No Policy is an Island: Finance and Food Security in India

Andre Butler[1] and Camille Boudot[2]

Abstract

In India, many of the poorest people depend on agriculture as a major source of income and employment, while the nation depends on these millions of smallholder farmers for its food security. Although agricultural technology has the potential to sharply increase yields, many farmers cite the lack of financial capital as the main constraint to adoption. In light of this, India implemented one of the world's largest social banking programme (1969-1990) which resulted in the opening of 30,000 rural bank branches and increased direct finance to agriculture from 0.4 to 158 billion rupees. Using an instrumental variable approach, we examine the policies guiding this financial expansion to empirically test their impact on agricultural investment and production during the 1980s. Our results suggest that rural branch expansion had a negative impact on usage of key agricultural technologies, including macro-nutrient fertilisers, thereby reducing the district-wise aggregate crop production to the tune of 11.7 million rupees for every additional rural bank branch. In contrast, while imposing agricultural credit targets increased mechanisation, there appears to be no significant improvement in aggregate production. This suggests a disconnect between policy targets on agricultural credit and their associated objectives at enhancing national food security. We draw upon these results to comment on the current financial support in the context of India's rapidly declining share of agricultural output to gross domestic product.

Acknowledgements

We would like to thank the National Stock Exchange of India and IFMR Finance Foundation Initiative for their financial support, and two independent reviewers for their comments and feedback on earlier versions of the manuscript. Special thanks also to Deepti George at the IFMR Finance Foundation for her guidance on obtaining Reserve Bank of India data, and to Ajay Tannirkulam and Charity Moore at IFMR LEAD for their helpful and detailed comments. All views expressed are that of the authors alone. Comments are to be sent to Andre Butler andre.butler@ifmr.ac.in

[1] Centre for Development Finance, IFMR – LEAD, India, Corresponding Author: andre.butler@ifmr.ac.in
[2] Centre for Microfinance, IFMR – LEAD, India

1 Introduction

In India, agricultural output as a share of gross domestic product (GDP) has been steadily declining over recent years; its percentage share dropping from 19% in 2004-05 to 13.7% in 2012-13. This is especially surprising given the mounting evidence from experimental field trials across Sub-Saharan Africa and India indicating that improved agricultural technologies frequently increase profitability by more than 100% (Harris & Orr 2014). Low credit penetration, relative to other sectors of the economy,[3] has often been reported as a major constraint which prevents farmers from making potentially profitable investments due to lack of the required capital (Fletschner et al. 2010; Foster & Rosenzweig 2010; Mor et al. 2013). The expansion of financial services into the traditionally neglected agricultural sector, which carries with it a high poverty burden, therefore has the potential to bolster food security (Barrett 2002; Godfray et al. 2010) while also effectively alleviating poverty (Burgess & Pande 2005; Kochar 2011). In fact, it has been estimated that a 1% growth in GDP which originates from agriculture leads to a 6% increase in expenditure among the poorest 30% of the population (Ligon & Sadoulet 2007). This is especially relevant in India, where an estimated 445 million people subsist on about $1/day, of which 74% are living in rural areas where agriculture is a major source of income and employment (Chen & Ravallion 2007).

With such emphasis on well-developed financial systems as a fundamental ingredient for a country to exploit growth opportunities in different sectors of the economy (De Gregorio & Guidotti 1995; King & Levine 1993), the central Government of India developed one of the world's most prominent social banking programme from 1969 to 1990 (Burgess & Pande 2005). This initiative resulted in the opening of branches in over 30,000 rural locations which were previously poorly serviced. During the same period, the amount of direct finance to agriculture increased from 0.4 to 158 billion rupees.[4] Evidence suggests that the rapid expansion of the rural banking network had clear benefits for the rural economy in terms of poverty reduction among non-agricultural households (Ayyagari et al. 2013; Burgess & Pande 2005; Imai et al. 2010; Kochar 2011). However, the same cannot be said for agricultural credit, which according to a study by Kochar (2011) has failed to improve the welfare of targeted beneficiaries. Overall, this evidence suggests that despite the prevalence of liquidity constraints, the impact of formal agricultural credit programmes has been largely disappointing.

Existing research evaluating this formal social banking programme have focused singularly on poverty reduction, largely ignoring the dual aim of food security. There is in fact very limited evidence on how formal credit programmes influence investment and production strategies. Access to agricultural credit has the potential to directly influence production through two main channels. Primarily, credit can increase investment in input use and hence productivity. Secondly, credit provides farmers with the opportunity to smooth consumption, and can thereby increase their willingness to take risks and engage in productive agricultural investments.

This study makes two main contributions. First, we evaluate the impact of India's formal social banking programme on measures of agricultural technology adoption and productivity, allowing us to directly address the outcome of financial expansion on food security and to subsequently attempt to substantiate

[3] In India, industry has a credit-to-GDP ratio of 87%, while agriculture is as low as 36% (Mor et al. 2013).
[4] Source: Reserve Bank of India Database on the Indian economy (http://dbie.rbi.org.in/DBIE/dbie.rbi?site=statistics)

the existing evidence of these policy failures on poverty reduction among agricultural households. Second, by independently analysing policies related to bank branch expansion as well as targeted finance, we are able to compare the effectiveness of these two financial inclusion instruments on agricultural productivity.

India has historically promoted an ambitious progressive financial inclusion agenda, providing a unique setting in which to examine the effectiveness of rural bank expansion and targeted agricultural credit as a means of promoting food security and alleviating poverty. Adopting an instrumental variable approach, we exploit two explicit and independent sets of policy regulations implemented in the 1980s: Branch Licensing Policies (BLPs), which were used to spread banking infrastructure to previously neglected districts in order to achieve a target population per rural bank office, and priority sector lending policies encouraging the provision of formal finance to farming households in districts which fell below a target ratio of direct finance to agriculture to total outstanding credit. Our analysis covers a total of 286 districts across 19 states over a period of 5 years (1982-1987), including indicators of agricultural input and production drawn from the Village Dynamics in South-Asia (VDSA) database, as well as banking statistics from the Reserve Bank of India's (RBIs) Basic Statistical Reports (BSRs).

Contrary to prior research on government-led banking programmes which argue that implementation failures due to political imperatives plagued the success of these policies (Adams et al. 1984), our results suggest bank compliance to both rural branch expansion and priority sector lending objectives. We find that an additional 18% of districts met the target population per bank ratio, and that direct finance to agriculture increased by approximately 64% from 1982-1987. Disappointingly, we find that this tremendous effort in formal financial inclusion of rural India had a limited impact on agricultural productivity. Targeted lending appears to have only marginally improved the adoption of agricultural machinery; however, additional investment did not translate into an increase in aggregate production. More worryingly, from the angle of food security, our findings on increased banking infrastructure during that period show a negative influence on usage of key agricultural inputs, and consecutively a fall in overall production at the district level. Specifically, we find a significant reduction in consumption of macro nutrient fertilisers - nitrogen and phosphorus - by 854 and 354 tonnenes respectively, thereby reducing the district-wise aggregate crop production by 11.7 million rupees for every additional rural bank branch. These results allow us to corroborate earlier findings on the failures of these banking policies aimed at strengthening the rural agricultural economy. We explore such misalignment between policy objectives and ground realities, and provide recommendations to address these challenges within the current Indian context of financial advocacy in agriculture.

The rest of the paper is structured as follows. Section 2 presents a review of the literature on agricultural technology adoption and productivity in developing countries together with evidence from studies on lending to agriculture for addressing liquidity constraints. Section 3 reports the historical expansion of formal credit in India. Section 4 describes the data including summary statistics on the main indicators. Section 5 outlines and justifies the methodology and Section 6 presents the results from our analysis. Section 7 concludes by relating the findings within current policy initiatives.

2 Technology Adoption and Liquidity Constraint

Agricultural development is a known precursor to industrialisation, largely influencing a country's capacity for economic growth and thereby its relative income level (Abramovitz & Morris 1967; Bezemer & Headey 2006; Gollin et al. 2002; Lewis 1954). Consequently, governments have historically extended significant resources towards research and development, as well as the diffusion of improved technologies for enhancing agricultural productivity. The Green Revolution, initiated during the late 1950s, represented the very beginning of a global push for agricultural innovation with a special focus on addressing the requirements of developing countries (Gollin et al. 2005). Efforts have not dwindled since, with worldwide public investments estimated to have doubled from 11.8 billion dollars in 1976 to nearly 21.7 billion dollars in 1995, including a growing contribution from developing countries (Pardey & Beintema 2002). In this section, we present a review of the literature on the adoption and impact of advanced agricultural technologies which emerged as a result of this international endeavour for the most critical productive inputs - seeds, fertiliser, irrigation, and mechanisation - as well as evidence of finance in alleviating constraints to adoption.

Crop breeding programmes, aimed at genetic improvement of traditional varieties was the leading breakthrough to changing the scope of agriculture in developing countries (Evenson & Gollin 2003b). High yielding varieties (HYVs) of rice and wheat, developed in the Philippines and Mexico respectively in the early 1960s, out-performed all local varieties, achieving what was commonly referred to as a "Green Revolution" in the production of cereals. Introduced more widely across Asian and Latin American countries by the late 1960s, these HYVs witnessed significant adoption over time. By the end of the 1970s, HYVs accounted for 35% of the rice cultivated in India, increasing to 80% by the turn of the century (Evenson & Gollin 2003a). The impact of this technology diffusion has been remarkable. According to a review of international research on germplasm by the Consultative Group for International Agricultural Research (CGIAR) Centres, HYVs accounted for approximately 46% of the growth in food production across Asia from 1980-2000.[5]

One of the favourable traits of modern varieties was their significant response rate to fertiliser application. Consequently, the spread of HYVs precipitated a sharp acceleration in fertiliser usage by farmers (Morris et al. 1998). According to a review by the Food and Agriculture Organisation (FAO), fertiliser consumption in India was less than 1 million tonnenes prior to the onset of the Green Revolution and grew exponentially to 18 million tonnenes by 2000 (Tewatia & Chanda 2005). Productivity gains from fertiliser applications cannot be denied. Evidence from randomized control trials in real world farms in Kenya and Mali for maize and rice respectively, showed an improvement in yields from fertiliser usage ranging between 28% and 63% (Beaman et al. 2013; Duflo et al. 2008). Such impressive impact on yields has made fertiliser one of the most profitable agricultural technologies. In India, a study on fertiliser usage across the Indo-Gangetic Plains by Satyanarayan et al. (2012) found that the rate of return on investment of nitrogen fertiliser was on average rupees 10.04 per rupee invested. This profitability potential however, especially in the context of Asia and nitrogen-based fertiliser, has slowly led to application levels above recommended values while neglecting other essential nutrients (Gollin et al. 2005). For instance, India's nationwide consumption of nitrogen, phosphorus, and potassium fertiliser (N:P:K) is currently estimated to be in the ratio of 100:39:18; which is clearly scarce in both phosphorus and potassium when compared

[5] For a complete review of the impact from diffusion of modern varieties based on research conducted by the CGIAR Centres, by region and country from 1960 to 2000, refer to the report for the SPIA by Evenson and Gollin (2003a).

to the worldwide ratio of 100:44:28.[6] This imbalance between fertiliser application and plant nutrient demand within intensive crop systems has resulted in widespread human-induced soil nutrient mining, which has been attributed to a recent trend of stagnating or even falling yields across the country (Ray et al. 2012). Mounting evidence suggests that essential secondary and micro-nutrients are now becoming the limiting factor to productivity (Gupta 2005; Ladha et al. 2003; Pampolino et al. 2012; Singh 2008).

Underlying the effectiveness of both seed and fertiliser is the use of irrigation. The dawn of the Green Revolution benefitted from significant public investment in irrigation channels (Gollin et al. 2005). India was in fact the single largest beneficiary of World Bank lending for irrigation between 1951 to 1993, spending approximately 33 billion dollars on public investment in large and medium scale irrigation projects (Duflo & Pande 2005; Thakkar 2000). However, unlike seed and fertiliser, irrigation has not witnessed a widespread level of adoption. Despite the total area equipped for irrigation having more than doubled from 1960 to 2010, it is estimated that only 35% of arable land in India was reliably irrigated in 2010.[7] This is despite clear evidence supporting the value of irrigation as an indispensable input for higher agricultural yields. In a review of 69 studies evaluating improved technologies – ranging from crop management, fertiliser, pesticides, and high yielding varieties – across Sub-Saharan Africa and India, Harris & Orr (2014) find that the profitability of these improved methods hinges on the use of irrigation. The authors observe that the net return from rain-fed crop production under these technologies is too little to lift a smallholder farmer (i.e. below 2 hectare farms) above the poverty line, thereby limiting further productive investment.

The mechanisation of agricultural production systems has the potential to increase yields, reduce labour requirements, and minimise the turnaround time between seasons, thereby enabling farmers to engage in double-cropping.[8] This technology was in fact a leading factor in increasing land productivity during Europe's Green Revolution in the late 1800s (Zanden 1991). However in developing countries, usage of agricultural implements and machinery has not boomed and continues to lag significantly behind other inputs. According to India's Agricultural Census, tractors for tillage and sowing were used on only 22.78% and 21.30% of total arable land area respectively in the early 2000s.[9] Further, the impact of mechanisation on developing country farms has been a subject of debate relative to other advanced technologies. In an extensive review of over 60 tractor surveys across India, Pakistan, and Nepal in the early 1970s, Binswanger (1978) concluded that the benefits of tractors at the time were small if at all present. However, recent evidence evaluating improved transplanting machinery in the Indo-Gangetic Plains showed an increase in rice yields of 27.3% and 50% compared to manual transplanting and direct seeding respectively, ultimately resulting in higher profitability (Gangwar et al. 2014).

Optimal crop management combining the above critical inputs - seed, fertiliser, irrigation and machinery - has the potential to dramatically improve yields. However, despite the long history of agricultural technology promotion in this sector, current trends across developing countries suggest that there continues to be large exploitable yield gaps (Ladha et al. 2003). That is, yields appear to be plateauing at levels well below the upper limit achievable by current modern varieties grown in favourable conditions

[6] Source: Food and Agriculture Organisation Statistics (http://www.fao.org/statistics/en/)
[7]Source: Food and Agriculture Organisation Statistics (http://www.fao.org/statistics/en/)
[8] Agricultural practice of growing two crops on the same piece of land within the same agricultural season.
[9] Source: Agricultural Census of India (http://agcensus.nic.in/)

of soil moisture and nutrition. In fact, average yields of irrigated rice in Northern India are only 3.7 tonnes per hectare, while experimental station yields are as high as 10 tonnes per hectare (FAO 2004). This remaining potential for productivity gain has been largely attributed to sub-optimal adoption and usage of improved technologies, alongside bio-physical constraints (Dobermann & Fairhurst 2000). Understanding the reason for slow and stubbornly low rates of improved agricultural technology adoption, despite consistent evidence of high returns, has been the subject of a broad and global research agenda. The extant literature has put forth a number of explanations, including; heterogeneity of returns (Suri 2011), information barriers (Conley & Udry 2010; Foster & Rosenzweig 2010; Munshi 2004), behavioural biases (Duflo et al. 2011; Giné & Yang 2009), market failures (Cole & Fernando 2012; Jack 2011), externalities (Besley & Case 1993), as well as liquidity constraints (Beaman et al. 2014). In this study, we specifically consider the condition of liquidity constraints for productive agricultural investment in the context of India during the 1980s, approximately 20 years following the onset of the Green Revolution and the propagation of improved technology across the country.

It has been widely assumed that relieving the liquidity constraints faced by smallholder farmers can be effective in promoting technology adoption, and hence production, through two main channels. Primarily, additional credit changes the budget constraints faced by farmers, enabling productive investment in inputs which were previously deemed unaffordable. Secondly, by addressing the risk and seasonality of agricultural income, credit provides the opportunity for farmers to smooth consumption and thereby increases their willingness to take risks associated with productive investments.[10] In a study evaluating the impact of direct cash transfers to farmers in rural Mali, Beaman et al. (2014) find that those benefitting from transfers increased their overall expenditure on inputs by 14%, which translated into an increase in agricultural output and profit of 13% and 12% respectively – corroborating the notion that farming households do face liquidity constraints to investment.

In light of the potential benefits of relieving liquidity constraints faced by smallholder farmers, many countries have devoted extensive resources to financial programmes targeting the agricultural sector (Braverman & Guasch 1986). However, initial assessments of government interventions in rural credit markets across the developing world during the 1960s and 70s were highly sceptical of the impact, documenting significant policy failures undermining credit institutions. Cases exemplifying the exclusion of poor farmers from credit markets, fungibility of loans for non-agricultural uses, and high default rates were rampant (Adams & Graham 1981; Adams et al. 1984; Adams & Vogel 1986; Von Pischke & Adams 1980). While these critiques provided anecdotal evidence of implementation failures and the wider consequences of these on the rural economy, they did not formally evaluate the impact of finance on agricultural investment decisions and productivity. Rigorous evidence in this field is in fact very limited. A study from India by Binswanger & Khandker (1993) provides the only insight into the impact of formal finance for agriculture in a developing country context. Their study uses district level data on both farm and non-farm output indicators from 1972 to 1980, a period of heavy public sector credit subsidisation in the country. The authors suggest that credit subsidies did in fact increase adoption in both fertiliser and machinery; however, this investment did not appear to translate into higher agricultural output.

Despite much debate and the lack of conclusive evidence, public sector finance continues to be the largest provider in rural areas (Burgess & Pande 2005). Further, given long-run estimates suggesting that without

[10] Binswanger & Khandker (1993) present a theoretical model for these two channels.

urgent action to redress stagnant or falling yields, more than 17% of the total population in South Asia may face food insecurity by 2050 (Titumir & Basak 2011), the value of agricultural finance is back to the forefront of the policy agenda. This study therefore addresses the question pertaining to the impact of formal finance on food security in developing countries, which has so far been absent from the extant literature. Furthermore, to the best of our knowledge, this is the first study to rigorously separate the influence from two different instruments of financial inclusion for the rural poor – banking infrastructure and targeted lending. Our findings will not only substantiate the lacuna in the literature on assessing finance for agriculture, but will importantly provide a platform for recommendations on current policy objectives aimed at improving yields for a growing population.

3 Formal Credit Systems in India: A Historical Perspective

Between 1969 to 1990, the central Government of India developed one of the world's most ambitious and prominent social banking programme (Burgess & Pande 2005).[11] The unprecedented public sector investment during this period resulted in the opening of branches in over 30,000 rural locations which were previously poorly serviced, and increased the amount of direct finance to agriculture from 0.4 to 158 billion rupees.[12] This setting provides a unique opportunity within which to examine the effectiveness of rural bank expansion and targeted agricultural credit as a means of promoting food security and alleviating poverty. In this section, we present a historical overview of the objectives and specificities of the most prominent policies guiding the expansion of formal credit systems in India at the time, as well as evidence of their influence on poverty alleviation.

Despite some initial regulations by the Reserve Bank of India (RBI) encouraging the spread of banking infrastructure by commercial banks during the early 1960s, the foundation stone for a nationwide social banking programme occurred in 1969 with the government seizing 'social control' of commercial banks (Panagariya 2006). The nationalization of 14 private sector banks, comprising 54% of bank branches across the country at the time, and an additional 6 banks in 1980 provided the government with the opportunity for a state-level model for the provision of finance towards weaker sectors of the economy. The following decade (1980-1990) witnessed the amplification of financial services at the core of the central government's anti-poverty campaign via three leading policies: branch licensing directed towards unbanked locations, targeted priority sector lending, and subsidised credit to the poor.

Branch Licensing Policies (BLP) stimulated the opening of bank branches in previously unbanked locations, thus encouraging an equitable distribution across the country. Though first instigated in the early 1960s[13], BLPs were later revised and adapted to become the leading policies for banking infrastructure expansion during the 1980s.[14] The objective of these policies was to direct resources towards previously neglected districts which were identified using a target rural population to bank

[11] Details of this banking programme can be found in the Government's Five Year Plans documentation, available on the site of the Planning Commission: http://planningcommission.gov.in/

[12] Source: Reserve Bank of India Database on the Indian economy (http://dbie.rbi.org.in/DBIE/dbie.rbi?site=statistics)

[13] Commercial banks were required to open branches in a ratio of 1:2 between banked and unbanked locations in 1962, later changed to 1:1 in 1968. In 1977, the 'entitlement formula' was introduced which required banks to open a minimum of four branches in rural and semi-urban locations for every branch opened in an urban centre. This ratio of 1:4 applied to banks with less than 60% of their offices in rural and semi-urban areas. Banks satisfying this threshold only had to abide to a ratio of 1:2 new bank branches in urban and rural areas respectively.

[14] Specific details on the implementation of these BLP are reported in the RBIs, Report on Currency and Finance annual volumes for 1979-80, 1982-83, and 1985-86.

branch ratio. The first BLP (1979-1981) initially set a target of 20,000 people per rural bank office, which was later revised down to 17,000 for the second (1982-1985) and third (1985-1990) BLP periods. Under these policies, any district falling above the specified threshold was considered 'deficit' and assigned a detailed branch expansion programme.[15] Towards the end of the third BLP period, in 1989, the emphasis started to shift from overt expansion to ensuring the viability of bank business in remote rural areas. In light of this, the Government of India introduced a Service Area Approach (SAA) to the BLP regulations, such that a block of 15 to 25 villages were assigned to a specific bank.[16] Evidence documenting bank branch expansion during this period suggests that the policies were in fact successfully implemented with an annual growth rate in rural branches peaking at 16.5% during the first two BLP periods followed by a complete stagnation at the close of the programme in 1990 (Panagariya 2006). Furthermore, a study by Burgess & Pande (2005) evaluating the impact of financial access on poverty levels using a 40 year panel dataset across 16 Indian States, finds that these policies have largely been effective – with every additional bank branch per 100,000 persons reducing rural poverty by 4.7%.

Simultaneously, but independent from the branch expansion programme, the central government significantly reinforced its priority sector lending initiative aimed at invigorating growth among the weaker sectors of the economy.[17] Agriculture represented a key priority sector due to its high poverty burden as well as its vital role in achieving self-sufficiency in food production. The initial target outlined by these policies at the onset of 1980 required banks to extend 50% of direct loans for agriculture to small and marginal farmers. However in 1983, the basis on which to calculate the target was modified to become a measure of direct finance for agriculture (DFA) as a proportion of total outstanding credit. The objectives were then revised to achieve a target of 15% by 1985, 16% by 1987, and finally 18% by 1990.[18] Compliance by banks was monitored on an annual basis and enabled the RBI to identify 'deficit' districts – that is districts where lending fell short of the specified target. In such cases, pressure was instilled on all banks in these districts to increase their proportionate lending to weaker sectors in accordance with the prevailing policies. Evidence documenting the increase in finance during this period clearly highlights a significant increase in DFA, by approximately 150 billion rupees from 1980 to 1990.[19] Furthermore, banks appear to have adhered to the priority sector lending policies, as the ratio of DFA to total outstanding credit also increased from 0.11 to 0.14 during the same period (Kochar 2011). However a study by Kochar (2011) on the impact of these targeted lending policies in Uttar Pradesh during the 1980s reveals no significant influence on poverty levels in the State.

Also promoted during this same period, yet independent from the regulations guiding either bank branch expansion or targeted lending, was the Integrated Rural Development Programme (IRDP). This initiative was aimed at encouraging self-employment and thereby income generation capacity; especially among small and marginal farmers, agricultural labourers, and rural artisans, through the disbursement of subsidised credit. Each block across the country was to provide the required assistance to meet an explicit target – lifting an average of 3,000 below poverty line (BPL) households above this threshold. During the

[15] This branch expansion programme was prepared by the Reserve Bank of India alongside the State Government and bank representatives.
[16] This policy is explained in the Reserve Bank of India, Report on Currency and Finance, 1987-88.
[17] During the previous decade, regulatory targets had been introduced compelling banks to extend at least one third of their outstanding credit to agriculture, small-scale industries and small borrowers by 1979.
[18] Rules related to this policy can be found in Reserve Bank of India, Report on Currency and Finance, 1982-83, 1988-89.
[19] Source: Reserve Bank of India Database on the Indian economy (http://dbie.rbi.org.in/DBIE/dbie.rbi?site=statistics)

1980s, this initiative was in fact the governments' leading anti-poverty programme. The scheme is estimated to have received approximately 35 billion Rupees from 1980-1985, substantially more than the allocation given to both general health and education programmes.[20] However evidence documenting the impact of this programme has been mixed. While initial studies suggested a reduction in the number of poor households by up to 22% (Copestake 1992), a more recent study by Kochar (2011) indicates that the programme may have actually increased income inequality by disproportionately benefitting wealthier farmers.

Following a decade of intensive public sector involvement in poverty alleviation programmes by leveraging rural credit markets, India suffered a severe imbalance of payments which forced it to largely abandon its social banking experiment at the dawn of the 1990s. Unfortunately, few credible studies have been able to establish the effect of this large-scale formal banking expansion on targeted beneficiaries, with no evidence on the potential impact of these measures on food security. In this study, we make use of the distinct regulations governing the expansion of bank branches and priority sector lending to rigorously evaluate their independent influence on agricultural investment and productivity.

4 Data and Descriptive Statistics

For this study, we compiled a detailed and comprehensive district-level panel dataset across 19 Indian states from 1982 to 1987. While the BLP periods dominated the financial inclusion agenda during both the 6th and 7th Five Year Plan (1980-1990) of the central government of India, evidence suggests that the growth rate of rural bank branches peaked at 16.5% during 1977-85, and later fell dramatically to just 2.9% between 1986-90 (Panagariya 2006). In light of this, we consider only the years spanning from 1982 to 1987 for the purpose of our analysis. This allows us to cover the entirety of the second BLP period (1982-1985), as well as part of the third BLP (1985-1989) during which branch expansion was still growing. Incorporating a time period which includes a re-classification of deficit districts on both financial inclusion instruments strengthens our identification strategy by providing further verification of the selection criteria of districts according to the governing policies (explained further in Section 5).

We draw upon the Village Dynamics in South Asia Database (VDSA)[21] in order to compile key district-level indicators of agricultural inputs and production. This database is the result of a long-standing collaborative project between the International Crop Research Institute for the Semi-Arid Tropics (ICRISAT), the International Rice Research Institute (IRRI), and the National Centre for Agricultural Economics and Policy Research (NCAP), funded principally by the Bill and Melinda Gates Foundation. The VDSA builds on the earlier ICRISAT district-level database of thirteen states[22] by including three additional states (Assam, Himachal Pradesh, Kerala) as well as three states founded in 2000 (Chhattisgarh, Jharkhand, and Uttarakhand). The database includes yearly data from 1966 to 2009 for all districts present in the base year.[23] Information available in this dataset includes; operational holdings, key agricultural inputs and technologies (irrigated area, HYVs cultivation, fertiliser usage, and machinery), production for widely cultivated crops, and agro-ecological variables (rainfall, soil type, and

[20] Source: Planning Commission (http://planningcommission.gov.in/)
[21] This dataset is available online (http://vdsa.icrisat.ac.in/.)
[22] Andhra Pradesh, Gujarat, Haryana, Karnataka, Madhya Pradesh, Maharashtra, Punjab, Rajasthan, Tamil Nadu, Uttar Pradesh, Bihar, West Bengal and Orissa.
[23] For districts formed after 1966, these are systematically allocated back to their original parent district.

soil moisture availability index). The dataset is complemented with key outcome features of the rural economy such as fertiliser and commodity prices, female and male wage rates, as well as demographic variables including the 1981 population.[24]

Our banking indicators – rural bank branches and targeted finance to agriculture – were compiled from the Basic Statistical Reports (BSR) available from the RBIs banking database.[25] These reports include district-wise information on the number of bank branch offices in rural, semi-urban, and urban areas, as well as the amount of total outstanding credit and direct finance to agriculture. Archive data is available for all Indian states from December 1972 onwards. In order to create a panel dataset for these banking indicators, it was necessary to track changes in district boundaries over time and reallocate newly created districts to their original parent.[26] Using the information presented by Kumar & Somanathan (2009) on mapping districts across census years from 1971 to 2001, we retain districts that have either not changed boundaries, or have been partitioned to form entirely new districts over that period.[27] In the case wherein territory was reallocated to neighbouring districts, we only retain districts for which 95% of the base territory remained intact.[28] Merging this RBI data with the VDSA, we obtain a final panel dataset covering 286 districts annually from 1982 to 1987.

A summary of how our main indicators – banking, agricultural inputs, and production – evolved over the study period (1982-1987) is presented in Table 1. Estimates on the number of rural branches indicate a rapid expansion leading to a fall in the population per bank ratio from 32,000 to 21,000 (Part A of Table 1) in alignment with other studies assessing this period (Burgess & Pande 2005; Kochar 2011; Panagariya 2006). In fact, our results suggest that 18% additional districts met the target ratio of 17,000 people per branch set by the second (1982-1985) and third (1985-1990) BLP periods. These results reveal that significant pressure must have successfully been placed on banks for them to comply with the governing objectives. Similarly, our results also lend support to the government's significant drive in promoting lending to agriculture (Part A of Table 1), with DFA increasing by approximately 64% from 126 million rupees in 1982 to 210 million rupees in 1987. Alongside the increase in DFA was an even more dramatic rise in total outstanding credit, explaining the fall in the ratio of DFA to total outstanding credit despite the overall increase in lending during that period.

With respect to agricultural input usage during the study period (Part B of Table1), we see a slight decrease in gross cropped area, highlighting the growing need to increase productivity per unit land area (Evenson & Gollin 2003a). In fact, we find that the average area cultivated by HYVs increased by 4% over this period, along with an increase in mean fertiliser use for all three macro-nutrients (nitrogen, phosphorous, and potassium) – suggesting a shift towards more intensive agriculture. Unlike HYVs and fertiliser, irrigation and mechanization (estimated as the number of tractors) did not evolve as quickly between 1982 and 1987. With irrigation, this could be related to the significant drop in public expenditure by the onset of the 1980s forcing the government to abandon a large number of projects leading to stagnation in the spread of irrigated land right until the turn of the century (Fan et al. 2008). Adoption of

---

[24] Taken from the Census of India, 1981

[25] This dataset is available online (http://dbie.rbi.org.in/DBIE/dbie.rbi?site=publications)

[26] In order to match most closely to the VDSA, which uses a base year of 1966 when reallocating districts, we use 1971 as the base year for redistributing districts in the RBI dataset.

[27] This refers to cases where 100% of a district was split into two or more new districts.

[28] This refers to cases where a proportion of a district is reallocated to one or more other districts.

tractors on the other hand, were held back due to other constraints – principally the lack of subsidisation to encourage take-up as was advocated for other inputs, as well as the slow rise in rural wage rates; a necessary precursor to mechanisation (Binswanger 1978).

Table 1: Descriptive statistics of the evolution of indicators for rural finance, input usage, labour wage rate, and production between 1982 and 1987.

		1982		1987	
A. Finance					
	Number of Rural Bank Branches	62.43	(39.13)	92.41	(50.78)
	Population to Bank Ratio ('000 People)	32.38	(15.28)	21.36	(8.17)
	Direct Finance to Agriculture (MN Rs.)	126.90	(121.75)	210.16	(202.05)
	Ratio of DFA to Outstanding Credit	0.33	(0.17)	0.22	(0.10)
B. Agricultural Inputs					
	Gross Cropped Area ('000 ha)	558.05	(303.99)	549.55	(300.16)
	Area Cultivated with High Yielding Varieties (% of cereal land)	43.80	(27.68)	48.30	(25.30)
	Irrigated Land Area (% of cultivated land)	41.39	(36.81)	46.64	(42.55)
	Nitrogen Intensity (kg/ha)	27.16	(26.52)	35.07	(32.62)
	Phosphate Intensity (kg/ha)	9.51	(9.44)	13.73	(11.77)
	Potash Intensity (kg/ha)	4.89	(5.80)	6.13	(8.63)
	Fertilizer Expenditure (Rs./ha)	199.2735	(186.35)	198.7974	(175.67)
3	Tractors (number/ha)	0.003	(0.005)	0.006	(0.008)
C. Agricultural Labour					
	District Male Wage Rate (Rs./day)	9.20	(4.24)	11.37	(4.57)
	District Female Wage Rate (Rs./day)	7.16	(2.39)	7.71	(2.63)
D. Production & Productivity					
	Average Yield of Major Cereal Crops (tonnes/ha)	1.18	(0.74)	1.27	(0.67)
	Average Yield of Major Pulse Crops (tonnes/ha)	0.56	(0.32)	0.49	(0.23)
	Average Yield of Major Oilseed Crops (tonnes/ha)	0.51	(0.28)	0.57	(0.28)
	Aggregate Yield (Rs./ha)	20612.42	(11674.47)	21651.81	(12399.26)

Notes:
1 Standard errors in parentheses.
2 Source: Village Dynamics in South Asia Database (VDSA) and Reserve Bank of India's Basic Statistical Reports (BSR).
3 Expressed on a per net cropped area bases.

In order to obtain comparable information on agricultural output, we calculate the monetized values of production ('000 Rs.) and yield (Rs. per hectare) for 20 major crops[29] using average district prices.[30] Our

[29] Aggregate production and yield include: rice, wheat, maize, barley, sorghum, pearl millet, finger millet, chickpea, pigeon pea, minor pulses, groundnut, sesame, rape and mustard seed, safflower, castor, linseed, sunflower, soyabean, sugarcane, and cottonne.

results suggest that despite the growth in input usage from fertiliser and seeds, the yield of major cereal crops and oilseeds grew only slightly, while those of pulses fell (Part C of Table 1). Accordingly, there was only a marginal increase in aggregate yield. However, low yield estimates in 1987 are likely due to a widespread drought during the summer growing season, where the mean annual rainfall across all districts was 20% below the norm. This would further explain the fall in yield of pulses, which are less likely to be irrigated and are thus more susceptible to drought.

5 Methodology

When attempting to evaluate the impact of formal lending on agricultural outcomes in a non-experimental setting, one of the main challenges is establishing a causal relationship by isolating the supply of credit from the demand. The observed amount of outstanding credit is the combined outcome of both the demand for and the supply of loans. Unless specified otherwise in regulation, we can expect that banks are likely to select the most productive borrowers in the best agro-climatic regions.[31] This selection creates a joint dependence on the observed amount of outstanding credit, investment in inputs, and productivity. Due to this problem of endogeneity, simple correlations estimates would be biased, and therefore not represent the true impact on the outcomes of interest.

One way of disentangling supply and demand in order to correctly estimate the impact of increased banking infrastructure on agricultural outcomes is through an instrumental variable approach. This method involves estimating the supply of credit independently by using an instrument which affects supply but is uncorrelated with demand. As in the study by Kochar (2011) evaluating the impact of India's social banking programme during the 1980s on income distribution in Uttar Pradesh, we exploit the explicit set of policy regulations independently guiding both rural bank branch expansion and targeted lending to priority sectors irrespective of demand factors. Further, the years covered by our dataset (1982-1987) incorporates both the second (1982-1985) and part of the third (1985-1990) BLP periods. The break between the two policy periods led to the re-classifying of districts as deficit and non-deficit in 1985, providing us with additional verification that the identification is based on banking indicators and not on other demand conditions faced by the districts. This variation is captured even more thoroughly for targeted lending, as districts were evaluated and re-classified on a yearly basis.

5.1 Estimation Strategy for the Impact of Rural Bank Branch Expansion

The instrumental variable approach requires a two-stage least squares estimation procedure wherein the first-stage estimates the endogenous financial indicator using an 'instrument', which in this study is the implementation guidelines for the financial inclusion policies of the 1980s. With respect to improvement in access to financial services, we can identify the expansion of rural bank branches based on the regulations of the BLPs by using the following equation:

$$B_{i,t} = \left(1 - D_{i,t}^{B}\right)B_{i,0} + D_{i,t}^{B}B_{i,0}\left(1 + \hat{g}_{i,t}^{B}\right) \quad (1)$$

[30] All monetary values, including crop prices, wages, and agricultural credit, are deflated using the Rural Consumer Price Index (Ozler & Ravallion 1996).

[31] This is the case for the BLP and priority lending policies of the 1980's, since regulations were set at the sectoral level and not the individual farmer. That is, priority lending regulations required banks to lend a certain proportion of their total outstanding credit to agriculture, and not specifically to small and marginal farmers.

where $B_{i,t}$ is the number of banks in district i at the end of period t (therefore, the initial BLP year in the case of $B_{i,0}$), $D^B_{i,t}$ is a dummy variable which takes the value of 1 for districts that are classified as 'deficit' based on their population to bank ratio, and $g^B_{i,t}$ is the growth rate of banks estimated using a linear function of the initial population per bank ratio $R^B_{i,0}$ (where, $g_{it} = \alpha_0 + \alpha_1 R^B_{i,0}$). Solving equation (1) using the growth rate function results in the following reduced form first-stage regression equation for estimating the number of rural bank branches:

$$B_{i,t} = \alpha_0 B_{i,0} + \alpha_1 (B_{i,0} \times D^B_{i,t}) + \alpha_2 (B_{i,0} \times D^B_{i,t} \times R^B_{i,0}) + X_{i,t} + \delta_i + \gamma_t + \varepsilon_{i,t} \quad (2)$$

where X is a set of time-variant district-specific determinants of the outcome variable, δ are district fixed effects accounting for time-invariant district characteristics which may affect rural bank branch expansion, and γ are year fixed effects to control for any unobserved heterogeneity within years.

The second-stage of the two-stage least squares regression involves estimating the outcome of interest using the estimated number of rural bank branches ($\hat{B}_{i,t}$) from the first-stage. The second-stage regression can therefore be represented as follows:

$$y_{i,t} = \beta_0 + \beta_1 \hat{B}_{i,t} + \beta_2 X_{i,t} + \delta_i + \gamma_t + \varepsilon_{i,t} \quad (3)$$

where y is the outcome variable of interest which will include different agricultural technologies as well as measures of aggregate production and yield. The coefficient of interest is therefore β_1, which measures the effect of our financial access indicator (rural bank branches) on the outcome variable of interest. $X_{i,t}$ is a vector of control variables including: number of registered rural markets, total rural road length (km), macro shocks (year dummies), and rainfall shocks.[32]

5.2 Estimation Strategy for the Impact of Targeted Agricultural Credit

Similarly, we can identify the increase in targeted agricultural lending using the following equation based on the priority sector lending regulations of the period:

$$C_{i,t} = (1 - D^C_{i,t-1}) C_{i,t-1} + D^C_{i,t-1} C_{i,t-1} (1 + \hat{g}^C_{i,t}) \quad (4)$$

where $C_{i,t}$ is the amount of direct finance to agriculture (DFA) in district i in the present period t, $D^C_{i,t-1}$ is a dummy variable which takes the value 1 for districts that are classified as 'deficit' based on their lagged total outstanding DFA, and $\hat{g}^C_{i,t}$ is the growth rate of the total amount of DFA estimated as a linear function of the lagged C to total outstanding credit ratio $R^C_{i,t-1}$ (where, $g_{it} = \alpha_0 + \alpha_1 R^C_{i,t-1}$). Accordingly, using the growth rate to solve equation (4) we can estimate the reduced form first-stage regression equation for the amount of priority sector lending to agriculture as:

$$C_{i,t} = \alpha_0 C_{i,t-1} + \alpha_1 (C_{i,t-1} \times D^C_{i,t-1}) + \alpha_2 (C_{i,t-1} \times D^C_{i,t-1} \times R^C_{i,t-1}) + X_{it} + \delta_i + \gamma_t + \varepsilon_{it} \quad (5)$$

[32] We define a rainfall shock as the fractional deviation of the annual average district rainfall from the long-term mean.

where similar to equation (2), X is a set of time-variant district-specific determinants of the outcome variable, δ are district fixed effects accounting for time-invariant district characteristics which may affect agricultural credit supply, and γ are year fixed effects to control for any unobserved heterogeneity within years.

The second-stage of the two-stage least squares regression involves estimating the outcome of interest using the first-stage estimate of agricultural credit $\hat{C}_{i,t}$ through priority sector lending policies. The second-stage regression can therefore be represented as follows:

$$y_{i,t} = \beta_0 + \beta_1 \hat{C}_{i,t} + \beta_2 X_{i,t} + \delta_i + \gamma_t + \varepsilon_{i,t} \quad (6)$$

where y is the outcome variable of interest which will include different agricultural technologies as well as measures of aggregate production and yield. The coefficient of interest is therefore β_1, which measures the effect of agricultural credit on the outcome variable of interest. $X_{i,t}$ is a vector of control variables including: number of registered rural markets, total rural road length (km), macro shocks (year dummies), and rainfall shocks.[33]

For the analysis to be robust, the instruments must be both exogenous (i.e. uncorrelated with the error term) and valid. An instrument is considered valid if it is sufficiently strongly correlated with the endogenous banking indicators once the other independent variables are controlled for. Given the unobservable nature of the error term, we cannot test for exogeneity. We can however, test for the validity condition. This requires expressing a reduced form equation of the endogenous banking indicators as a function of all exogenous variables (equations 2 and 5). Exogenous variables include all independent variables that are not correlated with the error term and the instrumental variable. Therefore, we present the robust first-stage Kleibergen-Paap Wald F-statistics statistics for all regressions as an indicator of the strength of the instrument.[34]

6 Results

Our study aims to measure the impact of both rural bank branch expansion and priority sector lending policies of the central Government of India during the 1980s on the agricultural economy. As defined in the methodology, the validity of our results hinges on the independent regulations governing these two financial inclusion instruments. Therefore, our first consideration is to verify the compliance of banks towards these policies across our sample districts. We find that contrary to earlier research into government-led banking programmes which emphasised rampant implementation failures undermining the success of these policies (Adams et al. 1984; Von Pischke & Adams 1980), both BLP and targeted lending to priority sectors where successfully executed. With respect to rural branch expansion, the coefficient on the interaction of initial banks with the dummy variable for deficit districts ($B_{i,0} \times D^B_{i,t}$ in equation 2) is positive and significant, indicating that the number of banks increased more rapidly in districts with a population per bank ratio above the target. Similarly, in districts where banks were constrained to lend more to the agricultural sector (variable for the interaction between lagged DFA and

[33] We define a rainfall shock as the fractional deviation of the annual average district rainfall from the long-term mean.

[34] We reject the null hypothesis that the instruments are under-identified at the 1% level based on the Kleibergen-Paap rk LM test that the excluded instruments are "valid", meaning correlated with the endogenous regressors. We further employ the Sargan-Hansen test to reject any over-identifying restrictions.

the dummy for deficit districts, $C_{i,t-1} \times D^C_{i,t-1}$ in equation 5) we find that lending to agriculture increased more rapidly. Furthermore, it appears that additional pressure was put on districts to increase lending to agriculture when banks fell significantly below the target ($C_{i,t-1} \times D^C_{i,t-1} \times R^C_{i,t-1}$ in equation 5). These results lend support to the findings presented by Kochar (2011) for Uttar Pradesh, confirming policy compliance across all Indian states.

Table 2: First-stage regression for number of rural bank branches and direct finance for agriculture.

	Estimated Coefficients	
A. Number of Rural Bank Branches		
Initial Banks ($B_{i,0}$)	0.396	***
	(0.126)	
Initial Banks × Deficit District ($B_{i,0} \times D^B_{i,t}$)	0.252	**
	(0.120)	
Initial Banks × Deficit District × Initial Population-to-Bank Ratio ($B_{i,0} \times D^B_{i,t} \times R^B_{i,0}$)	-0.011	
	(0.008)	
B. Direct Finance for Agriculture (MN Rs.)		
Lagged DFA ($C_{i,t-1}$)	0.951	***
	(0.039)	
Lagged DFA × Deficit District ($C_{i,t-1} \times D^C_{i,t-1}$)	0.604	***
	(0.170)	
Lagged DFA × Deficit District × Lagged DFA-to-Credit Ratio ($C_{i,t-1} \times D^C_{i,t-1} \times R^C_{i,t-1}$)	-4.648	***
	(1.331)	

Notes:
1 Standard errors in parentheses.
2 *** denotes 1% significance level, ** denotes 5% significance level, and * denotes 10% significance level.
3 Regressions include district fixed effects, year effects.

In light of the positive response from banks towards the financial inclusion agenda at that time, we continue the second-stage of our regression analysis which evaluates the impact of the guiding policies on agricultural technology adoption and production. We first consider the case of arable land and cultivation of HYVs. Given the concern of land scarcity faced by most developing countries, significant resources and effort were directed towards the development of improved germplasms for key crops considered essential for increasing food production intensity. Our results suggest that in accordance with the dominant land-scarce agricultural production systems prevalent across India, both the financial inclusion instruments do not change gross cropped area (see Part A of Table 3). Furthermore, we find that direct finance to agriculture leads to a slight reduction in area cultivated by HYVs (Part B of Table 3). At first glance this would appear to indicate that agricultural finance is causing a dis-adoption of modern varieties. However upon further inspection, this trend appears to be driven by a significant shift away from water-intensive cereal cultivation – including rice and wheat which were the focus of breeding efforts and diffusion of improved germplasm (Evenson & Gollin 2003a). Therefore, these results should not be viewed as a dis-adoption of HYVs, but rather as a mechanism of risk aversion towards more robust traditionally drought tolerant crops such as sorghum and millet.

Table 3: Effects of targeted lending and access to banks on cultivated and irrigated area.

	Direct Finance to Agriculture (1)	N	First stage F-statistic	**Bank Branches** (2)	N	First stage F-statistic
A. Cultivated Area						
Gross Cropped Area ('000 ha)	0.0303	919	96.60	0.0519	928	8.94
	(0.0848)			(0.8127)		
Total Water Intensive Cropped Area ('000 ha)	-0.0760 **	924	96.94	-0.4894	933	9.19
	(0.0298)			(0.2999)		
Total Non-Water Intensive Cropped Area ('000 ha)	0.0156	924	96.94	-0.1928	933	9.19
	(0.0402)			(0.3025)		
B. Area Cultivated with High Yielding Varieties						
Total HVY Area ('000 ha)	-0.0509 *	924	96.94	0.1476	933	9.19
	(0.0267)			(0.2928)		
Total Water Intensive HVY Area ('000 ha)	-0.0583 **	924	96.94	0.1009	933	9.19
	(0.0240)			(0.2925)		
Total Non-Water Intensive HYV Area ('000 ha)	0.0074	924	96.94	0.0467	933	9.19
	(0.0209)			(0.2248)		
C. Irrigated Area						
Gross Irrigated Area ('000 ha)	-0.0325	892	112.64	0.0135	898	11.41
	(0.0329)			(0.3809)		
Net Irrigated Area by Canals ('000 ha)	0.0046	924	96.94	-0.2707	933	9.19
	(0.016)			(0.179)		
Net Irrigated Area by Wells ('000 ha)	0.0009	924	96.94	0.1726	933	9.19
	(0.015)			(0.146)		

Notes:
1 Robust standard errors in parentheses (clustered at the district level).
2 The first stage F-statistcs are robust Kleibergen-Paap Wald statistics.
3 *** denotes 1% significance level, ** denotes 5% significance level, and * denotes 10% significance level.
4 Regressions include district fixed effects, year effects, number of rural markets, road length, and rain shocks.
5 Water intensive crops include wheat, rice and sugarcane. Non-water intensive crops include sorghum, millet, and maize.

The vast majority of HYVs were developed by the CGIAR and distributed through National Agricultural Research Systems (NARS) with little financial burden to adoption. Nevertheless, farmers incur additional costs on account of the higher input requirements of these modern varieties – including chemical fertilisers, irrigation and pesticides – in order to maximize the yield potential (Evenson & Gollin 2003b). Therefore, farmers clearly face liquidity constraints when shifting from traditional to modern crop varieties, hence the capacity for impact from improved financial inclusion into credit markets. However, adoption may be more immediately limited by the availability of high potential irrigated land as well as efficient distribution systems.

Irrigation is commonly accepted as a critical catalyst for improved agricultural yields, reducing the risk of crop failure due to an unpredictable climate. Our results on different irrigation infrastructures in Part C of Table 3 highlight the lack of investment in this key input. We find that policies governing both DFA and bank branch expansion had no impact on adoption of irrigation facilities and gross irrigated area during the 1980s. Given the nature of irrigation technology, this is not entirely surprising. Canal networks for instance, are largely the product of public sector investment and management due to the extensive infrastructure and political requirements which are necessary to coordinate river valleys across states (Fan et al. 2008). Therefore, there is no reason to believe that the financial inclusion schemes targeting smallholder farmers analysed in this study should impact the development and maintenance of canals. Wells on the other hand, are the result of private investment and could have been promoted by increased access to finance. However as described by Gollin et al. (2005), wells were initially adopted during the 1960s at the onset of the Green Revolution but later witnessed a significant drop by the 1980s. This was largely led by a shift in investment directed towards rehabilitation of existing systems rather than new constructions, due to rapid degradation from lack of proper maintenance. These results further coincide with the summary statistics presented earlier in Table 1 of Section 4, disclosing the lack of growth in irrigated land from 1982 to 1987 and highlighting water as a potential bottleneck to further technology adoption such as HYVs.

Unlike irrigation, investment in fertiliser can be minimal while still providing a significant rate of return (Beaman et al. 2013; Duflo et al. 2008; Udry & Anagol 2006). It is therefore unanticipated to find a consistent fall in fertiliser usage and subsequently expenditure in response to bank branch expansion during the 1980s (Part A of Table 4). Specifically, we find a significant reduction in usage of macro-nutrient fertilisers - nitrogen and phosphorus - by 854 and 354 tonnes respectively for each additional bank. This corresponds to an average aggregate reduction in fertiliser expenditure of 195,000 rupees. These findings are in contrast to those of Binswanger and Khandker (1993) who report a significant positive impact from the expansion of rural finance in India during the 1970s on overall fertiliser usage. However this study suffers from various methodological problems, including the use of weak instrument which is likely to bias the estimates.

In fact, we believe these results are aligned with the findings of Burgess & Pande (2005), which reveal that the increase in rural banking infrastructure was associated with a growth in both secondary and tertiary sector output, at the expense of the agricultural sector. These results were further substantiated in a recent study by Ayyagari et al. (2013), measuring the impact of financial access in India from 1983 to 2005. The authors find that financial access does alleviate poverty levels, but this is largely attributed to migration away from rural areas towards the tertiary sector in urban areas. Our results further contribute

Table 4: Effects of targeted lending and access to banks on fertiliser usage and expenditure, as well as mechanisation.

	Direct Finance to Agriculture		N	First stage F-statistic	**Bank Branches**		N	First stage F-statistic
	(1)				(2)			
A. Fertiliser Consumption								
Nitrogen Consumption (tonnes)	-71.2686		924	96.94	-853.5787	***	933	9.19
	(64.1293)				(331.3509)			
Phosphate Consumption (tonnes)	-1.4079		924	96.94	-354.2629	**	933	9.19
	(31.2175)				(148.2471)			
Potash Consumption (tonnes)	-3.7804		924	96.94	-37.7835		933	9.19
	(3.9367)				(23.8886)			
Total Fertiliser Consumption (tonnes)	-76.4569		924	96.94	-1245.6250	***	933	9.19
	(94.2929)				(474.7623)			
Total Fertiliser Expenditure ('000 Rs.)	14.9316		924	96.94	-195.6145	*	933	9.19
	(21.4405)				(102.6465)			
B. Agricultural Machinery								
Diesel Pump Sets ('000)	-0.0077		244	253.15	0.0285		258	18.24
	(0.006)				(0.054)			
Electric Pump Sets ('000)	0.0218	**	244	253.15	0.0573		258	18.24
	(0.011)				(0.050)			
Power Tiller ('000)	0.0001		244	253.15	0.0035		258	18.24
	(0.000)				(0.003)			
Tractors ('000)	0.0034	**	244	253.15	-0.0007		258	18.24
	(0.002)				(0.008)			

Notes:
1 Robust standard errors in parentheses (clustered at the district level).
2 The first stage F-statistcs are robust Kleibergen-Paap Wald statistics.
3 *** denotes 1% significance level, ** denotes 5% significance level, and * denotes 10% significance level.
4 Regressions include district fixed effects, year effects, number of rural markets, road length, and rain shocks.

to this discussion by demonstrating that access to banks provides farmers with the opportunity to move away from agriculture, leading to reduced investment in productive inputs.

Unlike expansion of rural banking infrastructure, we find that direct finance to agriculture has no influence on either fertiliser usage or expenditure. This may be related to the heavy government subsidies on urea, a commonly used nitrogen-based fertiliser, making it widely available at very affordable prices and thereby minimising liquidity constraints (Fan et al. 2008). Further, a study by Singh (2004) on the distribution of fertiliser in India across states and crops reveals that paddy, wheat and sugarcane farms have historically been the top three consumers of fertiliser, accounting for approximately 35%, 20%, and 5.5% of total fertiliser respectively. Our results on cultivated area showing a reduction in water-intensive crops - which include these three crops, provides further rational for the lack of impact on fertiliser usage.

As indicated in the review on technology adoption in Section 2, the introduction of mechanisation in developing countries has been the subject of wide debate due to its substitution effect on agricultural labour (Binswanger 1978). In contrast to other technologies such as HYVs, irrigation, and fertilisers, mechanisation has been spread almost entirely through the private sector and is often associated with large capital investment for adoption. As a result, a significant rise in rural wages is the obvious precursor to mechanisation of key labour-intensive operations such as land preparation, sowing, harvesting, and threshing. During the time period of this study, male rural wage rates increased by 23% (see Table 1 in Section 4), from 9.22 Rs./day in 1982 to 11.37 Rs./day in 1987, setting the scene for the adoption of labour-saving agricultural machinery. Agricultural finance in this case can clearly promote adoption by reducing potential liquidity constraints. Accordingly, we find that DFA caused a significant increase in investment for both electric pump sets for irrigation as well as tractors. Every additional million rupees of DFA resulted in 3.4 and 21.8 additional tractors and electric pump sets respectively at the district level. While, electric pump sets are not a labour-saving technology, they are more efficient than the diesel alternative, thus potentially reduce the cost of irrigation. In contrast, bank branch expansion did not result in any additional investment in agricultural machinery, similar to all other inputs considered in this study.

Unsurprisingly, the limited impact of DFA on the adoption of agricultural inputs resulted in no significant increase in aggregate production or yield, while reduced investment in agricultural inputs caused by rural bank branch expansion led to a large and significant reduction in production. Every additional rural bank branch reduced the district-wise aggregate crop production by 11 million rupees (Part A Table 5). These results clearly substantiate the results of a previous study by Burgess and Pande (2005) on the lack of influence from rural branch expansion on primary sector output, by demonstrating the diversion of productive investment away from agriculture.

Furthermore, both case study and empirical evidence suggests that farmers are risk-averse when investing uninsured loans. A study in Northern Ghana by Karlan et al. (2012) found that insured credit leads to significantly higher agricultural investment as well as riskier production choices relative to traditional loan products. We find evidence that targeted agricultural credit causes farmers to substitute towards less risky drought-tolerant crops. In fact, every additional thousand rupees of DFA causes a small but significant increase in yields of these non-water intensive crops amounting to 2.84 rupees per hectare (Part B Table 5). Similarly, the observed reduction in aggregate production caused by bank branch expansion appears to be driven by a disproportionate decline in water-intensive crops such as rice, wheat,

Table 5: Effects of targeted lending and access to banks on agricultural production and yields.

	Direct Finance for Agriculture	N	First stage F-statistic	**Bank Branches**	N	First stage F-statistic
	(1)			(2)		
B. Production						
Aggregate Production ('000 Rs.)	-278.70	879	102.11	-11045.31 ***	889	9.04
	(299.15)			(3995.57)		
Aggregate Production of Water Intensive Crops ('000 Rs.)	-400.63	862	85.56	-8212.80 ***	871	8.59
	(252.73)			(2987.35)		
Aggregate Production of Non-Water Intensive Crops ('000 Rs.)	80.60	749	87.53	1196.86	759	9.65
	(84.90)			(1048.15)		
C. Yield						
Aggregate Yield (Rs./ha)	-12.79	879	102.11	-82.51	889	9.04
	(7.79)			(99.65)		
Aggregate Yield of Water Intensive Crops (Rs./ha)	-5.26	860	86.98	-60.47	869	8.59
	(6.42)			(87.26)		
Aggregate Yield of Non-Water Intensive Crops (Rs./ha)	2.84 **	748	66.34	-4.65	758	9.63
	(1.28)			(12.96)		

Notes:
1 Robust standard errors in parentheses (clustered at the district level).
2 The first stage F-statistcs are robust Kleibergen-Paap Wald statistics.
2 *** denotes 1% significance level, ** denotes 5% significance level, and * denotes 10% significance level.
3 Regressions include district fixed effects, year effects, number of rural markets, road length, and rain shocks.
4 Water intensive crops include wheat, rice and sugarcane. Non-water intensive crops include sorghum, millet, and maize.

and sugarcane. These results have important implications with respect to the potential role of financial inclusion instruments, as well as how to best leverage their influence.

7 Conclusion

Over the past five decades India has witnessed dramatic technological changes in its agricultural production systems, helping to lift the country away from chronic food insecurity. This influx and spread of technology across the country have been accompanied by an aggressive financial inclusion agenda resulting in the expansion of formal financial services into rural areas. It has been widely assumed that the dual goals of ensuring national food security and advancing financial inclusion are complimentary. That is, capital-constrained farmers are given access to credit allowing them to invest in profitable technologies. However, the results of this study negates this assumption: we find that every additional rural bank reduced district-wise aggregate crop production to the tune of 11 million rupees, suggesting that simply expanding access to financial services through a larger network of rural bank branches is not automatically aligned with the food security agenda. This finding is supported by Burgess and Pande (2005), who suggest that increased access to financial products and services in rural India aided output and employment diversification away from agriculture.

The costs of India's social banking policies have been high: agricultural interest rates continue to be heavily subsidized, and the cost of high loan default rates have historically been borne by the government (Fan et al. 2008). It is essential for these costs to be balanced with evidence of economic and social benefits. The expansion of commercial banks to previously unbanked rural areas has clearly paid off in terms of economic growth, employment, and poverty reduction in non-agricultural sectors (Burgess & Pande 2005; Kochar 2011). The question is: are there any added benefits to imposing agricultural credit targets on commercial banks? Our results show marginal increases in technology adoption, particularly in terms of mechanization. Therefore, it appears that targets for priority sector lending have only slightly enhanced investment in agricultural technology. However ultimately, the benefits need to be measured in terms of output, which showed no signs of improvement.

Various implementation challenges with respect to targeted lending for agriculture have been identified over the years as potential obstacles to increasing production. One of the most documented issue relates to the disproportionate amount of credit going to wealthy cultivators with large landholdings (Bhende 1986). Recently a Committee on Comprehensive Financial Services (CCFS) reported an increase in per capita credit to cultivators with the largest landholdings despite their low share of agricultural production (Mor et al. 2013). Moreover, the report noted that only 14% of marginal farmers, who account for as much as 20% of the gross cultivated area, were taking loans from formal institutions in 2009. This trend limits the potential impact of agricultural finance on both production and poverty alleviation. Furthermore, case studies have highlighted the widespread diversion of loans towards off-farm activities, thereby further negating its potential impact (Bhende 1986; Von Pischke & Adams 1980).

Despite these concerns, and potentially due to the lack of rigorous evaluations in this field, the dual challenge of increasing financial inclusion and ensuring national food security are by no means a thing of the past. According to the 2014 Global Findex Data, only 53% of the adult population in India has a formal bank account, while only 6% have an outstanding loan from a formal financial institution.

Financial inclusion and capability therefore continue to be at the forefront of the policy agenda in India. On August 15th 2014, the current Central Government introduced the Jan Dhan Yojana scheme aimed at opening over 70 million formal bank accounts across the country within a year. Simultaneously, the government continues to promote agricultural credit by subsidising interest rates through the Kisan Credit Card (KCC) scheme. Since the inception of the scheme in August 1998, 54 million cards have been issued across India, giving farmers access to timely and cheap credit. Under the scheme, banks extend loans of up to 300,000 rupees to farmers at a concessional interest rate of 7%,[35] while commercial banks get a 2% interest rate subvention from the government. This scheme alone has been estimated to cost the taxpayer 81 billion rupees in the 2013-14 financial year.[36]

While the results of our research date back to the 1980s and the rural economy has gone through substantial changes over the past decades, there is no recent research to suggest that these changes have improved the productivity of agricultural credit. In light of our findings, it is therefore not surprising to find that despite this inflow of finance in agriculture, yield growth rates have started to stagnate - casting doubts over the future food security of the country (Ray et al. 2012). Long-run estimates suggest that if urgent action is not taken to reverse the trend, more than 17% of the total population in South Asia may face food insecurity by 2050 (Titumir & Basak 2011). Therefore, as India continues to pursue its financial inclusion agenda it needs to align itself better with the food security needs of the nation. In 2013, the Committee on Comprehensive Financial Services (CCFS) made a series of policy recommendations to promote greater geographic and socio-economic targeting (Mor et al. 2013). Following these recommendations, the RBI has set sub-targets for loans to small and marginal farmers. This policy has the potential to redistribute agricultural credit over a greater production surface area and thereby increase marginal returns. Secondly, as is the case with most bank loans - but not practiced for targeted lending - agricultural credit should be tied to a viable business plan. This could be achieved by integrating the rural credit market with agricultural extension services in an agent-based model. Such a policy initiative would have the potential to ensure that suitable investments are made on the suite of agricultural inputs required for maximising potential gains. Finally, a system of accountability needs to be attached to agricultural loans to address the concerns related to the diversion of funds into other economic activities. For example, loans could be linked to agro-shops such that farmers can only spend the money on required inputs. As made evident from our findings, targeted lending alone will not allow India to leverage the capacity of its agricultural sector. Research and development related to improved technologies have gone a long way to enhance productivity gains for smallholder farmers. Innovation in credit markets is now needed to provide farmers with financial tools that are appropriate for both improving their livelihoods, as well as ensuring that the country's food requirements are met.

[35] Farmers receive a further 3% discount for timely repayment, making the effective rate 4%.
[36] Source: Union Budget of India http://indiabudget.nic.in/

References

Abramovitz, M. & Morris, C., 1967. *Society, Politics and Economic Development: A Quantitative Approach*, Johns Hopkins University Press.

Adams, D. & Graham, D., 1981. A Critique of Traditional Agricultural Credit Projects and Policies. *Journal of Development Economics*, 8(3), pp.347–366.

Adams, D., Graham, D. & Pischke, J., 1984. *Undermining Rural Development with Cheap Credit*, Westview Press.

Adams, D. & Vogel, R., 1986. Rural Financial Markets in Low-Income Countries: Recent Controversies and Lessons. *World Development*, 14(4), pp.477–487.

Ayyagari, M., Beck, T. & Hoseini, M., 2013. Finance and Poverty: Evidence from India. *Working Paper*.

Barrett, C., 2002. Food Security and Food Assistance Programmes. *Handbook of Agricultural Economics*, 2(Part B), pp.2103–2190.

Beaman, L. et al., 2013. Profitability of Fertilizer: Experimental Evidence from Female Rice Farmers in Mali. *The American Economic Review*, 103(3), pp.381–86.

Beaman, L. et al., 2014. Self-Selection into Credit Markets: Evidence from Agriculture in Mali. *National Bureau of Economic Research.*, No. w20387.

Besley, T. & Case, A., 1993. Modeling Technology Adoption in Developing Countries. *American Economic Review*, 83(2), pp.396–402.

Bezemer, D. & Headey, D., 2006. Something of a Paradox: The Neglect of Agriculture in Economic Development. In *International Association of Agricultural Economists, 2006 Annual Meeting*.

Bhende, M., 1986. Credit Markets in Rural South India. *Economic and Political Weekly*, 21(38/39), pp.A119–A124.

Binswanger, H., 1978. *The Economics of Tractors in South Asia*, International Crops Research Institute for the Semi-Arid Tropics.

Binswanger, H., Khandker, S. & Rosenzweig, M., 1993. How Infrastructure and Financial Institutions Affect Agricultural Output and Investment in India. *Journal of Development Economics*, 41(2), pp.337–366.

Braverman, A. & Guasch, J., 1986. Rural Credit Markets and Institutions in Developing Countries: Lessons for Policy Analysis from Practice and Modern Theory. *World Development*, 14(10), pp.1253–1267.

Burgess, R. & Pande, R., 2005. Do Rural Banks Matter? Evidence from the Indian Social Banking Experiment. *American economic review*, 95(2), pp.780–795.

Chen, S. & Ravallion, M., 2007. Absolute Poverty Measures for the Developing World, 1981–2004. *Proceedings of the National Academy of Sciences*, 104(43), pp.16757–16762.

Cole, S. & Fernando, A., 2012. The Value of Advice: Evidence from Mobile Phone-Based Agricultural Extension. *Harvard Business School Finance Working Paper*, 13-047.

Conley, T. & Udry, C., 2010. Learning About a New technology: Pineapple in Ghana. *American Economic Review*, 100(1), pp.35–69.

Copestake, J., 1992. The Integrated Rural Development Programmeme: Performance during the Sixth Plan, Policy Responses and Proposals for Reform. *Poverty in India: Research and Policy*, pp.209–230.

Dobermann, A. & Fairhurst, T., 2000. *Rice: Nutrient Disorders & Nutrient Management*, International Rice Research Institute.

Duflo, E., Kremer, M. & Robinson, J., 2008. How High are Rates of Return to Fertilizer? Evidence from Field Experiments in Kenya. *American Economic Review*, 98(2), pp.482–488.

Duflo, E., Kremer, M. & Robinson, J., 2011. Nudging Farmers to Use Fertilizer: Theory and Experimental Evidence from Kenya. *American Economic Review*, 101(6), pp.2350–2390.

Duflo, E. & Pande, R., 2005. *Dams*, National Bureau of Economic Research.

Evenson, R. & Gollin, D., 2003a. Assessing the Impact of the Green Revolution, 1960 to 2000. *Science*, 300(5620), pp.758–762.

Evenson, R. & Gollin, D., 2003b. *Crop Variety Improvement and its Effect on Productivity: The Impact of International Agricultural Research*, Cabi.

Fan, S., Gulati, A. & Thorat, S., 2008. Investment, Subsidies, and Pro-poor Growth in Rural India. *Agricultural Economics*, 39(2), pp.163–170.

FAO, 2004. Rice and Narrowing the Yield Gap. *Food and Agricultural Organisation*.

Fletschner, D., Guirkinger, C. & Boucher, S., 2010. Risk, Credit Constraints and Financial Efficiency in Peruvian Agriculture. *Journal of Development Studies*, 46(6), pp.981–1002.

Foster, A. & Rosenzweig, M., 2010. Microeconomics of Technology Adoption. *Annual Review of Economics*, 2(1), pp.1–29.

Gangwar, K. et al., 2014. Mechanization Practices in Rice-Wheat Cropping Systems in Upper Gangetic Plains of India. *Ama-Agricultural Mechanisation in Asia Africa and Latin America*, 41(2).

Giné, X. & Yang, D., 2009. Insurance, Credit, and Technology Adoption: Field Experimental Evidence from Malawi. *Journal of Development Economics*, 89(1), pp.1–11.

Godfray, H. et al., 2010. Food Security: The Challenge of Feeding 9 Billion People. *Science*, 327(5967), pp.812–818.

Gollin, D., Morris, M. & Byerlee, D., 2005. Technology Adoption in Intensive Post-Green Revolution Systems. *American Journal of Agricultural Economics*, 87(5), pp.1310–1316.

Gollin, D., Parente, S. & Rogerson, R., 2002. The Role of Agriculture in Development. *American Economic Review*, 92(2), pp.160–164.

De Gregorio, J. & Guidotti, P., 1995. Financial Development and Economic Growth. *World Development*, 23(3), pp.433–448.

Gupta, A., 2005. Micronutrient Status and Fertilizer Use Scenario in India. *Journal of Trace Elements in Medicine and Biology*, 18(4), pp.325–331.

Harris, D. & Orr, A., 2014. Is Rainfed Agriculture Really a Pathway From Poverty? *Agricultural Systems*, 123, pp.84–96.

Imai, K., Arun, T. & Annim, S., 2010. Microfinance and Household Poverty Reduction: New Evidence from India. *World Development*, 38(12), pp.1760–1774.

Jack, K., 2011. Market Inefficiencies and the Adoption of Agricultural Technologies in Developing Countries. *White paper, Agricultural Technology Adoption Initiative*.

Karlan, D. et al., 2012. Agricultural decisions after relaxing credit and risk constraints. *Working PapeWorking Paper, National Bureau of Economic Research*.

King, R. & Levine, R., 1993. Finance and Growth: Schumpeter Might be Right. *Quarterly Journal of Economics*, 108(3), pp.717–737.

Kochar, A., 2011. The distributive consequences of social banking: a microempirical analysis of the Indian experience. *Economic Development and Cultural Change*, 59(2), pp.251–280.

Kumar, H. & Somanathan, R., 2009. Mapping Indian Districts Across Census Years, 1971-2001. *Economic and Political Weekly*, 44(41/42), pp.69–73.

Ladha, J. et al., 2003. How Extensive are Yield Declines in Long-Term Rice–Wheat Experiments in Asia? *Field Crops Research*, 81(2), pp.159–180.

Lewis, W., 1954. Unlimited Supplies of Labour. *Manchester School of Economics*.

Ligon, E. & Sadoulet, E., 2007. Estimating the Effects of Aggregate Agricultural Growth on the Distribution of Expenditures. *Social Science Research Network 1769944*.

Mor, N. et al., 2013. *Committee on Comprehensive Financial Services for Small Businesses and Low Income Households*, Reserve Bank of India.

Morris, M. et al., 1998. Maintaining Productivity Gains in Post-Green Revolution Asian Agriculture. *International Agricultural Development*, pp.458–473.

Munshi, K., 2004. Social Learning in a Heterogeneous Population: Technology Diffusion in the Indian Green Revolution. *Journal of Development Economics*, 73(1), pp.185–213.

Pampolino, M. et al., 2012. Development Approach and Evaluation of the Nutrient Expert Software for Nutrient Management in Cereal Crops. *Computers and Electronics in Agriculture*, 88, pp.103–110.

Panagariya, A., 2006. *Bank Branch Expansion and Poverty Reduction: A comment*, Mimeo, Columbia University.

Pardey, P. & Beintema, N., 2002. Slow Magic: Agricultural R&D a Century after Mendel. *International Food Policy Research Institute, Washingtonne, DC*.

Von Pischke, J. & Adams, D., 1980. Fungibility and the Design and Evaluation of Agricultural Credit Projects. *American Journal of Agricultural Economics*, 62(4), pp.719–726.

Ray, D.K. et al., 2012. Recent patterns of crop yield growth and stagnation. *Nature Communications*, 3, p.1293.

Satyanarayana, T. et al., 2012. Economics of Nitrogen Fertiliser Application in Rice, Wheat and Maize Grown in the Indo-Gangetic Plains. *Indian Journal of Fertilisers*, 8(8), pp.62–71.

Singh, M., 2008. *Micronutrient Deficiencies in Crops and Soils in India*, Springer.

Singh, R., 2004. Equity in Fertiliser Subsidy Distribution. *Economic and Political Weekly*, 39(3), pp.295–300.

Suri, T., 2011. Selection and Comparative Advantage in Technology Adoption. *Econometrica*, 79(1), pp.159–209.

Tewatia, R. & Chanda, T., 2005. *Fertiliser Use by Crop in India*, Food and Agriculture Organization.

Thakkar, H., 2000. Assessment of Irrigation in India. *World Commission of Dams*.

Titumir, R.A.M. & Basak, J.K., 2011. *Impacts of Changing Climatic Condition and Increasing Population on Food Security in South Asia: Based on Different Scenarios*, Unnayan Onneshan - The Innovators.

Udry, C. & Anagol, S., 2006. The Return to Capital in Ghana. *Yale University Economic Growth Center Discussion Paper*, (932).

Zanden, J., 1991. The First Green Revolution: The Growth of Production and Productivity in European Agriculture, 1870-1914. *The Economic History Review*, 44(2), pp.215–239.