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Occupational Diversification as an Adaptation to Rainfall Variability in Rural India

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Abstract

Occupational diversification among household members in rural India is investigated as an adaptation strategy against the risks arising from the variability of local rainfall. Nationally representative household level survey data are combined with the coefficient of variation of rainfall constructed based on historical rainfall data at the district level. The analysis finds that high rainfall variability has significant negative effects on the agricultural specialization of within-household occupational choices. This result is reinforced by the finding that improved access to irrigation, education, credit, roads, and postal services, are associated with a lower occupational diversification within families and a greater specialization of household members in agricultural-related employment.

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Keywords: Agriculture, Climate variability; India; Occupation

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1. Introduction

The role of adaptation to climate change and variability has been gaining increasing attention both as a complementary strategy to reducing net emission of greenhouse gases as well as a policy option for reducing social vulnerability to the changing environmental conditions.[1] A better understanding of how the increased risk and variability associated with climate change[2] is likely to affect welfare in the future, demands a more careful delineation of the different dimensions of household adaptation strategies adopted historically as well as a more careful assessment of the long-run consequences of the different adaptation strategies themselves.

Households in poor rural economies, where weather-related risks are prevalent and credit and insurance markets are absent, may adapt through precautionary and reactive actions protecting their welfare, but at the cost of lower returns (e.g., Morduch, 1995; Rosenzweig & Binswanger, 1993; Eakin, 2000; Dercon 2003, 2004; Jalan and Ravallion 2001; Cole et al., 2013). Such conservative portfolio choices and low-risk low-return strategies for the use of productive assets may reduce the likelihood that households accumulate the assets needed to escape poverty through their own savings and investment (Eswaran & Kotwal, 1990; Rosenzweig & Wolpin, 1993; Morduch, 1995; Carter and Barrett, 2006, 2013). Recent studies suggest that the effect of risk in the absence of effective formal insurance and credit markets is very important for investment and growth. Elbers et al., (2007), for example, estimate that households in Zimbabwe would accumulate much more capital in the absence of risk (46% lower than in the absence of risk) and that the total effect of risk is dominated by the *ex-ante* effect. In contrast, the *ex-post* impact of shocks appears to be less important. In such contexts, identification of the ways in which government actions and policies can remove constraints to adaptation, facilitate the process of adaptation as well as minimize the negative consequences of adaptation is essential.

Motivated by these considerations, this study investigates household adaptation to the historical variation in local rainfall in terms of the employment and occupational selection of the

[1] Adaptation as defined in the IPCC glossary includes "adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities". This broad definition reflects the different dimensions of adaptation such as anticipatory vs. reactive, and autonomous vs. planned adaptation to climatic stimuli from long-term trends in climatic norms (e.g., mean temperature and mean rainfall), extreme weather conditions (e.g., floods and droughts), and variability about climatic norms over long periods (Smit et al, 2000; Malik et al., 2010).

[2] Climate can be thought of as the 'average weather', or more rigorously, as the statistical description in terms of the mean and variability of relevant quantities (most often surface variables such as temperature, precipitation, and wind) over a period of 30 years, as defined by the World Meteorological Organization (WMO) In this study we will focus on one aspect of climate variability, i. e. rainfall variability at the local and regional level. Rainfall variability is expected to increase in a warming world. Climate change is projected to increase the number of extreme temperature and rainfall events, and hence climatic variability is expected to show an upward trend.

members of households in rural India. With approximately 70 percent of India's population living in rural areas in 2010 (World Bank, 2012), and about 58 percent of the total numbers of workers employed in the agricultural sector (Government of India, 2013), local rainfall variability during the monsoon season comprises the primary source of production and income risks. The sector of employment of the millions of rural households in India as well as many other developing countries is an important determinant of household welfare. Considering that there is a variety of factors involved in the decision of households to allocate labor between agricultural and non-agricultural occupations (on-farm and off farm), it is important to establish empirically the extent to which occupational diversification among household members represents an adaptation to the historic climatic variability as opposed to "pull" factors such as expanded opportunities to earn higher wage rates in other sectors. In principle, household members could also specialize by all working in the same occupation or sector and increase productivity by learning from each other's experience (Menon & Subramanian, 2008; Shenoy, 2013). However, lack of access to credit and capital, and the presence of idiosyncratic and uninsured risks may "push" rural households and their members away from specializing in the agricultural sector to diversified activities off the farm (Reardon, et al, 2006; Ellis, 2004; Lanjouw & Lanjouw, 2001). For example, Deininger & Olinto (2001), demonstrate in rural Colombia, that although households stand to gain by choosing a single specialized farm-based source of income, they choose to diversify into non-farm economic activities to reduce risks. Thus, at the household level, occupational diversification may result in more income security but at the cost of a lower level of welfare and overall growth.[3]

Much of the empirical literature in developing economies is concerned with the impacts of extreme weather events on key welfare outcomes.[4] Yet, these studies can only provide indirect inferences about the relationship between climatic norms and adaptation as measured by the prevalence of occupational diversification, other common practices among households, or the prevalence of social institutions and customs. Empirical studies shedding direct light and evidence on the relationship between climatic norms and adaptation are quite scarce. Rosenzweig and Stark (1989), for example, provide one of the early empirical studies on the role of marriage of daughters to locationally distant, dispersed yet kinship-related households, as an adaptation strategy facilitating consumption smoothing in an environment characterized by information costs and spatially covariant risks. They find that marriage with migration contributes significantly to a reduction in the variability of

[3] Households may also self-insure against weather risks by "saving for the rainy day." However, savings for self-insurance as opposed to investment in productive capital also hinders growth.

[4] For example, see Mueller and Osgood (2009) on the impacts of droughts on income and wages in Brazil, and the literature on consumption smoothing through precautionary savings, conservative cropping choices, and intra-household risk sharing (Jalan & Ravallion, 1999; Dercon S. , 1996; Dercon & Krishnan, 2000; Dercon & Hoddinott, 2003).

household food consumption, and that farm households afflicted with more variable profits tend to engage in longer-distance marriage with migration. However, the external validity of this study regarding adaptation behavior in the context of a changing climate is limited by the specificity of the sample used (a small 10 year panel of households from only 6 villages of semi-arid India).

More recently, Menon (2009), Ito & Kurosaki (2009), and Bandyopadhyay & Skoufias (2013) have explored more closely the relationship between rainfall variability and occupational diversification in different rural contexts. The current study complements these earlier studies in two ways. First, this study covers all of rural India which is characterized by diverse agro-ecological zones, different levels of rural infrastructure as well as a tremendous variation in climate, ranging from the desert-like western Rajasthan to the moist eastern foothills of the Himalaya to the tropical south. The studies above either covered less heterogeneous countries with specific features such as mountainous Nepal (Menon, 2009) and flood prone Bangladesh (Bandyopadhyay & Skoufias (2013), or a couple of northern states of India with relatively homogenous agro-ecological features (Ito & Kurosaki, 2009). Second, this paper carries out a more systematic investigation of the extent to which government investments in various types of rural infrastructure such as irrigation, roads, and information and communication, or credit services or education can facilitate household adaptation to increased risks due to climatic change.[5]

The rest of the paper considers the empirical underpinnings of the basic story outlined above in greater detail. Section 2 presents the various data sets used in analysis. Section 3 focuses on the methods and econometric specifications. Section 4 presents the main findings and results, while section 5 concludes.

2. Data

A variety of data sources are merged together for the purpose of this analysis. These data sources include household survey data from National Sample Survey (NSS), district level data on topography from the Food and Agriculture Organization (FAO) data and infrastructure from the Indian Village Census, and daily rainfall data from the India Meteorological Department.

The 59th round of the Indian National Sample Survey (NSS59: Schedule 18.2) collected in 2002-2003 is a nationally representative survey focused on rural and peri-urban households that collects detailed farm-level information including land holdings, stocks of assets (also sales and loss of assets),

[5] This line of work is very much in line with Smit, et al. (2000) who point out that adaptations vary not only with respect to their climatic stimuli but also with respect to other non-climate conditions sometimes called intervening conditions, which serve to influence the nature and sensitivity of the adjustments taking place.

incidence of indebtedness (also borrowings and repayments at the beginning of the agricultural year), access to formal and informal credit, etc. The 59th round also contains detailed demographic information of the household as well as labor information for each household member. Specifically the survey asks the "usual activity" performed by each household member with a reference period of 365 days preceding the date of survey. Focusing on the usual activity (instead of the last week activity as in most of surveys) allows differentiating ex-ante labor diversification due to the expectation of a shock (expected risk captured by the long-term coefficient of variation) from ex-post diversification to mitigate the occurrence of the shock (weather realization).[6]

The NSS household data were collected using clustered sampling, but the precise location of primary sampling units has not been released. Thus, the district is the lowest level of geographic disaggregation at which we can link household and climate variables. By 2003, India had 576 districts, excluding those in Lakshadweep, Andaman and Nicobar Islands, and in the mountainous northern state of Jammu/Kashmir, with an average land area of around 5000 km^2.

District level data on three classes of soil slope (flat, hilly, and mountainous) were extracted from the Food and Agriculture Organization's (FAO) Soil Map of the World (SMW) together with information on total district population to take into account some of the district level heterogeneity.[7] The FAO topographical data are complemented with district-level infrastructure from the Indian Village Census. Unfortunately the village level infrastructure data cannot be matched with the villages of the NSS households as the two datasets do not share a common village identifier. Thus, the proportion of villages in a district with access to the infrastructure in question is used as a measure of district level access to infrastructure. For example, the degree of access to credit in a district is measured by the share of villages in the district with banks.

Finally, we use high resolution gridded (on 1 degree latitude by 1 degree longitude cells) daily rainfall data from the India Meteorological Department (IMD) covering the years 1951 to 2003 based on daily records from more than 1800 weather stations. Normal (i.e. mean) precipitation and normal variability, as measured by the coefficient of variation (the ratio of the standard deviation to the mean rainfall in each district) during the 1960-2000 period for a district are interpolated from the 296 cells covering India, using the proportion of the district's area in each cell as weights. We use the cumulative

[6] Working with the occupation in the last week has two additional problems: (i) observed labor outcome might be due to the realization of a weather shock rather than to expected weather (or climate), (ii) need to link timing of recent shocks with timing of the survey.

[7] Dummy variables were created for the three classes of land slope (level to gently undulating, rolling to hilly, and steeply dissected to mountainous) in each district. Additional dummies were created for the main soil types in each district in India (acrisols, cambisols, luvisols, nitosols, and vertisols), the three textural classes (coarse, medium, and fine), which reflect the relative proportions of clay, silt, and sand in the soil. The latter ended up been dropped from the analysis.

rainfall during the monsoon season (agriculture is dependent on the southwest monsoon rains which usually becomes active around mid-June and recedes by mid-October). Too much rain received at a wrong time can have a devastating effect on yields. Annual rainfall data might not reflect the true effect on agricultural yields

Table 1 shows the list of key variables and their mean and standard errors. The first sets of variables are for about 61,000 individuals between 10 and 65 years of age that had been employed in the previous year which live in a household where the head of the household is employed in the agricultural sector. For example, "in agriculture" for all households with heads engaged in agriculture, takes the value 1 if the non-head member reported to be engaged in agriculture and 0 otherwise. Alternatively, occupational specialization is defined based not only on the sector but also on the type of occupation (self-employed or wage worker). In this case, specialization in agriculture occurs when the household head is self-employed in agriculture and the non-head member is also self-employed in agriculture. Thus, "Self-employed in agriculture" for all households with heads self-employed in agriculture, takes the value 1 if the non-head member reports being self-employed in agriculture and 0 otherwise. The second set of variables consists of household level variables that can be influenced by policy such as "credit" that takes the value 1 if the household had availed of any credit in the last 12 months. We refer to these variables as the "policy action" variables. The two other household level policy action variables are the irrigation ratio and the primary plus education of the head of the household.

The third set of variables consist of village level indicators aggregated from households to measure access to the infrastructure at the village level, such as the share of households availing of credit in a village excluding the current household. The village level policy action variables are used to measure village level access to credit, irrigation and education. The fourth set of variables measures access to infrastructure at the district level, such as the share of villages with Banks in a district. Finally, district level climate indicators include coefficient of variation of Kharif season rainfall over the thirty year period between 1960 and 1999.

Table 1

In addition to the main variables of interest described in Table 1, an effort is male to control for a wide set of individual characteristics for the member as well as of the head of the household augmented by indicators of household demographics, and district level infrastructure. The complete list of these variables is listed in annex Table A1.

3. Methodology

Two types of occupational choices made by household members are considered. First, a member may choose between the agricultural and non-agricultural sector. The household member may also decide on the type of employment, and choose between wage and self-employment. Sectoral diversification may be ideal when the risks are sector specific, such as rainfall variability may affect agricultural and non-agricultural sectors differently. However, opportunities, access to human, physical and social capital may limit the choices of sectoral diversification. Within the same sector diversification by employment type may not help mitigate all the risks associated with that sector, though diversifying between wage and self-employment may reduce some of the entrepreneurial risks of self-employment.

For example, self-employment in agriculture implies bearing higher risks and higher expected returns. On the other hand wage employment may imply lower returns with lower risks. Diversification in employment types within agriculture allows better utilization of generational knowledge of the sector while reducing *ex ante* risks. For example, in rice growing areas, unusually high rainfall in the sowing and transplanting time for rice cultivation may require redoing some of these activities thus increasing demand for wage labor. Thus, while the labor cost for the self-employed farmer increases, the opportunity and income of members in wage employed agriculture goes up.

The occupational choices of working non-head members are based on both pull and push factors. As noted above the main sources of push factors in rural India is local variability of rainfall. Thus, it is hypothesized that in districts where the variance of rainfall is high, household members other than the head of household are more likely to choose occupations unrelated to agriculture. Similarly, in districts where the variance of rainfall is high, the head and other members of the household may diversify between self and wage employment in agriculture.

The pull factors associated occupational diversification are taken into account by controlling for access to physical capital and infrastructure, the level of human capital, such as education of the non-head, and the size of land holdings. These factors contribute to households being "pulled into" high return occupationally diversified portfolio.

The hypothesis is tested using two indicators of within-household occupational and employment homogeneity, "in agriculture" and "self-employed in agriculture" discussed in greater detail in the data section. To estimate the probability of agricultural specialization of the non-head members we consider three types of explanatory variables; (a) rainfall variability and other climate indicators, (b) policy action variables, and (c) other control variables. The policy action variables need special consideration as these variables are often infrastructure variables that are influenced by policies. For example, shares of paved road, post offices, banks, middle schools, and irrigated land in districts may be broadly guided by policies that favor investments in these specific areas of infrastructures.

These policy action variables can also be interpreted as access to the specific infrastructure. For example, a district with a large share of villages with banks is expected to have greater access to credit. Similarly households that live in districts where a large proportion of cultivated land is irrigated are expected to have greater access to irrigation. However, a district level measure of access, as we have at our disposal, does not capture the heterogeneity within a district. A district may have a large share of villages with banks, but an individual living in the same district may have low access to credit if her village does not have a bank. Thus, we augment the district level access indicators with household level measures where possible. Data limitations prevent matching all the district level infrastructure indicators to a corresponding household indicator. For example, the paved road and communication infrastructure measured by share of villages with post, telegraph, and telephone services offices in a district do not have any corresponding household level indicators in the data.

It is important to bear in mind that household level measures of policy action variables have their own sets of problems. In particular, household measures of credit use and irrigation summarize both access as well as utilization. For example, when a household reports to have used credit in the last year, it means not only did the household have access to credit, but also it needed to use it. Similar arguments can be made for irrigation as well.

Linear probability models are used to estimate the effect of local rainfall variability on the probability that the non-head household member chooses the same occupation as the head. A linear probability model has some advantages over a logit or probit regressions. See Mullahy (1990), Klaassen and Magnus (2001), Horrace and Oaxaca (2006) for discussions on some of the advantages of linear probability models over nonlinear models like logit and probit. While sign and significance of the coefficients are similar between the models, the magnitude of the effects must be interpreted with care. One advantage of the linear probability model is that the coefficients can be interpreted as marginal effects.

For reasons that are elaborated in more detail below, the analysis is carried out by estimating different specifications with increasing level of complexity. The first and most simple specification estimated is that summarized by equation (1) below:

$$Y_{ijd} = \beta + \beta_{RV} RV_d + \beta_1 X_{1d} + \beta_2 X_{2jd} + \beta_3 X_{3ijd} + \sum_S \beta_S D_S + \varepsilon_{ijd}. \quad (1)$$

Y_{ijd} is the probability that non-head member *i* in household *j* in district *d* has the same occupation or employment characteristics as the household head, RV_d is the coefficient of variation of rainfall in the Kharif season over the last 30 years in the district *d*, and X_{1d}, X_{2jd}, and X_{3ijd} are exogenous variables specific to member *i*, household *j* and district *d*. These variables include observable district characteristics like mean Kharif season rainfall, annual average temperature, population, and indicators summarizing the district topography, household characteristics like size of land holdings, gender of the head, caste, and religion; and non-head working member characteristics like age, sex, and education. To take into account a large variety of physical, political, economic, institutional factors that vary between the different states of India that are unobservable in our data, all the models are estimated with state fixed effects summarized by the variables D_S denoting binary variables identifying the state of residence of the household.

The validity of the hypothesis that increased climatic variability risks *ex ante*, such as greater variability of local rainfall, are associated with a smaller probability of non-head members having a usual occupation in agriculture or being self-employed in agriculture as the head of the household can be tested by checking whether the coefficient β_{RV} is negative and is significantly different from zero.

Next, a variant of the specification in equation (1) is used so as to get a closer look into the role of contextual factors that can be influenced by policy. Extra resources made available through specific policies by the government and NGOs may facilitate the mitigation of climatic risk and the inventive to diversify occupations within households. Five variables that can be influenced by policy action are considered: (a) the share of villages in a district with paved roads, (b) the share of villages in a district with post, telegraph, and telephone service offices, (c) the share of villages in a district with banks, (d) the share of villages in a district with a middle school, and (e) the ratio in a district of the area irrigated to the area cultivable. If households have more access to credit then diversification in occupations as a means of insuring welfare against *ex ante* climate risks may be less pressing compared to the case of no access to credit. Similarly, access to social safety-nets may act as an insurance against *ex ante* climate risks. Finally access to markets may make new resources available to households allowing better protection against *ex ante* climate risks. In order to analyze how the access to resources made available through policy actions mediate the effects of *ex ante* rainfall variability risks on household welfare, the specification summarized by equation (2) below is estimated based on the district-level data on infrastructure from the Indian Village Census:

$$Y_{ijd} = \beta + \beta_{RV} RV_d + \beta_{PA} PA_d + \beta_{RV\times PA}(RV_d \times PA_d) + \beta_1 X_{1d} + \beta_2 X_{2jd} + \beta_3 X_{3ijd} + \sum_S \beta_S D_S + e_{ijd} \quad (2)$$

where PA_d is one of the five policy action variables in district *d*. Note, as alternate measures of policy action we also use household irrigation and education of the head for household *j* in district *d*. RV_d is as in equation (1) above. Equation (2) highlights the interaction term between RV_d and PA_d. The effects of *ex ante* rainfall variability risks on agricultural specialization or diversification that are not influenced by policy actions are captured by the coefficient β_{RV} that is expected to be negative. The contextual variables influenced by policy actions, such as having access to road, communications, credit, education, or irrigation, the additional effects of *ex ante* rainfall variability risks are captured by the coefficient $\beta_{RV\times PA}$. Since it is expected that the contextual variables summarized by the policy action variables contribute to households having a lower incentive to protect themselves from the negative effects of *ex ante* rainfall variability risks through occupational diversification, the coefficient $\beta_{RV\times PA}$ is expected to be positive. The combined or net effect of *ex ante* climate risks and policy action on occupational diversification is then measured by ($\beta_{RV} + \beta_{RV\times PA}$). If ($\beta_{RV} + \beta_{RV\times PA}$) is not significantly different from zero, then the policy action is effective in completely mitigating the effects of the *ex ante* rainfall variability risks on occupational diversification.

The policy action variable regarding education is quite different from the other policy action variables. First, education policy has a much longer gestation period as compared with policies related to credit or irrigation. Thus, it may appear that the share of villages with at least one middle school in a district may not influence current household *ex ante* risk avoidance strategies. However, we speculate that the existence of a middle school in a village may indicate a longer history of educational infrastructure in that village as compared with say a village with only a primary school.

In addition to abstracting from heterogeneity within districts, a shortcoming associated with the use of district level measures in place of the contextual variables influenced by policy actions, is the implicit assumption that district-level infrastructure is exogenous. It is quite likely, that infrastructure placement is not randomly assigned but instead based on district -specific unobserved attributes (e.g. Pitt et al., 1993). A correlation between observed district-level infrastructure and unobserved district factors included in the error term of regression equation (2) may lead to biased coefficients of the effects of these programs and their interaction with the rainfall coefficient of variation.

One possible way of addressing this endogeneity is to include district-level "fixed effects" or a full set of binary variables for each district in the sample, as regressors. However, this approach would preclude estimation of the impact of climatic variability on occupational diversification as well as its interaction with any other district level variable. In an effort to address these shortcomings associated with district level measures of infrastructure and/or assets, we also estimate two additional specifications using three policy action variables that we construct at the village-level rather than at the district-level, based on the household specific information regarding access to markets and infrastructure provided by the NSS. These variables are the share of households in the village that used credit last year, the ratio of area irrigated to area cultivated in the village and the shared of heads in the village with more than primary education. The NSS household data did not include any suitable analog to household access to paved roads, and post and telegraph services which precluded the analysis of these policy variables at the village level.

To control for the potential endogeneity of these policy variables the instrumental variable method is used. The excluded or identifying instrumental variable employed is the village-level aggregate of the endogenous variable in question whereby the village aggregate is constructed by excluding the current household observation. For example, the instrumental variable used for the potentially endogenous variable identifying whether the household used any credit in the past year is the share of "other" households in the village that had used any types of credit in the past year (where the share excludes the current household). Thus, in the first stage, the household-specific use of credit or the share of household land irrigated or the binary variable identifying whether the household head has more than primary education is regressed against a set of state binary variables, the respective village mean of the same policy variable constructed as above, and other district-level, and household characteristics summarized by X_{1d}, and X_{2jd}.[8] The estimated model of instrumented policy action variables may be expressed as:

$$PA_{jvd} = \theta + \theta_{\widetilde{PA}}\widetilde{PA_{vd}} + \theta_1 X_{1d} + \theta_2 X_{2jd} + \sum_S \theta_S D_S + \epsilon_{jd} \qquad (3)$$

[8] The individual-specific variables summarized by X_{3ijd} are not used in the first stage because the variable being instrumented is at the household level and not at the individual level.

$$Y_{ijvd} = \beta + \beta_{RV} RV_d + \beta_{PA} \widehat{PA_{jvd}} + \beta_{RV \times PA} \left(RV_d \times \widehat{PA_{jvd}} \right) + \beta_1 X_{1\,d} + \beta_2 X_{2\,jd} + \beta_3 X_{3\,ijd} + \sum_S \beta_S D_S + u_{ijd} \quad (4)$$

where $\widetilde{PA_{vd}}$ is the village level aggregate of the policy action variable PA excluding the household j in village v in district d, and $\widehat{PA_{jvd}}$ is the fitted value of the policy variable from regression (3)

The specifications discussed so far control only for unobserved heterogeneity among states. However, in principle unobserved heterogeneity may also be present among districts in the same state or even among villages in the same district. Since there is within-district variation in the village-level instrument used, their also the opportunity to test the robustness of the results by controlling for unobserved heterogeneity among districts, though not among villages.[9] It is conceivable that unobserved characteristics at the district level play a more important role in the placement of programs that is not fully captured by the few observed characteristics included in the regressions so far (summarized by $X_{1\,d}$). Thus, equations (3) and (4) can be rewritten using district-level fixed effects as:

$$PA_{jvd} = \theta + \theta_{\widetilde{PA}} \widetilde{PA_{vd}} + \theta_2 X_{2jd} + \sum_d \theta_d D_d + \epsilon_{jd} \quad (5)$$

$$Y_{ijvd} = \beta + \beta_{RV \times PA} \left(RV_d \times \widehat{PA_{jvd}} \right) + \beta_2 X_{2jd} + \beta_3 X_{3\,ijd} + \sum_d \beta_d D_d + u_{ijd} \quad (6)$$

In the specification above the inclusion of district level dummies precludes identification of the direct effect of the coefficient of variation of rainfall, i.e. RV_d, on occupational diversification summarized by the coefficient β_{PA} in equation (4), but it does allow for estimation of its interaction with the instrumented policy variable i.e., $\beta_{RV \times PA}$.

4. Results and Discussion

Table 2 presents the effects of rainfall variability and increase in mean rainfall and temperature on the likelihood of non-head member making the same occupational choice as the head. Columns 1 and 2 present estimates of specification (1) using as the dependent variable "in agriculture." For all

[9] This is because the village mean of the policy variable denoted by $\widetilde{PA_{vd}}$ and used as the identifying instrument would be perfectly collinear with the village binary variable used to control for village-level unobserved heterogeneity.

households with heads engaged in agriculture, “in agriculture” takes the value 1 if the non-head member reports to be engaged in agriculture and 0 otherwise. Columns 3 and 4 relate to the dependent variable "self-employed in agriculture." For all households with heads self-employed in agriculture, "self-employed in agriculture" takes the value 1 if the non-head member reports to be self-employed in agriculture and 0 otherwise. The estimates in columns 1 and 3 exclude all the policy action variables while the estimates in columns 2 and 4 include them all without any interactions. The main coefficient of interest is that of rainfall variability measured by the coefficient of variation of the Kharif season rainfall.

Table 2

Conditional on the household head being employed in agriculture, the probability that another household member is employed in the same sector is lower in the districts with higher coefficient of variation of rainfall. For example column 1 shows that a one point increase in the rainfall variability would reduce the probability of the non-member being in agriculture while the head is in agriculture by 7.5 percent. That is, occupational diversification is more common where climate risk is high. The magnitude of the coefficient is similar when we restrict the sample to household heads self-employed in agriculture.

We also note that an increase in the normal temperature, measured as the 30 year annual average temperature is associated with lower likelihood of households head and non-head members to be both in agriculture. That is, a one degree rise in annual average temperature is associated with a 0.5 to 0.6 percentage point lower probability that both a household head and a non-head member be engaged in the agricultural sector.

Policy actions that improve access to infrastructure and help build physical, social, and human capital may have two kinds of effects on household occupational diversity. The primary effects of better access to infrastructure and capital is the ability to access more ad perhaps better paying non-agricultural employment opportunities. For example, better roads may bring more tourists to local attractions and “pull” workers from agriculture to the tourism sector. On the other hand, better roads may make agricultural inputs cheaper and open new markets for agricultural outputs. Table 3 shows the effects of rainfall variability and access to paved roads and the interaction of these two variables on household agricultural focus based on the specification in equation (2). The district access to paved road is measured by share of villages in the district with paved roads. As expected the direct effects of paved road on agricultural focus is negative and significant. That is more paved roads in a district is associated with lower probability of the non-head member to be engaged in agriculture given the head of the household is in agriculture.

Table 3

The interaction between road and rainfall variability is positive but not significant. The expected positive sign of this coefficient shows that the net effects of rainfall variability and road makes the non-member more likely to be in agriculture given the head is in agriculture. That is, higher rainfall variability in conjunction with better access to paved roads allows more agricultural focus within households. We test the hypothesis that access to paved road neutralizes the need for occupational diversification as a means of *ex ante* rainfall variability risks as measured by $(\beta_{RV} + \beta_{RV\times PA})$ = 0. This hypothesis cannot be rejected when agricultural focus is measured by "in agriculture" and is rejected at the 10 percent level of significance when agricultural focus is measured as "self-employed in agriculture."

Access to communications may provide new employment as well as to new market opportunities in the rural economy. Much like access to paved road, the existence of postal services in a village may have either a positive or a negative effect on household agricultural focus. Table 4 shows the coefficients of the relevant variables for models that test the net effects of postal services and rainfall variability on the agricultural focus within a household (also based on the specification in equation (2) above).

Table 4

As with access to road, the access to postal services on its own has a negative effect on agricultural focus of the household. That is, households are less likely to be focused on agriculture alone in districts that have a higher share of villages with postal services. As expected the interaction between postal services and rainfall variability is positive but not significant in both specifications. The hypothesis that access to postal services neutralizes the need for occupational diversification as a means of *ex ante* rainfall variability risks as measured by $(\beta_{RV} + \beta_{RV\times PA})$ = 0 cannot be rejected at 10 percent or better.

Access to credit allows a household to smooth its consumption in case of adverse rainfall and agricultural outcomes. Policies that improve access to credit as well as allow households to better utilize credit may thus diminish the need for diversification from agriculture within households as an *ex ante* risk avoidance strategy. Table 5 shows the relevant estimated coefficients for these sets of models. The part A of the table relate to the dependent variable “in agriculture” and the part B of the table relate to “self-employed in agriculture.” Column (1) shows the results of district level access to credit indicator measured by share of villages in a district with at least one bank. As expected the direct effect of access to banks on agricultural focus of the household is negative whereas the net effect of the interaction between access to banks and rainfall variability is positive but not significant. The total effect of the rainfall variability on agricultural focus is not significantly different from zero.

Table 5

Columns (2), and (3) present the estimates obtained using state level fixed effects and the instrumental variable method summarized in equations (3) and 4) with the household measure of credit instrumented by village aggregate of credit. The results are qualitatively similar to those obtained from the district level indicators in columns (1). Column (4) does the same using district level fixed effects in place of state level fixed effects. The coefficients of the district level fixed effects estimations of instrumented use of credit in columns (4) are not statistically significant. This shows that when the district level effects are absorbed in the fixed effects model, the intra-district variability in credit use and its interaction with rainfall variability has no significant effects on household agricultural focus.

Irrigation arguably has one of the most direct linkages with aversion of *ex ante* rainfall variability risks. Stored ground water from previous years of rainfall or distant rain water in the form of canal or river based irrigation systems can substitute if local rainfall falls short. Table 6 presents the results of the effects of irrigation and its interaction with rainfall variability on the household agricultural focus. Column (1) uses the share of irrigated to cultivated land in the districts as measures of access to irrigation. Columns (2) through (4) use household level share of irrigated to cultivated land data. Columns (1), (2), and (3) uses state fixed effects while column (4) uses district fixed effects. Columns (3) and (4) instrument household irrigation with village level irrigation aggregates excluding the current household.

Table 6

The coefficients of the interaction between irrigation and rainfall variability are positive in all the estimated models and statistically significant where household irrigation is used. In four out of six specifications the hypothesis that the total effects of rainfall variability and irrigation are significantly different from zero is rejected. The specification in column 2 where the household-level irrigation is not instrumented is the only case in which the null hypothesis that ($\beta_{RV} + \beta_{RV\times PA}$) = 0 is rejected at the 5 percent level of significance. However, this may be due to the presence of endogeneity bias in this specification. The positive and significant interaction coefficients in columns 3 and 4 strengthen our hypothesis that household irrigation in combination with local rainfall variability is a significant determinant of agricultural focus of occupation within a household.

Past as well as current education policy may exert both "pull" as well as "push" towards non-agricultural occupational choices. Table 7 shows the results of the effects of education and its interaction with rainfall variability on the household agricultural focus. Column (1) uses share of villages with at least one middle school in the districts as a measure of current education policy. Columns (2) through (4) use primary plus education of the head of the household as a measure of past education policy action. Columns (1), (2), and (3) use state fixed effects while column (4) uses district fixed effects. Columns (3) and (4) instrument household education with village level education aggregates excluding the current household.

Table 7

The estimated coefficients of measures of education policy in columns (1) through (3) are all negative and significant as expected, while the estimated coefficients of the interaction between education and rainfall variability are positive and significant in columns (1) and (2). The null hypothesis ($\beta_{RV} + \beta_{RV\times PA}$) = 0 is rejected for the share of middle schools (column 1) but could not be rejected when the household level measure is used (columns 2 and 3). Thus, it is unclear whether the net effects of the interaction between education and rainfall variability would help agricultural focus within household more or less likely. This ambiguous result is not unexpected, as education can both increase agricultural productivity and make household agricultural focus more rewarding. On the other hand, education can also open doors for more productive non-agricultural occupations.

5. Concluding remarks

This study investigated the extent to which occupational diversification among household members in rural India is an adaptation strategy against the risks arising from the variability of local rainfall. For this purpose nationally representative household level survey data were combined with the coefficient of variation of rainfall constructed based on historical rainfall data at the district level as well as other district observed characteristics. The analysis revealed that high rainfall variability has a significant negative effect on the agricultural specialization within-household occupational choices. This confirms the hypothesis that local variability in rainfall "pushes" household members towards employment in non-agricultural sector. Data limitations do not allow the measurement of the extent to which being pushed out of agriculture affects household welfare or wage and non-wage earnings. However, the strong correlations between local rainfall variability and intra-household sectoral diversity points towards the predominance of the *ex ante* "push" factor rather than the "pull" of higher potential earnings in the non-agricultural sectors driving the agricultural household members to choose non-agricultural employments and likely lower household earnings for those exposed to this *ex ante* risk.

To a large extent this finding is reinforced by the results of the more systematic investigation of the extent to which government investments in various types of rural infrastructure can facilitate household adaptation to increased risks due to climatic change. Policies that improve access to education, credit, roads, and information, such as postal services, have two kinds of potential effects. First, better access to education, markets, and information may make agriculture more productive, and thus reduce the need for seeking low return non-agricultural activities for the purpose of minimizing *ex ante* rainfall risks. If this is the predominant channel through which access to education, information, and markets, affects intra-household employment choices, one would expect households with access to these services to be more specialized in agriculture. On the other hand access to the same set of services, namely, education, information, and markets, also allows employment in high-return non-agricultural sectors. If access to these services predominantly extends the "pull" of high-returns non-agricultural activities, then one would expect the combination of high *ex ante* rainfall risks and access to education, information, and markets, to reduce the household specialization in agriculture. Given that the results are not always robust across specifications, it is not possible to determine with certainty whether access to these services diminishes the "push" *ex ante* rainfall risks or increases the "pull" of high-return non-agricultural employments. In either case, the agricultural households are likely to gain from a higher level of access to these services.

However, the empirical analysis did reveal that expansion of irrigation projects has a strong potential of facilitating household adaptation to increased risks due to climatic change. The results show that irrigation weakens the effect of rainfall variability on the incentive to diversify the occupational portfolio of household members. Therefore, as a component of "climate-smart" policy packages in India, irrigation may not only stabilize and increase agricultural yields directly, but also indirectly through the increase in potential output associated with the gains from specialization in agriculture.

References

Bandyopadhyay, S., & Skoufias, E. (2013). "Rainfall variability, occupational choice, and welfare in rural Bangladesh." *Review of Economics of the Household*, DOI 10.1007/s11150-013-9203-z.

Carter, M. R., & Barrett, C. B. (2006). "The Economics of Poverty Traps and Persistent Poverty: An Asset-Based Approach". *Journal of Development Studies*, 42, 178–199.

Carter, M. R., & Barrett, C. B. (2013). "The economics of poverty traps and persistent poverty: Empirical and Policy Implications." *Journal of Development Studies*, 49, no. 7. 976-990.

Cole, S., Giné, X., & Vickery, J. (2013). "How Dose Risk Management Influence Production Decisions? Evidence from a Field Experiment." Washington DC: Policy Research Working Paper 6546, World Bank.

Deininger, K., & Olinto, P. (2001). "Rural Nonfarm Employment and Income Diversification in Colombia". *World Development*, 455–465.

Dercon, S. (1996). "Risk, Crop Choice and Savings: Evidence from Tanzania." *Economic Development and Cultural Change*, 44(3):485–514.

________ (2004). "Growth and Shocks: Evidence from Rural Ethiopia." *Journal of Development Economics* 74(2):309–29.

Dercon, S., & Hoddinott, J. (2003). "Health, shocks and poverty persistence." WIDER Discussion Papers // World Institute for Development Economics (UNU-WIDER) 2003/08.

Dercon, S., & Krishnan, P. (2000). "Vulnerability, seasonality and poverty in Ethiopia." *The Journal of Development Studies*, 25-53.

Eakin, Hallie (2000). "Smallholder maize production and climatic risk: A case study from Mexico." *Climatic Change*, 45, 19-36.

Ellis, F. (2004). "Occupational Diversification in Developing Countries and the Implications for Agricultural Policy." London: Programme of Advisory and Support Services to DFID (PASS).

Eswaran, M., & Kotwal, A. (1990). "Implications of Credit Constraints for Risk Behaviour in Less Developed Economies." *Oxford Economic Papers*, 473-482.

Government of India. (2013). *Economic Survey 2012-2013.* New Delhi: Ministry of Finance.

Horrace, W. C., & Oaxaca, R. L. (2006). "Results on the bias and inconsistency of ordinary least squares forthe linear probability model." *Economic Letters*, 321-327.

Ito, T., & Kurosaki, T. (2009). "Weather Risk, Wages in Kind, and the Off-Farm Labor Supply of Agricultural Households in a Developing Country." *American Journal of Agricultural Economics*, 697-710.

Jalan, Jyotsna and Martin Ravallion (1999). "Are the poor less well insured? Evidence on vulnerability to income Risk in rural China." *Journal of Development Economics*, 58(1): 61-81

____________(2001). "Behavioral Responses to Risk in Rural China." *Journal of Development Economics* 66(1):23–49.

Klaassen, F., & Magnus, J. (2001). Are Points in Tennis Independent and Identically Distributed? Evidence From a Dynamic Binary Panel Data Model. *Journal of the American Statistical Association*, 500-509.

Lanjouw, J. O., & Lanjouw, P. (2001). The rural non-farm sector: issues and evidence from developing countries. *Agricultural Economics*, 1-23.

Malik A., X. Qin, and S. C. Smith (2010) " Autonomous Adaptation to Climate Change: A Literature Review" IIEP-WP-2010-27, Institute for International Economic Policy Working Paper Series Elliott School of International Affairs, The George Washington University

Menon, N. (2009). Rainfall Uncertainty and Occupational Choice in Agricultural Households of Rural Nepal. *Journal of Development Studies*, 864-888.

Menon, N., & Subramanian, N. (2008). Learning, diversification and the nature of risk. *Economic Theory*, 117–145.

Morduch, J. (1995). Income Smoothing and Consumption Smoothing. *Journal of Economic Perspectives*, 103-114.

Mueller, V. A., & Osgood, D. E. (2009). Long-term Impacts of Droughts on Labour Markets in Developing Countries: Evidence from Brazil. *Journal of Development Studies*, 1651-1662.

Mullahy, J. (1990). Weighted least squares estimation of the linear probability model, revisited. *Economics Letters*, 35-41.

Oviedo, A. M., and H. Moroz (2013): "A Review of the *Ex post* and *Ex ante* Impacts of Risk" Background paper for the World Development Report 2014.

Pitt, Mark, Mark Rosenzweig, and Donna Gibbons (1993) "The Determinants and Consequences of the Placement of Government Programs in Indonesia," *The World Bank Economic Review*, 7, (3), 319-348

Reardon, T., Berdegué, J., Barrett, C. B., & Stamoulis, K. (2006). Household Income Diversification into Rural Nonfarm Activities. In S. Haggblade, P. Hazell, & T. Reardon, *Transforming the Rural Nonfarm Economy.* Baltimore: Johns Hopkins University Press.

Rosenzweig, M.R., and O. Stark (1989) 'Consumption Smoothing, Migration, and Marriage: Evidence form Rural India" *Journal of Political Economy* Vol. 97, No. 4 (Aug., 1989), pp. 905-926

Rosenzweig, M., & Binswanger, H. (1993). Wealth, Weather Risk and the Composition and Profitability of Agricultural Investments. *The Economic Journal*, 56–78.

Rosenzweig, M., & Wolpin, K. (1993). Credit Market Constraints, Consumption Smoodiing, and the Accumulation of Durable Production Assets in Low-Income Countries: Investments in Bullocks in India. *Journal of Political Economy*, 223-244.

Shenoy, A. (2013). *Risk and Economic Under-specialization: Why the Pin-Maker Grows Cassava on the Side.* Working paper available at SSRN: http://dx.doi.org/10.2139/ssrn.2211799.

Smit, B., Burton I., Klein R., and Wandel J. (2000) "An Anatomy of Adpatation to Climate Change and Variability" *Climatic Change*. 45: 223-251.

Townsend, Robert, 1994. Risk and Insurance in Village India. *Econometrica*, Vol. 62, pp. 539-91.

World Bank. (2012). *World Development Indicators.* Washington DC: The World Bank.

Table 1: Key variables of analysis with descriptive statistics

Description	N	Mean	S.E.
Non-head member indicators (Source: NSS59)			
"In agriculture" for all households with heads engaged in agriculture, takes the value 1 if the non-head member reports to be engaged in agriculture and 0 otherwise	60895	87.8%	0.0013
"Self-employed in agriculture" for all households with heads self-employed in agriculture, takes the value 1 if the non-head member reports to be self-employed in agriculture and 0 otherwise	41499	86.6%	0.0017
Household and head of the household indicators (Source: NSS59)			
"Credit" takes the value 1 if the household used cash or in kind credit in last year and 0 otherwise	30517	59.3%	0.0028
"Irrigation ratio" is the proportion of area irrigated to cultivated land by the household	30517	48.3%	0.0027
"Head primary plus" takes the value 1 if the head of the household has primary or more education and 0 otherwise	30517	41.4%	0.0028
Village indicators (Source: NSS59)			
"Village credit" is the share of households in the village used credit last year	5817	51.3%	0.0021
"Village irrigation ratio" is the ratio of area irrigated to area cultivable in the village	5817	55.1%	0.0052
"Village education" is the share of heads in the village with more than primary education	5817	41.5%	0.0029
District indicators (Source: IMD & India Village Census)			
"CV Kharif rain" is the coefficient of variation for Kharif season rain between 1960-1999	554	0.73	0.0081
"Normal Kharif rain" is the long term mean Kharif season rain between 1960-1999	554	220	4.8922
"Normal annual temperature" is the long term mean annual temperature between 1960-1999	554	25	0.0802
"District road" is the share of villages with paved roads in a district	554	75.1%	0.0117
"District post office" is the share of villages with post telegraph and telephone service offices in a district	554	49.7%	0.0118
"District bank" is the share of villages with banks in a district	554	10.2%	0.0063
"District middle school" is the share of villages with middle schools in a district	554	32.3%	0.0092
"District irrigation ratio" is the ratio of area irrigated to area cultivable in the district	554	39.0%	0.0125

Source: Authors' calculations. The full list of variables is in the annex Table A1.

Table 2: the effects of changes in climatic parameters on the likelihood of non-head member making the same occupational choice as the head

	(1)	(2)	(3)	(4)
Dependent Variables	In agriculture		Self-employed in agriculture	
Policy / Interactions	No Policy	All Policies	No Policy	All Policies
Fixed Effects	State	State	State	State
CV Kharif Rain	-0.0749***	-0.0728***	-0.0937***	-0.0760***
	(0.0219)	(0.0259)	(0.0277)	(0.0288)
Normal Kharif rain	-0.000140***	-0.000140***	-0.000106***	-0.000137***
	(2.99e-05)	(3.08e-05)	(3.41e-05)	(3.43e-05)
Normal annual temperature	-0.00668***	-0.00533**	-0.00404	-0.00482
	(0.00225)	(0.00260)	(0.00291)	(0.00296)
Observations	59,480	46,844	41,152	38,851
R-squared	0.141	0.135	0.143	0.137
F-Stat	127.9	82.06	102.5	73.30

Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1
Models include state fixed effects. Complete estimations are in Table A2.

Table 3: Interaction between access to roads and rainfall variability

	(1)	(2)
Dependent Variables	In agriculture	Self-employed in agriculture
CV Kharif Rain (β_{RV})	-0.104*	-0.0940
	(0.0631)	(0.0746)
District road	-0.203***	-0.181***
	(0.0513)	(0.0636)
Road X CV Rain ($\beta_{RV\times PA}$)	0.0723	0.0364
	(0.0728)	(0.0874)
($\beta_{RV} + \beta_{RV\times PA}$) = 0	-0.0317	-0.0576*
F-Stat($\beta_{RV} + \beta_{RV\times PA}$)	1.482	2.992

Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1
Models include state fixed effects. Complete estimations are in Table A3 and Table A.

Table 4: Interaction between access to postal communications and rainfall variability

	(1)	(2)
Dependent Variables	In agriculture	Self-employed in agriculture
CV Kharif Rain (β_{RV})	-0.119***	-0.175***
	(0.0429)	(0.0523)
District post office	-0.135***	-0.189***
	(0.0410)	(0.0515)
Post office X CV Rain ($\beta_{RV\times PA}$)	0.0940	0.156**
	(0.0613)	(0.0748)
($\beta_{RV} + \beta_{RV\times PA}$) = 0	-0.0254	-0.0185
F-Stat($\beta_{RV} + \beta_{RV\times PA}$)	0.601	0.201

Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Models include state fixed effects. Complete estimations are in Table A3 and Table A.

Table 5: Interaction between access to credit and rainfall variability

	(1)	(2)	(3)	(4)
Policy Action variables	District bank	Householdhold Credit		
A. In agriculture				
CV Kharif Rain (β_{RV})	-0.0965***	-0.0871***	-0.683**	
	(0.0290)	(0.0259)	(0.321)	
Credit	-0.279**	-0.0104	-0.541**	0.227
	(0.115)	(0.0152)	(0.248)	(1.613)
Credit X CV Kharif rain ($\beta_{RV\times PA}$)	0.205	0.0189	0.938*	-0.249
	(0.178)	(0.0218)	(0.493)	(1.918)
($\beta_{RV} + \beta_{RV\times PA}$) = 0	0.109	-0.0683***	0.255	
F-Stat($\beta_{RV} + \beta_{RV\times PA}$)	0.462	8.600	2.144	
Under identification test			10.63***	1.015
Chi-sq P-val			0.00111	0.314
Weak ID Kleibergen-Paap rk Wald F [1]			5.115	0.511
Fixed Effects	State	State	State	District
Policy variable is instrumented	No	No	Yes	Yes
B. Self-employed in agriculture				
CV Kharif Rain (β_{RV})	-0.126***	-0.0994***	-1.543*	
	(0.0359)	(0.0326)	(0.875)	
Credit	-0.322**	0.00136	-1.156*	-0.267
	(0.150)	(0.0186)	(0.626)	(0.248)
Credit X CV Kharif rain ($\beta_{RV\times PA}$)	0.301	0.00812	2.183*	0.381
	(0.225)	(0.0261)	(1.313)	(0.308)
($\beta_{RV} + \beta_{RV\times PA}$) = 0	0.175	-0.0913***	0.640	
F-Stat($\beta_{RV} + \beta_{RV\times PA}$)	0.738	9.840	2.113	
Under identification test			3.220*	40.61***
Chi-sq P-val			0.0727	1.86e-10
Weak ID Kleibergen-Paap rk Wald F [1]			1.568	21.67***
Fixed Effects	State	State	State	District
Policy variable is instrumented	No	No	Yes	Yes

Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1
[1] Kleibergen-Paap rk Wald F use Stock-Yogo (2005) weak ID test critical values from the log file.
Models include state or district fixed effects. Complete estimations are in Table A3, Table A. Table A4. And Table A5.

Table 6: Interaction between access to irrigation and rainfall variability

	(1) District irrigation ratio	(2)	(3) Household Irrigation ratio	(4)
A. In agriculture				
CV Kharif Rain (β_{RV})	-0.0850***	-0.135***	-0.160***	
	(0.0318)	(0.0278)	(0.0267)	
Irrigation ratio	-0.0103	-0.0329*	-0.0666***	-0.0617*
	(0.0438)	(0.0193)	(0.0258)	(0.0366)
Irrigation ratio X CV Kharif rain ($\beta_{RV\times PA}$)	0.0207	0.0679**	0.119***	0.0962*
	(0.0581)	(0.0276)	(0.0369)	(0.0536)
($\beta_{RV} + \beta_{RV\times PA}$) = 0	-0.0642	-0.0673**	-0.0406	
F-Stat($\beta_{RV} + \beta_{RV\times PA}$)	2.414	4.982	1.878	
Under identification test			8355***	2388***
Chi-sq P-val			0	0
Weak ID Kleibergen-Paap rk Wald F [1]			9490***	2153***
Fixed Effects	State	State	State	District
Policy variable is instrumented	No	No	Yes	Yes
B. Self-employed in agriculture				
CV Kharif Rain (β_{RV})	-0.111***	-0.145***	-0.169***	
	(0.0397)	(0.0311)	(0.0300)	
Irrigation ratio	-0.00669	-0.0385*	-0.0654**	-0.0591
	(0.0551)	(0.0211)	(0.0275)	(0.0396)
Irrigation ratio X CV Kharif rain ($\beta_{RV\times PA}$)	0.0310	0.0794***	0.125***	0.0990*
	(0.0714)	(0.0299)	(0.0390)	(0.0579)
($\beta_{RV} + \beta_{RV\times PA}$) = 0	-0.0798	-0.0652**	-0.0437	
F-Stat($\beta_{RV} + \beta_{RV\times PA}$)	2.425	3.912	1.951	
Under identification test			7126***	1694***
Chi-sq P-val			0	0
Weak ID Kleibergen-Paap rk Wald F [1]			8360***	1567***
Fixed Effects	State	State	State	District
Policy variable is instrumented	No	No	Yes	Yes

Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1
[1] Kleibergen-Paap rk Wald F use Stock-Yogo (2005) weak ID test critical values from the log file.
Models include state or district fixed effects. Complete estimations are in Table A3, Table A. Table A4. And Table A5.

Table 7: Interaction between access to education and rainfall variability

	(1)	(2)	(3)	(4)
	District middle school	Head primary plus		
A. In agriculture				
CV Kharif Rain (β_{RV})	-0.195***	-0.0925***	-0.0762***	
	(0.0331)	(0.0228)	(0.0264)	
District or household education	-0.381***	-0.0464***	-0.154***	-0.0102
	(0.0514)	(0.0162)	(0.0474)	(0.0794)
Education X CV Kharif rain ($\beta_{RV\times PA}$)	0.385***	0.0611***	-0.00626	-0.280**
	(0.0761)	(0.0229)	(0.0710)	(0.130)
($\beta_{RV} + \beta_{RV\times PA}$) = 0	0.190***	-0.0314	-0.0824	
F-Stat($\beta_{RV} + \beta_{RV\times PA}$)	11.62	1.298	2.205	
Under identification test			1315***	338.9***
Chi-sq P-val			0	0
Weak ID Kleibergen-Paap rk Wald F [1]			712.5***	176.9***
Fixed Effects	State	State	State	District
Policy variable is instrumented	No	No	Yes	Yes
B. Self-employed in agriculture				
CV Kharif Rain (β_{RV})	-0.227***	-0.117***	-0.104***	
	(0.0407)	(0.0289)	(0.0326)	
district or household education	-0.405***	-0.0558***	-0.157***	-0.00347
	(0.0619)	(0.0187)	(0.0507)	(0.0818)
Education X CV Kharif rain ($\beta_{RV\times PA}$)	0.431***	0.0705***	0.00191	-0.300**
	(0.0905)	(0.0261)	(0.0764)	(0.135)
($\beta_{RV} + \beta_{RV\times PA}$) = 0	0.204***	-0.0466	-0.102*	
F-Stat($\beta_{RV} + \beta_{RV\times PA}$)	9.300	2.001	3.073	
Under identification test			1057***	286.9***
Chi-sq P-val			0	0
Weak ID Kleibergen-Paap rk Wald F [1]			582.7***	152.2***
Fixed Effects	State	State	State	District
Policy variable is instrumented	No	No	Yes	Yes

Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Models include state or district fixed effects. Complete estimations are in Table A3, Table A. Table A4. And Table A5.

FIGURE 1: Coefficient of Variation of Rainfall (June-October 1960-2000)

Data Source: India Meteorological Department

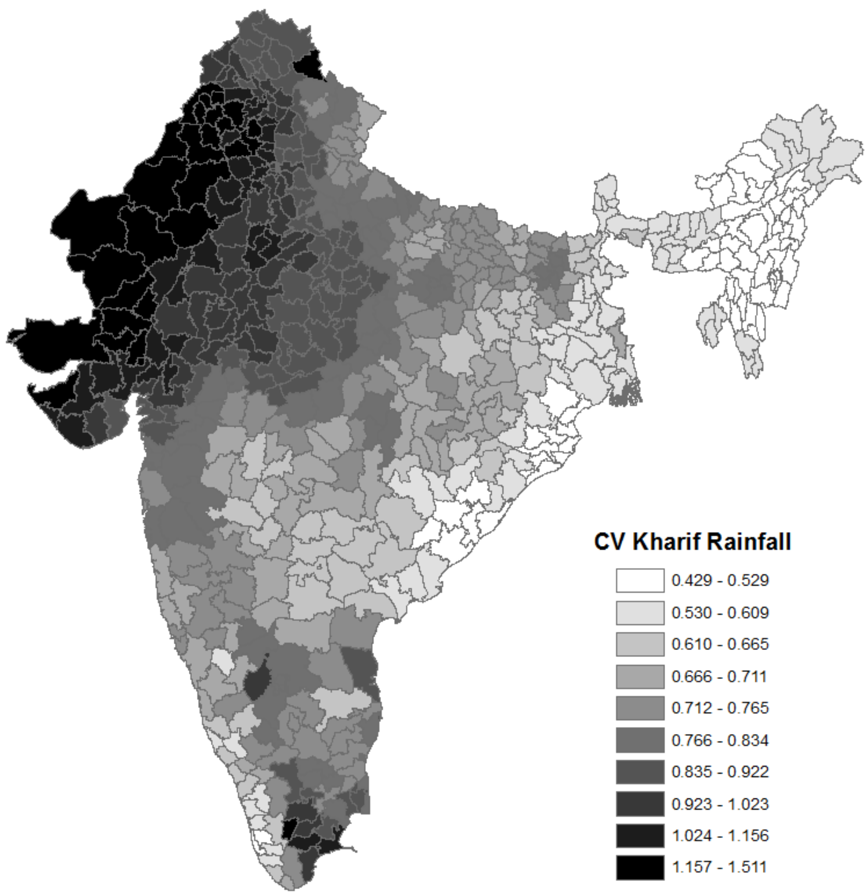

Table A1: All the variables of analysis with descriptive statistics

Description	N	Mean	S.E.
Non-head member indicators (Source: NSS59)			
"In agriculture" for all households with heads engaged in agriculture, takes the value 1 if the non-head member report to be engaged in agriculture and 0 otherwise	60895	87.8%	0.0013
"Self-employed in agriculture" for all households with heads self employed in agriculture, takes the value 1 if the non-head member report to be self-employed in agriculture and 0 otherwise	41499	86.6%	0.0017
Age of the non-head member in years	60895	30	0.0476
"Male" takes the value 1 if the non-head member is male and 0 otherwise	60895	49.6%	0.0020
"Completed primary" takes the value 1 if the non-head member has completed primary education and 0 otherwise	60882	14.7%	0.0014
"Completed secondary" takes the value 1 if the non-head member has completed secondary education and 0 otherwise	60882	24.3%	0.0017
"Completed higher secondary" takes the value 1 if the non-head member has completed higher secondary education and 0 otherwise	60882	3.2%	0.0007
"Graduate and above" takes the value 1 if the non-head member has more than higher secondary education and 0 otherwise	60882	2.1%	0.0006
"Married" takes the value 1 if the non-head member is married and 0 otherwise	60895	65.4%	0.0019
Household and head of the household indicators (Source: NSS59)			
"Credit" takes the value 1 if the household used cash or in kind credit in last year and 0 otherwise	30517	59.3%	0.0028
"Cultivable land" is the total cultivable land in hectares operated by the household	30517	1.23	0.0111
"Irrigation ratio" is the proportion of area irrigated to cultivated land by the household	30517	48.3%	0.0027
"Female members" number of female household members aged 10 years or more	30517	2.3	0.0069
"Male members" number of male household members aged 10 years or more	30517	2.5	0.0074
"Dependents" number of household members below 15 and above 64 years of age	30517	2.1	0.0105
"Schedule tribe" takes the value 1 if the household belongs to schedule tribes and 0 otherwise	30517	20.0%	0.0023
"Schedule caste" takes the value 1 if the household belongs to schedule castes and 0 otherwise	30517	15.4%	0.0021
"Other backward class" takes the value 1 if the household belongs to other backward classes and 0 otherwise	30517	39.1%	0.0028

Table A1: All the variables of analysis with descriptive statistics

Description	N	Mean	S.E.
"Hinduism" takes the value 1 if the household practices Hinduism and 0 otherwise	30517	82.9%	0.0022
"Islam" takes the value 1 if the household practices Islam and 0 otherwise	30517	6.3%	0.0014
"Christianity" takes the value 1 if the household practices Christianity and 0 otherwise	30517	6.6%	0.0014
"Head primary plus" takes the value 1 if the head of the household has primary or more education and 0 otherwise	30517	41.4%	0.0028
"Old head" takes the value 1 if the head of the household is above 65 years old and 0 otherwise	30517	11.2%	0.0018
"Male head" takes the value 1 if the head of the household is male and 0 otherwise	30517	95.9%	0.0011
Village-level policy action variables (Source: NSS59)			
"Village credit" is the share of households in the village used credit last year	5817	51.3%	0.0021
"Village irrigation ratio" is the ratio of area irrigated to area cultivable in the village	5817	55.1%	0.0052
"Village education" is the share of heads in the village with more than primary education	5817	41.5%	0.0029
District-level variables (Source: IMD & India Village Census)			
"CV Kharif rain" is the coefficient of variation for Kharif season rain between 1960-1999	554	0.73	0.0081
"Normal Kharif rain" is the long term mean Kharif season rain between 1960-1999	554	220	4.8922
"Normal annual temperature" is the long term mean annual temperature between 1960-1999	554	25	0.0802
"District road" is the share of villages with paved roads in a district	554	75.1%	0.0117
"District post office" is the share of villages with post telegraph and telephone service offices in a district	554	49.7%	0.0118
"District bank" is the share of villages with banks in a district	554	10.2%	0.0063
"District middle school" is the share of villages with middle schools in a district	554	32.3%	0.0092
"District irrigation ratio" is the ratio of area irrigated to area cultivable in the district	554	39.0%	0.0125
"District population" is the total population of a district as of 2001	554	1800000	55000
"District flat ground" takes the value 1 if on average the ground in the district is flat and 0 otherwise	554	47.8%	0.0212
"District hilly ground" takes the value 1 if on average the ground in the district is hilly and 0 otherwise	554	10.8%	0.0132

Source: Authors' calculations.

Table A2: The effects of rainfall variability on the probability of agricultural focus

	(1)	(2)	(3)	(4)
Dependent Variables	In agriculture		Self-employed in agriculture	
Policy / Interactions	No Policy	All Policies	No Policy	All Policies
CV Kharif rain	-0.0749***	-0.0728***	-0.0937***	-0.0760***
	(0.0219)	(0.0259)	(0.0277)	(0.0288)
Normal Kharif rain	-0.000140***	-0.000140***	-0.000106***	-0.000137***
	(2.99e-05)	(3.08e-05)	(3.41e-05)	(3.43e-05)
Normal annual temperature	-0.00668***	-0.00533**	-0.00404	-0.00482
	(0.00225)	(0.00260)	(0.00291)	(0.00296)
District road		-0.138***		-0.133***
		(0.0216)		(0.0233)
District post office		-0.00636		-0.0213
		(0.0153)		(0.0183)
District bank		-0.00356		-0.0113
		(0.0294)		(0.0388)
Credit		0.00559		0.00700*
		(0.00366)		(0.00418)
District irrigation ratio		0.0203		0.0298**
		(0.0126)		(0.0144)
Irrigation ratio		0.0131***		0.0154***
		(0.00443)		(0.00511)
District middle school		-0.0693***		-0.0575**
		(0.0213)		(0.0244)
Head primary plus		-0.00745*		-0.00619
		(0.00398)		(0.00440)
Age	0.000197*	0.000176	0.000290**	0.000235
	(0.000115)	(0.000127)	(0.000141)	(0.000143)
Male	-0.0624***	-0.0678***	-0.0732***	-0.0754***
	(0.00386)	(0.00426)	(0.00464)	(0.00474)
Completed primary	-0.0500***	-0.0445***	-0.0468***	-0.0443***
	(0.00437)	(0.00476)	(0.00512)	(0.00526)
Completed secondary	-0.0965***	-0.0878***	-0.0925***	-0.0850***
	(0.00430)	(0.00473)	(0.00499)	(0.00516)
Completed higher secondary	-0.162***	-0.151***	-0.159***	-0.151***
	(0.0108)	(0.0112)	(0.0115)	(0.0117)
Graduate and above	-0.394***	-0.388***	-0.390***	-0.383***
	(0.0149)	(0.0155)	(0.0155)	(0.0159)
Married	0.0146***	0.00932**	0.00785*	0.00762
	(0.00371)	(0.00414)	(0.00456)	(0.00465)
Female members	-0.00791***	-0.00839***	-0.00940***	-0.00894***
	(0.00160)	(0.00171)	(0.00189)	(0.00190)
Male members	-0.00244*	-0.00321**	-0.00253	-0.00229
	(0.00146)	(0.00160)	(0.00173)	(0.00175)
Dependents	0.000858	0.000854	0.00177	0.00108
	(0.00104)	(0.00114)	(0.00126)	(0.00127)
Old head	-0.0162***	-0.0185***	-0.0153***	-0.0185***
	(0.00542)	(0.00575)	(0.00593)	(0.00609)
Male head	0.0185**	0.0139	0.0212**	0.0163
	(0.00815)	(0.00950)	(0.0104)	(0.0107)

Cultivable land	0.0104***	0.0100***	0.0110***	0.0106***
	(0.00106)	(0.00110)	(0.00120)	(0.00119)
	(1)	(2)	(3)	(4)
Dependent Variables	In agriculture		Self-employed in agriculture	
Policy / Interactions	No Policy	All Policies	No Policy	All Policies
Schedule tribe	0.0212***	0.00767	0.00966	0.00205
	(0.00576)	(0.00655)	(0.00730)	(0.00755)
Schedule caste	-0.00189	-0.0124*	-0.0206***	-0.0229***
	(0.00562)	(0.00654)	(0.00752)	(0.00783)
Other backward class	-0.0102**	-0.00993*	-0.0127**	-0.0134**
	(0.00488)	(0.00529)	(0.00571)	(0.00581)
Hinduism	-0.00514	0.00523	-0.00924	0.00314
	(0.0107)	(0.0120)	(0.0134)	(0.0135)
Islam	-0.0820***	-0.0755***	-0.0889***	-0.0756***
	(0.0138)	(0.0157)	(0.0173)	(0.0176)
Christianity	0.0309**	0.0358***	0.0430***	0.0418***
	(0.0126)	(0.0132)	(0.0144)	(0.0141)
District population	-7.24e-09***	-4.24e-09**	-5.84e-09***	-3.74e-09*
	(1.67e-09)	(1.95e-09)	(2.15e-09)	(2.23e-09)
District flat ground	0.00218	0.00760	0.00296	0.00658
	(0.00415)	(0.00490)	(0.00559)	(0.00581)
District hilly ground	0.000272	0.00126	0.00377	0.00148
	(0.0108)	(0.0110)	(0.0117)	(0.0119)
Constant	1.208***	1.289***	1.153***	1.268***
	(0.0625)	(0.0726)	(0.0791)	(0.0816)
Observations	59,480	46,844	41,152	38,851
R-squared	0.141	0.135	0.143	0.137
F-Stat	127.9	82.06	102.5	73.30
Fixed Effects	State	State	State	State

Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Table A3: Policy interactions with rainfall variability for non-head members in agriculture

	(1)	(2)	(3)	(4)
Dependent variable	In agriculture			
Policy variables	District road	District post office	District bank	Credit
CV Kharif rain (β_{RV})	-0.104*	-0.119***	-0.0965***	-0.0871***
	(0.0631)	(0.0429)	(0.0290)	(0.0259)
Normal Kharif rain	-0.000159***	-0.000147***	-0.000139***	-0.000139***
	(3.00e-05)	(3.00e-05)	(2.91e-05)	(3.00e-05)
Normal annual temperature	-0.00694***	-0.00780***	-0.00729***	-0.00668***
	(0.00225)	(0.00225)	(0.00225)	(0.00225)
Policy	-0.203***	-0.135***	-0.279**	-0.0104
	(0.0513)	(0.0410)	(0.115)	(0.0152)
Policy X CV Kharif rain (β_{RVxPA})	0.0723	0.0940	0.205	0.0189
	(0.0728)	(0.0613)	(0.178)	(0.0218)
(β_{RV}+β_{RVxPA}) = 0	-0.0317	-0.0254	0.109	-0.0683
F-Stat(β_{RV}+β_{RVxPA})	1.482	0.601	0.462	8.600
Prob > F	0.224	0.438	0.496	0.00336
Age	0.000208*	0.000199*	0.000203*	0.000197*
	(0.000115)	(0.000115)	(0.000115)	(0.000115)
Male	-0.0625***	-0.0622***	-0.0625***	-0.0624***
	(0.00387)	(0.00386)	(0.00386)	(0.00386)
Completed primary	-0.0488***	-0.0496***	-0.0495***	-0.0501***
	(0.00437)	(0.00436)	(0.00436)	(0.00436)
Completed secondary	-0.0949***	-0.0960***	-0.0962***	-0.0965***
	(0.00431)	(0.00430)	(0.00430)	(0.00431)
Completed higher secondary	-0.160***	-0.162***	-0.162***	-0.162***
	(0.0107)	(0.0107)	(0.0107)	(0.0108)
Graduate and above	-0.392***	-0.393***	-0.393***	-0.394***
	(0.0149)	(0.0150)	(0.0150)	(0.0149)
Married	0.0145***	0.0145***	0.0145***	0.0146***
	(0.00371)	(0.00371)	(0.00371)	(0.00371)
Female members	-0.00807***	-0.00789***	-0.00797***	-0.00795***
	(0.00159)	(0.00159)	(0.00159)	(0.00160)
Male members	-0.00236	-0.00233	-0.00242*	-0.00246*
	(0.00145)	(0.00146)	(0.00146)	(0.00146)
Dependents	0.000755	0.000682	0.000776	0.000859
	(0.00104)	(0.00104)	(0.00104)	(0.00104)
Old head	-0.0157***	-0.0159***	-0.0159***	-0.0161***
	(0.00541)	(0.00542)	(0.00541)	(0.00543)
Male head	0.0165**	0.0187**	0.0183**	0.0184**
	(0.00814)	(0.00813)	(0.00813)	(0.00816)
Cultivable land	0.0104***	0.0103***	0.0103***	0.0103***
	(0.00106)	(0.00106)	(0.00106)	(0.00106)
Schedule tribe	0.0187***	0.0162***	0.0188***	0.0213***
	(0.00577)	(0.00580)	(0.00577)	(0.00576)
Schedule caste	-0.00137	-0.00242	-0.00260	-0.00181
	(0.00559)	(0.00561)	(0.00562)	(0.00562)

Other backward class	-0.0102**	-0.0114**	-0.0113**	-0.0102**
	(0.00487)	(0.00489)	(0.00489)	(0.00488)
Hinduism	-0.00413	-0.00230	-0.00537	-0.00512
	(1)	(2)	(3)	(4)
Dependent variable	In agriculture			
Policy variables	District road	District post office	District bank	Credit
	(0.0107)	(0.0107)	(0.0107)	(0.0107)
Islam	-0.0810***	-0.0792***	-0.0821***	-0.0820***
	(0.0138)	(0.0138)	(0.0138)	(0.0138)
Christianity	0.0356***	0.0343***	0.0335***	0.0308**
	(0.0126)	(0.0126)	(0.0125)	(0.0126)
District population	-4.78e-09***	-6.47e-09***	-6.63e-09***	-7.25e-09***
	(1.69e-09)	(1.69e-09)	(1.68e-09)	(1.67e-09)
District flat ground	0.00505	0.00592	0.00313	0.00225
	(0.00415)	(0.00417)	(0.00415)	(0.00415)
District hilly ground	-0.00304	-0.000996	0.00158	0.000374
	(0.0108)	(0.0107)	(0.0108)	(0.0108)
Constant	1.348***	1.297***	1.250***	1.214***
	(0.0731)	(0.0667)	(0.0640)	(0.0634)
Observations	59,480	59,480	59,480	59,480
R-squared	0.143	0.142	0.142	0.141
F-Stat	119.8	119.1	119.2	118.6
Fixed Effects	State	State	State	State

Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Table A3: Policy interactions with rainfall variability for non-head members in agriculture

	(5)	(6)	(7)	(8)
Dependent variable	In agriculture			
Policy variables	District irrigation ratio	Irrigation ratio	District middle school	Head primary plus
CV Kharif rain (β_{RV})	-0.0850***	-0.135***	-0.195***	-0.0925***
	(0.0318)	(0.0278)	(0.0331)	(0.0228)
Normal Kharif rain	-0.000138***	-0.000115***	-0.000152***	-0.000140***
	(3.02e-05)	(3.10e-05)	(2.92e-05)	(3.00e-05)
Normal annual temperature	-0.00662***	-0.00391	-0.00820***	-0.00659***
	(0.00226)	(0.00260)	(0.00226)	(0.00225)
Policy	-0.0103	-0.0329*	-0.381***	-0.0464***
	(0.0438)	(0.0193)	(0.0514)	(0.0162)
Policy X CV Kharif rain (β_{RVxPA})	0.0207	0.0679**	0.385***	0.0611***
	(0.0581)	(0.0276)	(0.0761)	(0.0229)
($\beta_{RV}+\beta_{RVxPA}$) = 0	-0.0642	-0.0673	0.190	-0.0314
F-Stat($\beta_{RV}+\beta_{RVxPA}$)	2.414	4.982	11.62	1.298
Prob > F	0.120	0.0256	0.000652	0.255
Age	0.000196*	0.000143	0.000199*	0.000214*
	(0.000115)	(0.000126)	(0.000115)	(0.000115)
Male	-0.0624***	-0.0662***	-0.0623***	-0.0629***
	(0.00387)	(0.00424)	(0.00386)	(0.00388)
Completed primary	-0.0501***	-0.0472***	-0.0496***	-0.0487***
	(0.00437)	(0.00469)	(0.00436)	(0.00444)
Completed secondary	-0.0966***	-0.0923***	-0.0954***	-0.0947***
	(0.00431)	(0.00462)	(0.00429)	(0.00442)
Completed higher secondary	-0.162***	-0.157***	-0.162***	-0.160***
	(0.0108)	(0.0111)	(0.0107)	(0.0108)
Graduate and above	-0.395***	-0.395***	-0.392***	-0.392***
	(0.0149)	(0.0154)	(0.0150)	(0.0150)
Married	0.0146***	0.00951**	0.0149***	0.0145***
	(0.00371)	(0.00414)	(0.00371)	(0.00371)
Female members	-0.00791***	-0.00810***	-0.00796***	-0.00799***
	(0.00160)	(0.00172)	(0.00158)	(0.00159)
Male members	-0.00246*	-0.00323**	-0.00224	-0.00247*
	(0.00146)	(0.00160)	(0.00146)	(0.00146)
Dependents	0.000853	0.000951	0.000808	0.000929
	(0.00104)	(0.00114)	(0.00104)	(0.00104)
Old head	-0.0162***	-0.0176***	-0.0158***	-0.0168***
	(0.00542)	(0.00573)	(0.00540)	(0.00545)
Male head	0.0186**	0.0144	0.0191**	0.0197**
	(0.00816)	(0.00948)	(0.00810)	(0.00819)
Cultivable land	0.0104***	0.00981***	0.0102***	0.0103***
	(0.00107)	(0.00108)	(0.00106)	(0.00107)
Schedule tribe	0.0214***	0.0142**	0.0118**	0.0208***
	(0.00579)	(0.00639)	(0.00579)	(0.00583)
Schedule caste	-0.00184	-0.00852	-0.00493	-0.00208
	(0.00562)	(0.00651)	(0.00562)	(0.00566)

Other backward class	-0.0102**	-0.00704	-0.0146***	-0.0103**
	(0.00489)	(0.00525)	(0.00491)	(0.00491)

	(5)	(6)	(7)	(8)
Dependent variable	In agriculture			
Policy variables	District irrigation ratio	Irrigation ratio	District middle school	Head primary plus
Hinduism	-0.00496	0.00162	0.000507	-0.00457
	(0.0107)	(0.0119)	(0.0107)	(0.0107)
Islam	-0.0817***	-0.0787***	-0.0761***	-0.0816***
	(0.0139)	(0.0157)	(0.0138)	(0.0138)
Christianity	0.0309**	0.0287**	0.0333***	0.0320**
	(0.0126)	(0.0132)	(0.0124)	(0.0126)
District population	-7.26e-09***	-6.44e-09***	-6.59e-09***	-7.22e-09***
	(1.71e-09)	(1.93e-09)	(1.68e-09)	(1.67e-09)
District flat ground	0.00171	0.00256	0.0106**	0.00213
	(0.00422)	(0.00472)	(0.00427)	(0.00415)
District hilly ground	0.000589	0.00374	0.000142	0.000440
	(0.0108)	(0.0109)	(0.0108)	(0.0108)
Constant	1.211***	1.177***	1.363***	1.217***
	(0.0629)	(0.0713)	(0.0660)	(0.0627)
Observations	59,480	46,844	59,480	59,480
R-squared	0.141	0.133	0.144	0.142
F-Stat	118.4	99.18	119.9	118.6
Fixed Effects	State	State	State	State

Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Table A4: Policy interactions with rainfall variability for non-head members self-employed in agriculture

	(1)	(2)	(3)	(4)
Dependent variable	Self-employed in agriculture			
Policy variables	District road	District post office	District bank	Credit
CV Kharif rain (β_{RV})	-0.0940	-0.175***	-0.126***	-0.0994***
	(0.0746)	(0.0523)	(0.0359)	(0.0326)
Normal Kharif rain	-0.000130***	-0.000114***	-0.000105***	-0.000105***
	(3.42e-05)	(3.42e-05)	(3.33e-05)	(3.41e-05)
Normal annual temperature	-0.00493*	-0.00556*	-0.00458	-0.00398
	(0.00291)	(0.00290)	(0.00292)	(0.00291)
Policy	-0.181***	-0.189***	-0.322**	0.00136
	(0.0636)	(0.0515)	(0.150)	(0.0186)
Policy X CV Kharif rain (β_{RVxPA})	0.0364	0.156**	0.301	0.00812
	(0.0874)	(0.0748)	(0.225)	(0.0261)
(β_{RV}+β_{RVxPA}) = 0	-0.0576	-0.0185	0.175	-0.0913
F-Stat(β_{RV}+β_{RVxPA})	2.992	0.201	0.738	9.840
Prob > F	0.0837	0.654	0.390	0.00171
Age	0.000295**	0.000295**	0.000294**	0.000289**
	(0.000141)	(0.000141)	(0.000141)	(0.000141)
Male	-0.0737***	-0.0731***	-0.0733***	-0.0732***
	(0.00464)	(0.00463)	(0.00464)	(0.00464)
Completed primary	-0.0453***	-0.0462***	-0.0465***	-0.0470***
	(0.00513)	(0.00512)	(0.00512)	(0.00512)
Completed secondary	-0.0905***	-0.0917***	-0.0923***	-0.0928***
	(0.00500)	(0.00499)	(0.00499)	(0.00500)
Completed higher secondary	-0.157***	-0.159***	-0.159***	-0.159***
	(0.0115)	(0.0115)	(0.0115)	(0.0115)
Graduate and above	-0.387***	-0.388***	-0.388***	-0.389***
	(0.0155)	(0.0155)	(0.0155)	(0.0155)
Married	0.00776*	0.00767*	0.00759*	0.00784*
	(0.00455)	(0.00455)	(0.00455)	(0.00456)
Female members	-0.00962***	-0.00942***	-0.00943***	-0.00949***
	(0.00189)	(0.00189)	(0.00189)	(0.00189)
Male members	-0.00243	-0.00238	-0.00250	-0.00259
	(0.00172)	(0.00173)	(0.00173)	(0.00173)
Dependents	0.00167	0.00161	0.00172	0.00178
	(0.00125)	(0.00126)	(0.00126)	(0.00126)
Old head	-0.0147**	-0.0148**	-0.0150**	-0.0152**
	(0.00591)	(0.00592)	(0.00591)	(0.00593)
Male head	0.0186*	0.0218**	0.0212**	0.0209**
	(0.0104)	(0.0104)	(0.0104)	(0.0105)
Cultivable land	0.0111***	0.0111***	0.0110***	0.0110***
	(0.00120)	(0.00120)	(0.00120)	(0.00120)
Schedule tribe	0.00692	0.00379	0.00757	0.00999
	(0.00732)	(0.00736)	(0.00732)	(0.00730)
Schedule caste	-0.0196***	-0.0208***	-0.0212***	-0.0205***
	(0.00749)	(0.00752)	(0.00753)	(0.00752)
Other backward class	-0.0125**	-0.0140**	-0.0135**	-0.0127**
	(0.00570)	(0.00571)	(0.00572)	(0.00571)

	(1)	(2)	(3)	(4)
Dependent variable	Self-employed in agriculture			
Policy variables	District road	District post office	District bank	Credit
Hinduism	-0.00704	-0.00596	-0.00994	-0.00929
	(0.0134)	(0.0133)	(0.0134)	(0.0134)
Islam	-0.0863***	-0.0848***	-0.0895***	-0.0890***
	(0.0173)	(0.0173)	(0.0173)	(0.0173)
Christianity	0.0490***	0.0461***	0.0444***	0.0432***
	(0.0145)	(0.0143)	(0.0144)	(0.0144)
District population	-3.19e-09	-5.21e-09**	-5.39e-09**	-5.88e-09***
	(2.18e-09)	(2.16e-09)	(2.16e-09)	(2.15e-09)
District flat ground	0.00591	0.00748	0.00367	0.00308
	(0.00558)	(0.00561)	(0.00559)	(0.00558)
District hilly ground	-0.00121	0.00227	0.00445	0.00408
	(0.0117)	(0.0117)	(0.0117)	(0.0117)
Constant	1.288***	1.279***	1.198***	1.152***
	(0.0909)	(0.0836)	(0.0805)	(0.0802)
Observations	41,152	41,152	41,152	41,152
R-squared	0.145	0.144	0.143	0.143
F-Stat	95.88	95.46	95.23	95.18
Fixed Effects	State	State	State	State

Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Table A4: Policy interactions with rainfall variability for non-head members self-employed in agriculture

	(5)	(6)	(7)	(8)
Dependent variable	Self-employed in agriculture			
Policy variables	District irrigation ratio	Irrigation ratio	District middle school	Head primary plus
CV Kharif rain (β_{RV})	-0.111***	-0.145***	-0.227***	-0.117***
	(0.0397)	(0.0311)	(0.0407)	(0.0289)
Normal Kharif rain	-0.000103***	-0.000109***	-0.000121***	-0.000107***
	(3.45e-05)	(3.47e-05)	(3.34e-05)	(3.41e-05)
Normal annual temperature	-0.00386	-0.00288	-0.00613**	-0.00400
	(0.00293)	(0.00297)	(0.00291)	(0.00291)
Policy	-0.00669	-0.0385*	-0.405***	-0.0558***
	(0.0551)	(0.0211)	(0.0619)	(0.0187)
Policy X CV Kharif rain (β_{RVxPA})	0.0310	0.0794***	0.431***	0.0705***
	(0.0714)	(0.0299)	(0.0905)	(0.0261)
(β_{RV}+β_{RVxPA}) = 0	-0.0798	-0.0652	0.204	-0.0466
F-Stat(β_{RV}+β_{RVxPA})	2.425	3.912	9.300	2.001
Prob > F	0.119	0.0479	0.00229	0.157
Age	0.000282**	0.000218	0.000289**	0.000317**
	(0.000141)	(0.000142)	(0.000141)	(0.000142)
Male	-0.0732***	-0.0737***	-0.0735***	-0.0741***
	(0.00465)	(0.00471)	(0.00463)	(0.00466)
Completed primary	-0.0470***	-0.0468***	-0.0466***	-0.0449***
	(0.00513)	(0.00518)	(0.00512)	(0.00520)
Completed secondary	-0.0928***	-0.0891***	-0.0912***	-0.0898***
	(0.00500)	(0.00503)	(0.00498)	(0.00513)
Completed higher secondary	-0.160***	-0.155***	-0.158***	-0.157***
	(0.0115)	(0.0116)	(0.0115)	(0.0116)
Graduate and above	-0.390***	-0.389***	-0.387***	-0.386***
	(0.0155)	(0.0158)	(0.0155)	(0.0156)
Married	0.00790*	0.00774*	0.00820*	0.00765*
	(0.00456)	(0.00466)	(0.00455)	(0.00455)
Female members	-0.00944***	-0.00858***	-0.00954***	-0.00952***
	(0.00190)	(0.00191)	(0.00189)	(0.00189)
Male members	-0.00258	-0.00231	-0.00232	-0.00260
	(0.00173)	(0.00175)	(0.00173)	(0.00173)
Dependents	0.00176	0.00123	0.00179	0.00188
	(0.00126)	(0.00127)	(0.00126)	(0.00126)
Old head	-0.0153***	-0.0180***	-0.0150**	-0.0166***
	(0.00592)	(0.00605)	(0.00591)	(0.00599)
Male head	0.0212**	0.0170	0.0222**	0.0229**
	(0.0105)	(0.0106)	(0.0104)	(0.0105)
Cultivable land	0.0112***	0.0103***	0.0110***	0.0111***
	(0.00122)	(0.00117)	(0.00120)	(0.00121)
Schedule tribe	0.0102	0.00883	0.00108	0.00896
	(0.00732)	(0.00738)	(0.00731)	(0.00740)
Schedule caste	-0.0205***	-0.0203***	-0.0228***	-0.0211***
	(0.00753)	(0.00780)	(0.00753)	(0.00757)
Other backward class	-0.0127**	-0.0109*	-0.0161***	-0.0129**
	(0.00572)	(0.00577)	(0.00573)	(0.00575)

	(5)	(6)	(7)	(8)
Dependent variable	Self-employed in agriculture			
Policy variables	District irrigation ratio	Irrigation ratio	District middle school	Head primary plus
Hinduism	-0.00861	-0.000787	-0.00189	-0.00839
	(0.0134)	(0.0135)	(0.0133)	(0.0134)
Islam	-0.0878***	-0.0793***	-0.0804***	-0.0883***
	(0.0173)	(0.0176)	(0.0172)	(0.0173)
Christianity	0.0431***	0.0336**	0.0460***	0.0443***
	(0.0144)	(0.0140)	(0.0142)	(0.0144)
District population	-6.02e-09***	-6.01e-09***	-5.38e-09**	-5.82e-09***
	(2.18e-09)	(2.20e-09)	(2.15e-09)	(2.15e-09)
District flat ground	0.00145	0.00162	0.0109*	0.00284
	(0.00565)	(0.00560)	(0.00572)	(0.00558)
District hilly ground	0.00474	0.00434	0.00262	0.00409
	(0.0117)	(0.0118)	(0.0117)	(0.0117)
Constant	1.154***	1.153***	1.327***	1.168***
	(0.0798)	(0.0803)	(0.0827)	(0.0794)
Observations	41,152	38,851	41,152	41,152
R-squared	0.143	0.134	0.145	0.143
F-Stat	95.00	88.63	95.68	95.08
Fixed Effects	State	State	State	State

Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Table A4: Instrument variables estimations of policy action and their interactions

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent variables	In agriculture			Self-employed in agriculture		
Policy Action variables	Credit	Irrigation	Education	Credit	Irrigation	Education
CV Kharif rain (β_{RV})	-0.683**	-0.160***	-0.0762***	-1.543*	-0.169***	-0.104***
	(0.321)	(0.0267)	(0.0264)	(0.875)	(0.0300)	(0.0326)
Normal Kharif rain	-0.000110***	-0.000112***	-0.000125***	-2.00e-05	-0.000104***	-9.29e-05***
	(3.20e-05)	(2.51e-05)	(2.34e-05)	(6.96e-05)	(2.80e-05)	(2.77e-05)
Normal annual temperature	-0.00664***	-0.00349	-0.00685***	-0.00386	-0.00250	-0.00463*
	(0.00209)	(0.00215)	(0.00190)	(0.00309)	(0.00247)	(0.00246)
Policy	-0.541**	-0.0666***	-0.154***	-1.156*	-0.0654**	-0.157***
	(0.248)	(0.0258)	(0.0474)	(0.626)	(0.0275)	(0.0507)
Policy X CV Kharif rain (β_{RVxPA})	0.938*	0.119***	-0.00626	2.183*	0.125***	0.00191
	(0.493)	(0.0369)	(0.0710)	(1.313)	(0.0390)	(0.0764)
(β_{RV}+β_{RVxPA}) = 0	0.255	-0.0406	-0.0824	0.640	-0.0437	-0.102*
F-Stat(β_{RV}+β_{RVxPA})	2.144	1.878	2.205	2.113	1.951	3.073
Prob > F	0.143	0.171	0.138	0.146	0.163	0.0796
Under ID test	10.63***	8355***	1315***	3.220*	7126***	1057***
Chi-sq P-val	0.00111	0	0	0.0727	0	0
Weak ID Kleibergen-Paap rk Wald F [1]	5.115	9490***	712.5***	1.568	8360***	582.7***
Age	0.000161	0.000151	0.000753***	0.000254	0.000229*	0.000927***
	(0.000123)	(0.000119)	(0.000131)	(0.000190)	(0.000134)	(0.000162)
Male	-0.0631***	-0.0663***	-0.0801***	-0.0718***	-0.0738***	-0.0921***
	(0.00378)	(0.00392)	(0.00427)	(0.00547)	(0.00435)	(0.00508)
Completed primary	-0.0536***	-0.0475***	-0.0176***	-0.0582***	-0.0472***	-0.0148**
	(0.00563)	(0.00440)	(0.00561)	(0.0109)	(0.00485)	(0.00639)
Completed secondary	-0.0999***	-0.0917***	-0.0456***	-0.103***	-0.0888***	-0.0423***
	(0.00603)	(0.00424)	(0.00720)	(0.0108)	(0.00461)	(0.00806)
Completed higher secondary	-0.160***	-0.156***	-0.0971***	-0.162***	-0.155***	-0.0945***
	(0.0106)	(0.0107)	(0.0130)	(0.0133)	(0.0111)	(0.0141)
Graduate and above	-0.383***	-0.396***	-0.322***	-0.361***	-0.391***	-0.320***
	(0.0154)	(0.0144)	(0.0165)	(0.0250)	(0.0147)	(0.0173)
Married	0.0152***	0.00935**	0.0118***	0.0107*	0.00766*	0.00355
	(0.00366)	(0.00392)	(0.00359)	(0.00560)	(0.00440)	(0.00442)
Female members	-0.00925***	-0.00822***	-0.00789***	-0.0134***	-0.00876***	-0.00944***
	(0.00202)	(0.00133)	(0.00125)	(0.00379)	(0.00148)	(0.00149)
Male members	-0.00335**	-0.00331***	-0.00349***	-0.00530*	-0.00238*	-0.00345**
	(0.00152)	(0.00123)	(0.00115)	(0.00283)	(0.00135)	(0.00136)
Dependents	0.000852	0.000981	0.00144*	0.00182	0.00127	0.00213**
	(0.000843)	(0.000872)	(0.000822)	(0.00125)	(0.000967)	(0.000982)
Old head	-0.0119**	-0.0174***	-0.0456***	-0.00220	-0.0178***	-0.0486***
	(0.00558)	(0.00470)	(0.00575)	(0.0111)	(0.00495)	(0.00667)
Male head	0.0135	0.0149*	0.0536***	0.00544	0.0171*	0.0599***
	(0.00894)	(0.00805)	(0.00808)	(0.0164)	(0.00912)	(0.0105)
Cultivable land	0.00869***	0.00979***	0.0133***	0.00767***	0.0104***	0.0133***
	(0.00166)	(0.000814)	(0.000948)	(0.00282)	(0.000870)	(0.00100)
Schedule tribe	0.0251***	0.0141***	-0.00979	0.0201	0.00909	-0.0203***
	(0.00761)	(0.00520)	(0.00607)	(0.0127)	(0.00600)	(0.00733)

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent variables	In agriculture			Self-employed in agriculture		
Policy Action variables	Credit	Irrigation	Education	Credit	Irrigation	Education
Schedule caste	0.00139	-0.00834	-0.0303***	-0.0164*	-0.0201***	-0.0488***
	(0.00584)	(0.00540)	(0.00598)	(0.00839)	(0.00646)	(0.00756)
Other backward class	-0.00910**	-0.00752*	-0.0270***	-0.00996	-0.0114**	-0.0296***
	(0.00452)	(0.00433)	(0.00465)	(0.00642)	(0.00475)	(0.00538)
Hinduism	-0.00409	0.00109	-0.00506	-0.00231	-0.00147	-0.00786
	(0.00922)	(0.00988)	(0.00889)	(0.0140)	(0.0112)	(0.0111)
Islam	-0.0786***	-0.0791***	-0.0949***	-0.0865***	-0.0798***	-0.0996***
	(0.0119)	(0.0129)	(0.0116)	(0.0171)	(0.0144)	(0.0144)
Christianity	0.0264**	0.0278**	0.0397***	0.0350***	0.0322***	0.0530***
	(0.0106)	(0.0108)	(0.0104)	(0.0134)	(0.0115)	(0.0118)
District population	-7.49e-09***	-6.52e-09***	-6.72e-09***	-5.78e-09***	-6.18e-09***	-5.41e-09***
	(1.49e-09)	(1.56e-09)	(1.38e-09)	(2.07e-09)	(1.77e-09)	(1.75e-09)
District flat ground	0.00547	0.00221	0.00177	0.0166	0.00107	0.00261
	(0.00404)	(0.00395)	(0.00354)	(0.0110)	(0.00468)	(0.00471)
District hilly ground	0.00414	0.00354	0.00186	0.0217	0.00463	0.00472
	(0.00999)	(0.00898)	(0.00871)	(0.0186)	(0.00974)	(0.00962)
Observations	59,479	46,785	59,479	41,152	38,802	41,152
R-squared	0.011	0.090	0.044	-0.459	0.091	0.053
Number of state	31	31	31	31	31	31

Robust standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1

[1] Kleibergen-Paap rk Wald F use Stock-Yogo (2005) weak ID test critical values from the log file.

Table A5: Instrument variable estimations of interactions between policy and rainfall variability with district fixed effects

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent Variables	In agriculture			Self-employed in agriculture		
Policy Action Variables	Household Credit	Household Irrigation	Head w/ Primary+ Edu	Household Credit	Household Irrigation	Head w/ Primary+ Edu
Policy	0.227	-0.0617*	-0.0102	-0.267	-0.0591	-0.00347
	(1.613)	(0.0366)	(0.0794)	(0.248)	(0.0396)	(0.0818)
Policy X CV Kharif rain	-0.249	0.0962*	-0.280**	0.381	0.0990*	-0.300**
	(1.918)	(0.0536)	(0.130)	(0.308)	(0.0579)	(0.135)
Under identification test	1.015	2388***	338.9***	40.61***	1694***	286.9***
Chi-sq P-val	0.314	0	0	1.86e-10	0	0
Weak ID Kleibergen-Paap rk Wald F [1]	0.511	2153***	176.9***	21.67***	1567***	152.2***
Age	0.000234	0.000172	0.000872***	0.000289**	0.000233*	0.00105***
	(0.000182)	(0.000120)	(0.000146)	(0.000135)	(0.000136)	(0.000183)
Male	-0.0637***	-0.0672***	-0.0842***	-0.0745***	-0.0752***	-0.0973***
	(0.00393)	(0.00396)	(0.00483)	(0.00435)	(0.00442)	(0.00565)
Completed primary	-0.0484***	-0.0452***	-0.0107	-0.0443***	-0.0441***	-0.00678
	(0.00993)	(0.00443)	(0.00660)	(0.00492)	(0.00489)	(0.00736)
Completed secondary	-0.0967***	-0.0919***	-0.0360***	-0.0918***	-0.0894***	-0.0327***
	(0.0180)	(0.00434)	(0.00916)	(0.00502)	(0.00473)	(0.00997)
Completed higher secondary	-0.155***	-0.153***	-0.0754***	-0.154***	-0.153***	-0.0737***
	(0.0164)	(0.0107)	(0.0153)	(0.0110)	(0.0111)	(0.0164)
Graduate and above	-0.381***	-0.383***	-0.293***	-0.374***	-0.379***	-0.290***
	(0.0188)	(0.0143)	(0.0187)	(0.0146)	(0.0146)	(0.0195)
Married	0.0116***	0.00705*	0.00846**	0.00600	0.00500	-0.000562
	(0.00423)	(0.00388)	(0.00362)	(0.00432)	(0.00437)	(0.00453)
Female members	-0.00777	-0.00769***	-0.00658***	-0.00859***	-0.00839***	-0.00861***
	(0.00629)	(0.00132)	(0.00125)	(0.00167)	(0.00147)	(0.00151)
Male members	-0.00302	-0.00363***	-0.00393***	-0.00245*	-0.00254*	-0.00391***
	(0.00357)	(0.00122)	(0.00117)	(0.00142)	(0.00134)	(0.00139)
Dependents	0.000981	0.00109	0.00157*	0.00175*	0.00140	0.00227**
	(0.00163)	(0.000874)	(0.000839)	(0.000965)	(0.000972)	(0.00101)
Old head	-0.0104**	-0.0129***	-0.0492***	-0.0105**	-0.0141***	-0.0566***
	(0.00449)	(0.00468)	(0.00727)	(0.00496)	(0.00494)	(0.00841)
Male head	0.0125	0.0137*	0.0613***	0.0196**	0.0174*	0.0748***

	(0.0219)	(0.00812)	(0.00953)	(0.00946)	(0.00929)	(0.0124)
Cultivable land	0.00999***	0.0106***	0.0158***	0.0122***	0.0117***	0.0169***
	(0.00368)	(0.000865)	(0.00122)	(0.00103)	(0.000949)	(0.00129)
Schedule tribe	0.0159	0.0108*	-0.0335***	0.00453	0.00464	-0.0428***
	(0.0225)	(0.00583)	(0.00859)	(0.00697)	(0.00681)	(0.0102)
Schedule caste	-0.00530	-0.0120**	-0.0465***	-0.0241***	-0.0245***	-0.0664***
	(0.0105)	(0.00567)	(0.00784)	(0.00658)	(0.00681)	(0.00948)
Other backward class	-0.00928	-0.00841*	-0.0355***	-0.0108**	-0.0115**	-0.0379***
	(0.00892)	(0.00469)	(0.00594)	(0.00516)	(0.00519)	(0.00690)

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent Variables	In agriculture			Self-employed in agriculture		
Policy Action Variables	Household Credit	Household Irrigation	Head w/ Primary+ Edu	Household Credit	Household Irrigation	Head w/ Primary+ Edu
Hinduism	0.0115	0.0199*	0.0104	0.0202*	0.0216*	0.0167
	(0.0117)	(0.0106)	(0.00970)	(0.0121)	(0.0122)	(0.0122)
Islam	-0.0595***	-0.0571***	-0.0769***	-0.0599***	-0.0595***	-0.0808***
	(0.0147)	(0.0140)	(0.0129)	(0.0156)	(0.0158)	(0.0162)
Christianity	0.00937	0.0139	0.0130	0.0147	0.0237*	0.0222*
	(0.0123)	(0.0120)	(0.0114)	(0.0135)	(0.0130)	(0.0132)
Observations	59,479	46,785	59,479	41,151	38,801	41,151
R-squared	0.065	0.082	-0.001	0.074	0.085	0.004
Number of district_ii	549	549	549	548	548	548

Robust standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1

[1] Kleibergen-Paap rk Wald F use Stock-Yogo (2005) weak ID test critical values from the log file.