al., 2018). Results from a cross country analysis suggest that higher adoption of HYV seeds was associated with significant decreases in mortality rates across ages and genders, decreases in fertility, but due to the relative size of these effects - an overall decline in population growth (Gollin et al., 2018). The estimated effects of the Green Revolution on population indicate that a 10 percentage point higher HYV adoption rate in a country was associated with a 5 percentage point decrease in population (Gollin et al., 2018).

Finally, the Green Revolution has also been associated with significant impacts at the macroeconomic level. A 10 percentage point increase in the share of area under HYVs in 2000 was associated with a 10-15 percentage increase in per capita GDP, with linked evidence that structural change in the economy, caused by higher productivity in the primary sector, was an important channel for the effect (Gollin et al., 2018; Rangarajan, 1982).

Whilst the above paragraphs have identified the positive effects of the Green Revolution, research has also identified adverse impacts of the Green Revolution. Specifically, there are concerns that the spread of HYVs and the accompanying practices came at an environmental cost, and that the benefits were enjoyed by larger farmers leading to higher inequality. Some of the key environmental concerns related to the advent of HYVs and the required inputs are the environmental impacts of excessive fertilizer use[7], increasing soil salinity due to intensive

[7] For example, some work on India has found that water pollution potentially caused by excessive use of fertilizers is associated with higher infant mortality (Menon, 2013). However, in the absence of reported magnitudes it is hard to put these results in proper perspective.

irrigation and water scarcities - both in rivers and underground- caused by higher water requirements (Dogra, 1986; Shah et al., 2003; Hazell, 2009). Research on inequality within adopting regions has come to mixed conclusions, with older studies on the initial impact finding that larger farmers received most of the benefits, but subsequent studies recording more favourable long term impacts on inequality (Hazell, 2009).

3.2 Regional variations in the application of Green Revolution in India

The previous section has shown how and why in general the Green Revolution had far reaching impacts, but the success of the Green Revolution varied widely within adopting countries and regions. In India, the variation between states was dramatic. By 1985, many states like Punjab, Haryana and Tamil Nadu had at least 80% of their area under HYVs while others like Orissa, Madhya Pradesh and West Bengal hovered around 40%. Perhaps even more interestingly, some states like Bihar did expand their use of HYVs to 60% of the area but still lagged behind in their use of inputs such as fertilizers and in their agricultural productivity (Das, 1999). Associated evidence suggests these variations across the country made a meaningful difference. There was a visible increase in regional inequality and poverty figures were negatively correlated with agricultural productivity in different states (Ninan, 1994; Das, 1999). Given the significant role of the Green Revolution in raising agricultural productivity, improving human capital and reducing poverty, it is important to analyse the underlying causes of success or failure in different regions. The rest of this section will summarise the existing literature on this, before some new evidence is presented in the next section.

The most straightforward explanation for differences in the spread and success of HYVs can be found in geography. The spread of HYVs was most successful in regions that had favourable climate - low humidity and plentiful rainfall - and in particular soils for particular crops such as wheat in the Indo-Gangetic plains (Patnaik, 1986). This was the reason for the immediate success of wheat; while the Indo-Gangetic plains provided consistent and uniform geographical conditions in a contiguous area, regions that grew other crops were interspersed across the country (Dasgupta, 1977). The importance of soil characteristics and presence of underground aquifers has also been used to predict the spread of the Green Revolution. For instance, D'Agostino (2017) records that groundwater rich districts had 21 percentage point higher area planted with HYV crops.

However, other analyses have focussed on the historical preconditions that created more conducive conditions in some areas relative to others. The literature on this topic coalesces around three key conditions for the success of the Green Revolution - long run public and private investment, the presence of an owner-occupier class of peasants, and the role of the state during the Green Revolution. There is evidence that historical land revenue institutions interacted with each of these leading to serious path dependent impacts on the Green Revolution.

There is a literature, for example, that emphasises the fact that areas that were not under the *zamindari* landlord based system were already more commercialised (Byres, 1981). These features meant they had the preconditions for the new agricultural techniques to be successful. In addition, there are multiple reasons why areas that were not under landlords would have higher access to infrastructure. Firstly, the construction of irrigation canals was concentrated in the non-landlord regions, particularly in Punjab (Whitcombe, 1983). In Chapter 2, this thesis also found evidence for lower historical (tanks) and post-independence investment (tube-wells) in irrigation in zamindari villages compared to raiyatwari ones. Irrigation was a key prerequisite for HYV cultivation to be possible, and this was likely a significant disadvantage for such areas. Secondly, there is some evidence that, particularly in states with mixed land tenure types, railways would often circumvent landlord estates due to difficulties associated with uncertain property rights and the threat of litigation (Baker, 1984). Potentially lower access to the railways is likely to have contributed to lower pre-existing market access and commercialization[8], and also have been a disadvantage as the new technologies diffused. Thirdly, given higher revenues could be extracted from non-landlord areas, there was historically a greater incentive to invest in other public goods such as education (Chaudhary, 2010a). Research has shown literacy and education to be important determinants of technology adoption in developing countries - in India, an interesting analysis found that literacy was a strong contributor to HYV adoption in the post independence period (Mittal and Kumar, 2000). Finally, there is a literature that argues the rent-usury barrier - whereby landlords exploited high inequality to extract profits from higher rents and usury rather than productive investments - was a serious historical problem in India. This research suggests that this led to variations in private investments, in part related with historically higher inequalities that were in turn related with land tenure type (Bharadwaj, 1982; Das, 1999).

The second broad precondition for the success of the Green Revolution was the presence of a dominant class of rich peasants who owned small to medium plots of land. This class of rural elite was the product of historical institutions but also, crucially, was brought to

[8]For a historical analysis of the importance of railways to the expansion of cash crops and market intergration, see Hurd II (1975) & Donaldson (2018).

the forefront by the attempted land reforms that preceded the introduction of HYVs. In the non-landlord raiyatwari and mahalwari regions there was historically a larger class of self cultivators as opposed to absentee landlords (Das, 1999).[9] This cultivating class had higher rates of capital accumulation, employed wage labour and were already more market oriented (Byres, 1981). The land reforms implemented after independence, discussed at length in the previous section, had important impacts. Banerjee and Iyer (2005) consider land reforms as one of the potential channels for the long run institutional impacts they find, but only consider their role in reducing land inequality, and discount them as being a key channel. However, as seen in Section 2, land reforms had more wide ranging and nuanced impacts. Two of these impacts are particularly relevant here. Firstly, land reforms were relatively successful in abolishing intermediaries from which the clearest gainers were the richer strata of rural peasants. Secondly, the implementation of the tenancy reforms had the unintended consequence of mass eviction of tenants. The eviction of tenants occurred in both landlord and non-landlord regions, but there is evidence that there were more blatant evictions in landlord areas due to insecure property rights (Eashvaraiah et al., 1985). However, the crucial difference was that in non-landlord areas small to medium cultivators were more common and were able to consolidate power and dominate the countryside while also gaining political influence at the state level (Dasgupta, 1977; Byres, 1981). The extent to which the abolition of large landlords and the unintended consequences of tenancy reforms affected evictions is evidenced by the statistics. In Punjab, one of the epicentres of HYV adoption, the area under owner occupiers increased rapidly from 51% in 1947 to 66% in 1957 and finally to 80% in 1970 through a combination of evictions and land resumption (Dasgupta, 1977).[10] But why was this class of rich peasants so important? Essentially, this strengthened rural class was crucial because it was able to acquire greater access to information, greater access to credit and higher literacy which made it best placed to adopt new technologies (Byres, 1981).

The third vital condition that was needed for a successful HYV take off revolved around the role of the state. The pre-existence of infrastructure and resources and/or a class that was in a position to exploit and obtain them, would not have in itself been sufficient. The import of HYV seeds and their initial distribution was very much a state initiative. The Green Revolution was based on a "selective approach" that targeted "progressive farmers" via an allocation system that worked through pre-existing village level institutions (Dasgupta, 1977). This conscious policy choice to target certain regions with favourable conditions and

[9]Even in 1990, small to medium holdings constituted 48% of all holdings in formerly non-landlord areas, while the corresponding figure for formerly landlord areas was 35% .(Banerjee and Iyer, 2005)

[10]It is probable that evictions were partly driven in such regions by the potential for agricultural profits due to higher long run infrastructure investments discussed in the previous paragraph.

certain type of cultivators - the very same rural elite discussed above - was based on a desire to maximise the chances of success (Byres, 1981). Another important aspect of this targeting was that it was accompanied by significant public investment which was also spread unevenly across the country. This public investment, in irrigation, in subsidies and in institutional credit, increased the profitability of agriculture in certain areas thereby inducing higher investments in new technologies, but crucially it also came at the cost of other regions being deprived of such investments (Das, 1999). The importance of public investments was also highlighted by Banerjee and Iyer (2005) who argued this was the most important channel for the persistence of long run institutional impacts. As per their paper, more conflict in the landlord regions of India led to under-investment in development relative to regions that were based on non-landlord land tenure systems in colonial India. Further, the political strength of the rural class established both historically, cemented through the land reforms in the 1950s and 1960s, meant that the productivity enhancements in successful regions were not efficiently taxed by the state to alleviate the initially unequal allocations (Das, 1999).

The literature discussed above provides indications for how the impacts of the Green Revolution were distributed unevenly across space, not just because of fundamental differences in geography, but also and critically, due to differences between public and private investments, colonial revenue systems, the role of the state, and the various interactions between these.

3.3 Further analysis

In this section, some further exploratory analysis is presented. The starting point of this analysis is that an important geographical feature that varied across regions has been neglected in the existing literature. Chapter 1 showed the importance of rainfall shocks and volatility for historical development, and the importance of rainfall patterns for patterns in food production is well established (Krishna Kumar, 2004). However, the relevance of weather risk is also likely to have been important in determining the ability of peasants to adopt new technologies. This is well established both theoretically and empirically in the literature (Foster and Rosenzweig, 2010). But there is no analysis that explicitly looks at risk associated with uncertain rainfall and its impact on agricultural productivity during the years of the Green Revolution. There are plenty of hints that it was important. For example, Evenson and Gollin (2003) say that HYVs were "rapidly adopted in tropical and subtropical regions with good irrigation systems or reliable rainfall" (pg. 758), and in the Indian context Bharadwaj (1982) suggests that the lowest productivity regions were "areas of uncertain rainfall and of no assured irrigation" (pg 612). I put this to a simple test.

For this, the India Agriculture and Climate dataset[11], that has been widely used in various studies (including Banerjee and Iyer 2005) is used. This dataset includes district level measures for the share of area under HYVs, the yields for various crops as well as basic geographical variables including soil type and average rainfall. To this, I merge monthly rainfall data from the India Water Portal[12] so that I am able to calculate both annual and monsoon level variability in district level rainfall. In the first instance, the following equation was estimated:

$$y_{it} = \beta_0 + \beta_1 NL_i + \beta_3 RV_i + \beta_3 IRR_{it} + \alpha_t + X_{it}\gamma + e_{it} \qquad (1)$$

where y is the outcome of interest in district i and year t, NL is the proportion of the district that was historically not under landlords based on Banerjee and Iyer (2005)'s measure, RV is a the rainfall variability over a thirty year period calculated as coefficient of variation for district level rainfall, IRR measures the proportion of area irrigated in district i in year t, *alpha* is a full set of year fixed effects and the vector X contains other controls. This specification is very similar to Banerjee and Iyer (2005) with two significant differences: I include the newly constructed variable of rainfall variability as an explanatory variable and I also include irrigation as an explanatory variable. Irrigation has been shown to be endogenous to the measure of institutions, so in part, irrigation will capture a specific channel through which institutions may have an effect. As a next step, dummies have been included for four quartiles of districts based on their level of irrigation and include an interaction between the irrigation quartile dummies and the rainfall variability variable. This yields the following model to estimate:

$$y_{it} = \beta_0 + \beta_1 NL_i + \beta_2 RV_i + \beta_3 IRR_{it} + \beta_4 RV * IRR_{it} + \alpha_t + X_{it}\gamma + e_{it} \qquad (2)$$

In both specifications, errors are clustered at the district level. The results are presented in Tables 3.1 and 3.2. Column 1 of Table 3.1 reports results for equation (1) with the share of area under HYV rice, wheat and other cereals as dependent variables across the three panels. Controlling for irrigation and also including rainfall volatility reduces the coefficient on non-landlord proportion but these historical institutions are still significant. The coefficient on rainfall volatility that captures the weather associated risk of a district is significant and negative for rice and cereals. The coefficient implies that a one standard deviation increase in the rainfall variability associated with a district was associated with a 3 percentage point

[11] For a full description of this dataset, see http://ipl.econ.duke.edu/dthomas/dev_data/

[12] See https://www.indiawaterportal.org/data for details

Table 3.1: Proportion of area under HYV crops

	(1)	(2)
HYV Rice Area:		
Prop. non-landlord	0.069**	0.065**
	(0.032)	(0.033)
Rainfall Volatility	-0.583*	-1.571**
	(0.352)	(0.612)
Prop area irrigated	0.162***	
	(0.056)	
Irrigation		-0.047
		(0.043)
Irrigation=2 × Rainfall Volatility		0.626**
		(0.279)
Irrigation=3 × Rainfall Volatility		1.013**
		(0.502)
Irrigation=4 × Rainfall Volatility		1.291*
		(0.720)
Observations	4788	4788
R^2	0.50	0.50
HYV Wheat Area:		
Prop. non-landlord	0.085***	0.080***
	(0.031)	(0.030)
Rainfall Volatility	0.525	-0.986
	(0.333)	(0.610)
Prop area irrigated	0.096*	
	(0.057)	
Irrigation		-0.091***
		(0.035)
Irrigation=2 × Rainfall Volatility		0.798***
		(0.267)
Irrigation=3 × Rainfall Volatility		1.178***
		(0.442)
Irrigation=4 × Rainfall Volatility		1.844***
		(0.579)
Observations	4632	4632
R^2	0.71	0.71
Other cereals:		
Prop. non-landlord	0.049**	0.049**
	(0.025)	(0.023)
Rainfall Volatility	-0.596**	-1.512***
	(0.265)	(0.484)
Prop area irrigated	-0.015	
	(0.044)	
Irrigation		-0.086**
		(0.036)
Irrigation=2 × Rainfall Volatility		0.483**
		(0.236)
Irrigation=3 × Rainfall Volatility		0.894**
		(0.411)
Irrigation=4 × Rainfall Volatility		1.235**
		(0.561)
Observations	4769	4769
R^2	0.42	0.43
Controls	Yes	Yes
Year fixed effects	Yes	Yes

Notes: *, ** and *** signify significant at the 10, 5 and 1% level respectively. Errors are clustered at the district level. The dependent variable is the proportion of area in district i and year t that is planted with HYV crops (rice, wheat, other cereals). The non-landlord prop variable is taken from Banerjee and Iyer (2005). Rainfall volatility measures the standard deviation of rainfall across a 30 year period for a district. Irrigation is measured as proportion of gross area irrigated in column (1) and as 4 quartiles of irrigation in column (2).

decrease in the HYV area for both rice and other cereals. Given that the mean area covered by HYV rice and other cereals in the sample is 16 and 12 per cent respectively, this is a

Table 3.2: Yield of crops

	(1)	(2)
15 major crops:		
Prop. non-landlord	0.041	0.037
	(0.056)	(0.059)
Rainfall Volatility	-0.613	-4.326***
	(0.593)	(1.472)
Prop area irrigated	1.041***	
	(0.124)	
Irrigation		-0.090
		(0.090)
Irrigation=2 × Rainfall Volatility		1.674**
		(0.662)
Irrigation=3 × Rainfall Volatility		3.390***
		(1.130)
Irrigation=4 × Rainfall Volatility		4.827***
		(1.559)
Observations	4895	4895
R^2	0.61	0.61
Rice:		
Prop. non-landlord	0.095	0.067
	(0.073)	(0.070)
Rainfall Volatility	0.368	-3.765***
	(0.875)	(1.335)
Prop area irrigated	0.798***	
	(0.148)	
Irrigation		-0.140
		(0.094)
Irrigation=2 × Rainfall Volatility		2.446***
		(0.599)
Irrigation=3 × Rainfall Volatility		3.720***
		(1.047)
Irrigation=4 × Rainfall Volatility		5.181***
		(1.510)
Observations	4877	4877
R^2	0.47	0.48
Wheat:		
Prop. non-landlord	0.146**	0.157**
	(0.064)	(0.069)
Rainfall Volatility	1.664**	-1.335
	(0.828)	(1.900)
Prop area irrigated	0.609***	
	(0.124)	
Irrigation		-0.165*
		(0.095)
Irrigation=2 × Rainfall Volatility		1.100
		(0.772)
Irrigation=3 × Rainfall Volatility		2.764**
		(1.325)
Irrigation=4 × Rainfall Volatility		4.202**
		(1.776)
Observations	4360	4360
R^2	0.56	0.56
Controls	Yes	Yes
Year fixed effects	Yes	Yes

Notes: *, ** and *** signify significant at the 10, 5 and 1% level respectively. Errors are clustered at the district level. The dependent variable is the agricultural yield in district i and year t for an average of 15 crops, rice and wheat. The non-landlord prop variable is taken from Banerjee and Iyer (2005). Rainfall volatility measures the standard deviation of rainfall across a 30 year period for a district. Irrigation is measured as proportion of gross area irrigated in column (1) and as 4 quartiles of irrigation in column (2).

reasonably meaningful impact. However, in the case of wheat, which was the biggest HYV success, rainfall variability is not significantly associated with the area under the modern varieties and the coefficient is in fact positive. This suggests that the qualitative literature is right to highlight wheat as being a standout Green Revolution success and its spread was to do with a combination of favourable preconditions being met across a wide area. The HYVs of wheat introduced at the start of the Green Revolution in 1966 were robust to a variety of growing conditions and spread rapidly across the Indo-Gangetic plains due to their higher profits and social learning, including in areas where previously rice was grown (Munshi, 2004). In contrast, the spread of HYV rice and cereals was more dependent on local conditions, and it is likely that this is what the results here reflect. Column 2 of Table 3.1 displays the results of estimating equation (2) with the same outcome variables. Here the results are more consistent. When including irrigation quartiles and their interaction with volatility, it seems that the negative effect of volatility is felt strongly by districts that have inadequate irrigation infrastructure, while for the districts above the 75th percentile, there is essentially no impact of rainfall variability. This result is a confirmation of what the literature states: at least one of the two - irrigation or assured rainfall - was needed for a region to adopt the new HYV seeds.

Columns 1 and 2 of Table 3.2 contain the parallel results for the yields of the different crops. There is no significant impact for rainfall volatility on the yields overall, as can be seen by the estimates reported in column 1. However, the results for equation (2) containing the interaction are largely consistent with the story from Table 3.1. There is a significant negative association of rainfall volatility with yields, however this effect is felt by districts with below median irrigation facilities, with districts better off immune to this variance. The effect is felt for the overall yield of 15 major crops and for rice separately but wheat is again the exception as the estimate for rainfall volatility is not statistically significant at the 10% level. This reaffirms the exceptionalism of wheat that led to some contemporary authors to call the Green Revolution the 'wheat revolution' (Dasgupta, 1977).

So far a Pooled OLS specification very similar to Banerjee and Iyer (2005) has been used to allow for comparability and to demonstrate that district level patterns of rainfall variability affected the spread of HYV crops and the agricultural yields in post-Independence India. However, in the next step of this analysis, a fixed effects specification that exploits the time dimension of the dataset is used. A district fixed effects regression is run to capture the effects of rainfall deviations and shocks on the HYV share and yields of various crops in the given agricultural year. The model estimated is:

$$y_{it} = \beta_0 + \beta_1 RainShock_{it} + \beta_2 IRR_{it} + \alpha_t + e_{it} \qquad (3)$$

where y is again one of the outcomes of interest, the measure of RainShock captures different versions of rainfall deviations or shocks, IRR is still the proportion of irrigated area and year fixed effects are also included. All district level variables that didn't vary across time, such as the measure of institutions, are now captured in the district fixed effects.

Table 3.3: Area under HYV crops: rainfall shocks

	HYV Rice	HYV Wheat	HYV Cereals
With deviations from mean:			
Monsoon deviation	0.047***	0.022**	0.035***
	(0.009)	(0.011)	(0.007)
Prop area irrigated	0.105***	0.515***	-0.122***
	(0.027)	(0.031)	(0.023)
Observations	7489	6905	7557
F	227.08	475.89	234.25
With shocks:			
Monsoon shock	0.013***	0.009**	0.015***
	(0.004)	(0.004)	(0.003)
Prop area irrigated	0.116***	0.508***	-0.121***
	(0.026)	(0.030)	(0.022)
Observations	7736	7152	7801
F	228.73	484.67	237.03
With +tive and -tive deviations:			
Monsoon -tive deviation	-0.081***	0.040*	-0.090***
	(0.019)	(0.022)	(0.015)
Monsoon +tive deviation	0.022	0.066***	-0.004
	(0.015)	(0.017)	(0.012)
Prop area irrigated	0.107***	0.512***	-0.118***
	(0.027)	(0.031)	(0.023)
Observations	7489	6905	7557
F	220.44	462.48	228.25

Notes: *, ** and *** signify significant at the 10, 5 and 1% level respectively.The dependent variable is the agricultural yield in district i and year t for an average of 15 crops, rice and wheat. Rainfall deviation is measured as the deviation of rainfall from its mean in the previous year, or as positive or negative shocks above 80th percentile or below the 20th percentile, or as absolute negative and positive deviations from the mean.

The results for the six outcome variables are presented in Tables 3.3 and 3.4. The first panel uses a measure of rainfall shocks that measures the absolute deviation from the mean or average rainfall in a district. The results indicate that contemporaneous rainfall deviations have systematic effects on the share of HYV crops in the year. Here we see that the share of the wheat in a given year is also significantly associated with the quality of the monsoon rainfall, although somewhat smaller in magnitude and significance. In the middle panel, a different definition of rainfall shocks is explored. A season with rainfall above the 80th percentile of a district's rainfall distribution is coded as 1, a season with rainfall below the 20th percentile is coded as -1, and all other seasons are coded as 0.[13] The results confirm the importance of rainfall shocks. The bottom panel differentiates between negative and positive

[13]This is a common definition of rainfall shocks employed in literature, see for e.g. Shah and Steinberg (2017)

Table 3.4: Yields: rainfall shocks

	Yield (15)	Yield Rice	Yield Wheat
With deviations from mean:			
Monsoon deviation	0.236***	0.342***	0.083***
	(0.013)	(0.021)	(0.021)
Prop area irrigated	0.631***	0.705***	0.622***
	(0.039)	(0.058)	(0.067)
Observations	7715	7274	7067
F	153.82	97.50	157.47
With shocks:			
Monsoon shock	0.059***	0.110***	0.040***
	(0.005)	(0.008)	(0.008)
Prop area irrigated	0.629***	0.707***	0.580***
	(0.038)	(0.057)	(0.066)
Observations	7962	7508	7289
F	149.16	93.22	165.53
With +tive and -tive deviations:			
Monsoon -tive deviation	-0.526***	-0.760***	-0.078*
	(0.027)	(0.042)	(0.042)
Monsoon +tive deviation	0.028	0.035	0.086**
	(0.021)	(0.034)	(0.033)
Prop area irrigated	0.647***	0.723***	0.622***
	(0.039)	(0.058)	(0.067)
Observations	7715	7274	7067
F	156.85	100.21	152.67

Notes: *, ** and *** signify significant at the 10, 5 and 1% level respectively. The dependent variable is the proportion of area in district i and year t that is planted with HYV crops (rice, wheat, other cereals). Rainfall deviation is measured as the deviation of rainfall from its mean in the previous year, or as positive or negative shocks above 80th percentile or below the 20th percentile, or as absolute negative and positive deviations from the mean.

deviations from mean rainfall. The results indicate that while rice and other cereals were most susceptible to negative deviations from the mean, wheat responded positively to favourable seasons. A one standard deviation negative deviation from normal rainfall in the season is associated with area under HYV rice and cereals being approximately 3 percentage points lower, while a positive standard deviation from normal rainfall increases the area under HYV wheat in the district by 5 percentage points. This suggests that the unique circumstances of the introduction of robust HYV wheat meant that low rainfall seasons were not able to stem the progress unlike for others. But nevertheless, favourable monsoons aided this progress to a substantial degree.

Table 3.4 uses the same rainfall shock variables but with different outcome variables relating to agricultural yield. The results are very similar - deviations from annual rainfall and large shocks are systematically correlated with agricultural yields in a given district over time. The similarity extends to results for analysis looking at positive and negative deviations separately: district agricultural yields in a season seem to be responsive to seasonal fluctuations in rainfall, although the results for wheat yields stand out as being most immune. While the majority of these results simply indicate an expected reliance on rainfall, the weaker results for wheat are interesting as they again suggest that the favourable irrigation facilities and the robustness of the seeds was reflected in stable yields.

Taking stock of the results from this further analysis in light of the preceding chapters, some key ideas are worth highlighting.

First, the role of rainfall volatility which was shown to be substantial in colonial India, now plays a more limited but nonetheless significant role. It is important to consider what has changed - the scale of irrigation and the type of agriculture. In early 20th century colonial India, less than 4% of gross expenditure was on irrigation and the only around 20% of agriculture area could be irrigated (Chaudhary, 2015). The area irrigated increased from 20 million hectares after independence to more than 50 million hectares in early 2000s; in terms of proportion of cultivated area irrigated, this equates to a rise to around 40% and further increases since. However, the type of agriculture practised also changed. In post-independence India, the spread of High Yielding Varieties (HYVs) starting in the 1960s dramatically altered the dominant type of agriculture. This type of agriculture relied on the availability of favourable geographical conditions and adequate irrigation facilities. The new agricultural practices and the spread of irrigation fed off each other, and geographical variations in both seem to have resulted in restricted the impact of rainfall volatility largely to those areas that were left behind in these respects.

Second, the results of the analysis in this section tie closely to the findings on the effect of institutions on development. The importance of cultivator based land systems has been established using very similar data in Banerjee and Iyer (2005). Chapter 2 of this thesis argued that the assignment of different land tenures during colonial rule had important impacts for long run development, including for the proportion of irrigated land. The analysis here allows us to control for geography, but also include irrigation as an important channel through which institutions may have an impact. The results suggest that irrigation was an important channel: the coefficients on irrigation are large and statistically significant and the in Table 3.2 the coefficient on non-landlord proportion is insignificant. In general, compared to Banerjee and Iyer's results, even when statistically significant, the estimated coefficients on the non-landlord proportion variable are smaller. This result allows us to bring together these different strands of literature. It highlights how the Green Revolution and its interaction with historical institutions (discussed earlier in this chapter), which led to significant impacts on availability of tube-well irrigation, should be central to our understanding of the long run impacts of institutions.

3.4 Conclusion

The Green Revolution marked an increase in agricultural productivity and by extension, and its consequent impacts on incomes, poverty, health and education have formed a large part of the post Independence development story. As such any studies that seek to explain Indian economic development in the very long run often capture the impacts of the Green Revolution. However, most such analyses do not explicitly incorporate the role of the Green revolution into their narratives. Given the impacts summarised in Section 3.1, this is unfortunate.

The impact of historical institutions on the Green Revolution has always been suggested as a strong possibility. The various studies both suggesting and confirming such a possibility have been brought together in Section 3.2 and three channels through which historical institutions played a role have been proposed - higher initial development, the presence of an owner-occupier class and the role of the state. While confirming the impact of institutions, Section 3.3 also suggested the continuing importance of geographical factors, particularly rainfall variability for a subset of infrastructure poor districts.

Future studies on the topic of the Green Revolution need to unpack in more detail the diffusion of new HYV technologies at the local level across the subcontinent to better understand how historical institutions and/or geography impeded or aided such diffusion.

4 Concluding thoughts

The aim of this chapter was to analyse the land reforms and the Green Revolution to understand how they affected the rural economic structure established by colonial rule. In doing so, this thesis has fleshed out the narrative of long run Indian economic development and 'joined the dots' between historical institutions and modern outcomes. The findings showed that the land reforms failed to a great extent due to the lack of political will, the power of the landlords and the lack of state capacity. The failure of the land reforms was stronger in areas that had large landowners during colonial rule, but this straightforward correlation is generally obscured due to the standout success of West Bengal. However, a study of the exceptions of West Bengal and Kerala is interesting precisely because it tells us the ingredients of what's required to break through pre-existing power structures - a combination of political will and peasant organisation.

Another interesting result to emerge from the land reforms literature was that the impacts that the reforms *did* have were very clearly in favour of the richer cultivating peasants in the countryside. This class of richer peasants then accumulated sufficient power to block further reforms. And this same class of rich peasants then were the state sanctioned targets and enthusiastic early adopters of new imported technology consisting of HYV seeds at the start of the Green Revolution in the 1960s. The 'success' of the land reforms directly affected the success of the Green Revolution, indicating the importance of interactions between two different sets of programmes.

The success of the Green Revolution was also directly affected by a plethora of regional conditions - the nature of pre-existing infrastructure and market access, the existence of a historical class of rich, commercial cultivators and the role of the state. Historical evidence and the qualitative literature clearly shows that each of these is likely to have, in turn, been associated with historical land tenure type.

All in all, this chapter gives good reason to believe that the colonial assignment of some regions to landlord based land tenure systems had substantial path dependent impacts that drove these regions to a lower income equilibrium. Institutions seem fundamental to long run development but the analysis in Section 3.3 suggests that geography continues to play a role in economic development. Regions at the mercy of variable rainfall have lower yields and agricultural productivity, although the findings suggest that such risk can be compensated for by favourable institutions that permit more favourable infrastructural access.

Conclusion

This thesis investigated the fundamental determinants of growth by examining the roles of geography and institutions in India's long term development. India's performance in agriculture and manufacturing has been poor in relative terms, and progress that has been made shows a large degree of spatial variation. Across the three chapters, this thesis has used new and existing data and various methodological approaches to explain the roots of this uneven development. This concluding note will briefly summarise the results, discuss the implications and suggest avenues for future research.

Chapter 1 analysed the role of rainfall shocks and uncertainty on historical patterns of development. The monsoons have always been a key defining feature of climate on the Indian subcontinent, but they have barely featured in debates on long run Indian development. Analysing their spatial patterns in Chapter 1 demonstrated that higher rainfall variability was significantly associated with lower literacy in late colonial India, with the effect likely being transmitted via an impact on agricultural incomes. Chapter 2 constructed an original village level data set and used a Regression Discontinuity Design (RDD) framework to estimate long run persistence in development outcomes such as literacy and irrigation due to different historical land tenure institutions. The channels suggested included historical out-migration, public good provision and the differential impact of access to the railways. Chapter 3 explored the question of why the effect of these institutions could persist over 50 years into independence. It brought together multiple strands of work to explain how the policies and programmes associated with the land reforms and the Green Revolution did not nullify the impact of historical institutions, and indeed in some ways may have actually accentuated historical differences. This final chapter also showed how rainfall variability continued to be an important determinant of agricultural productivity during the Green Revolution, but only for a subset of districts with poor irrigation facilities.

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There are some important implications of these findings for the current state of literature, which fall broadly into four categories.

The first set of implications are for research on geography and its role in long run development. The results in this thesis suggest that it is important to explore specific geographical dimensions of relevance, moving beyond broad characterisations based on latitude or distance to coast. The results of Chapter 1 and 3 together also suggest that the role of geographical factors changes across different historical phases. Rainfall variability was more relevant in an early 20th century India with low levels of irrigation compared to an independent India during the Green Revolution with more modern technologies, a richer class of rural cultivators and active state intervention. This hints that institutions and geography could each be important during different phases. The importance of geography in colonial times does not contradict the effect of historical land tenure institutions in engendering greater conflict in certain regions after independence. That some geographical factors are important only in historical periods does perhaps make it easier in literature to miss the role that geography plays in shaping development.

The second set of implications concerns research on institutions. Existing research in the Indian context has been afflicted with serious concerns about the definition and measurement of institutions, and results have not been robust to proposed re-classifications (Iversen et al., 2013). The results in this thesis suggest that there is merit to exploring the role of historical institutions at a more dis-aggregated level. Taking the analysis to the village level also opens up many intriguing avenues for research. The conventional understanding of institutional persistence in India has relied on differences in policy at the state level, but results here indicate that inequalities in development have persisted between neighbouring villages subject to the same state and district level policies across many years.

The third broad lesson from this thesis is regarding the importance of studying interactions between geography, institutions and access to markets. In Chapter 1, there was a strong suggestion that districts that grew more cash crops for export, were less exposed to risk from variable rainfall. While it is true that a part of the commercialisation could be explained by better initial geographical conditions, such a result is in line with research from other developing countries that finds more export oriented areas are less susceptible to rainfall shocks (Papaioannou, 2016). Analysis in Chapter 2 indicated that the benefit of access to the railways accrued mostly to non-landlord villages, with associated historical evidence that landlords were reluctant for their tenants to participate in increasing commercialisation. Taken together, the work in both these chapters suggests that there are strong and significant linkages between geography, institutions and market access.

The fourth set of implications to emerge from the results of this thesis is regarding the centrality of the land reforms and the Green Revolution to understanding long run development. The land reforms are often dismissed as having small or insignificant impacts[14] but Chapter 3 demonstrated that they had more nuanced impacts on rural agrarian society such as in creating a new class of rich peasants, who then went on to play a key role in the Green Revolution. The introduction of HYVs starting in the 1960s sparked increases in irrigation and agricultural productivity and led to wide ranging consequences for poverty, health and human capital. In some way therefore, all studies on long run Indian development capture the impacts of the Green Revolution. Yet the details surrounding the Green Revolution are generally not included in such studies, as anything more than an afterthought. Work in Chapter 3, that identified key reasons for unevenness in the take up of HYV technologies, in conjunction with results from Chapter 1, that showed much more tube-well irrigation in non-landlord villages, confirms the crucial role of the Green Revolution in explaining long run patterns of development.

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There is a lot of potential for interesting work going forward. Simply obtaining additional data would lead to meaningful extensions. The collection of monthly rainfall data would allow for a season and crop specific analysis in Chapter 1. Plans to create linked village level data for multiple periods of time, to explore when the divergence in development outcomes captured in Chapter 2 took place, remain in abeyance. Finally, there is a desire to obtain household data on land reform implementation and the Green Revolution that would permit a finer analysis of their determinants.

More broadly, this research highlights the scope for separate but linked research projects. In the Indian context, railways have been shown to have an impact on market integration, trade and famine resistance, but there is little evidence on the impact of railways on income, industrial location or human capital. There is scope for research on the impact of historical access to railways on development, specifically the magnitude and timing of the move from agricultural to non-agricultural occupations (either in the rural non-farm sector or via rural to urban migration) and linked decisions on human capital. Within this framework,

[14] For example, Banerjee and Iyer (2005) argue that land reforms had a negligible direct role in explaining institutional persistence.

other factors are likely to have had an impact. For instance, there is likely to have been more out-migration from well-connected villages that have worse geographical conditions for agriculture. Similarly, the interaction between the communication networks and caste and religious characteristics of villages is likely to be hugely fascinating. Furthermore, how the increased trade and communication opportunities interacted with existing geographical and institutional conditions would be very interesting to analyse.

The second promising line of research suggested by the current thesis is a systematic analysis of the political economy channels of development. Given the introduction of village level electoral organisations, the village elite that cemented their power historically as landlords could have subsequently been able to capture village electoral institutions in modern India. It would be interesting to test this by using village level electoral data to analyse potential differences between variables such as political competition and political participation in villages with different historical institutions, for example. Any such effect discovered is also likely to be affected by the degree of agricultural commercialisation, transport linkages to nearby urban centres, and the caste composition of the particular villages. Such a project would also have scope to analyse the effectiveness of affirmative action policies implemented in large parts of India. Many village council leader positions are reserved for women or members of the lower caste: the big question to answer here is whether such affirmative action is able to dilute the impact of the village elite and thereby lead to better implementation of developmental programmes and the achievement of better developmental outcomes. Finally, such a project would provide the possibility of analysing the role of different political parties and the ways in which they interact with different political structures in the villages.

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This thesis began with the question of why some places were poor while others rich. The lessons from this thesis suggest that the central role for institutions in discussions on long run growth and development is well deserved. Historical institutions from the colonial era have significant impacts on current development. However, this thesis shows the importance of identifying these impacts with care. Geographical factors play a role and need to be accounted for, while the persistence of institutional impacts needs to be traced across different time periods. For India, with its idiosyncratic and unequal achievements in growth, addressing these fundamental causes is likely to be key in attempts to redress inequities and fulfil its future potential.

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