Occupational Diversification as Pro-Active Adaptation Rainfall Variability in Rural India

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ABSTRACT

The determinants of occupational focus versus diversification between household members in rural India are investigated as an autonomous and proactive adaptation strategy against ex ante local rainfall variability risks. Nationally representative household level survey data are combined with historical climate variability information at the district level. This study finds that high rainfall variability has strong negative effects on the agricultural focus of within household occupational choices. This confirms the hypothesis that local variability in rainfall "pushes" household members towards employment in non-agricultural sector. 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. The study finds that policies that improved access to irrigation, education, credit, roads, and postal services, appear to increase the agricultural focus of household members.

JEL classification: J43, Q54, O12
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1. Introduction

This paper uses historical local rainfall variability as a measure of the ex-ante risks faced by rural households and analyzes how historical climatic patterns such as the long term coefficient of variation in local rainfall affects the employment and occupational selection of the members of households in rural India. About 70 percent of India's population lived in rural areas in 2010 (World Bank, 2012). The employment in the agriculture sector as share of total workers in India was 58.2 percent (Government of India, 2013). In this setting local rainfall variability during monsoon is the primary source of production and income risks.

In the context of traditional macroeconomics where a rural economy is identified with activities solely in the agricultural sector, sectoral diversification is synonymous with rural to urban migration. However, the view that rural economies are purely agricultural has recently been questioned. Reardon et al. (2006) review survey evidence from a large number of developing economies and show that on average rural nonfarm income constitutes about 40 percent of household incomes.

The choices of sector of employment of the millions of rural households in developing countries are important determinants of household welfare. Considering that both push and pull factors contribute to the decisions of households to allocate labor between activities on-farm and off the arm, it is necessary to have a better understanding of which one of these two factors plays a more important role in the observed choices of households and their members. To the extent that pull factors, such as higher wage rates, and higher returns, dominate the decision to diversify occupations and/or the choice between farm and non-farm sector of employment, economic efficiency and aggregate output are likely to be higher.

In principle, higher output could also be achieved by focusing on a single occupation or sector. Household members could also specialize by all working in the same occupation or sector and increase productivity by learning from each other's experience. If the son enters the same sector as the father, he might be able to pick up the necessary skills faster by learning from his father's experience (Menon & Subramanian, Learning, diversification and the nature of risk, 2008). 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 a specific sector to diversified activities. Thus, diversification of occupations and sector of employment may not always be associated with higher output or higher productivity depending on the context and the relative strength of pull and push factors e.g. (Shenoy, 2013).

In rural India, one important push factor is year to year variability in rainfall and associated farm-income variability. Households may engage in nonfarm activities with low risks even if these activities have low returns. In areas with poor agro-climatic conditions, risky agriculture, and no insurance markets, nonfarm activities allow households to cope with severe downturns in agricultural productivity (Reardon, Berdegué, Barrett, & Stamoulis, 2006) (Ellis, 2004). Households pushed to diversify their activities may thus have lower returns and experience lower consumption in comparison to households that diversify due to pull factors. At the household level, diversification due to push factors may result in more income security but at the cost of a lower level of welfare and overall growth. [1]

[1] 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.

The increased variability in rainfall that is increasingly associated with climate change[2], implies that the prevailing risk mitigation strategies developed after years of exposure and experience with the prior climate regime may become less and less effective. Thus, it is imperative to establish empirically whether auxiliary government interventions can facilitate household adaptation to increased risks due to climatic change faced by households.

The analysis carried out consists of two parts. The first focuses on documenting the extent to which households diversify their occupation *ex ante* as a means of protecting their welfare in the presence of uncertainty about climatic variability. We hypothesize that occupational choices of working members other than the head of the household (referred to as 'non-heads' from now on) are partly based on *ex ante* risks to household welfare. As noted above the main sources of *ex ante* risks in rural India is local variability of rainfall. That is, in areas where the variance of rainfall is high we expect the head and the other members of the household to diversify between agriculture and non-agriculture.

The second part of the paper relates directly to policy. One critical concern to policy is whether household access to key policy instruments such as irrigation, credit, and improvement in human capital tends to "weaken" the effect of climatic variability on the incentive to diversify the occupational portfolio of household members, thus enhancing the gains from specialization and increasing the output potential.

About 35 percent of total agricultural area in India is irrigated (World Bank, 2012) If irrigated crop cultivation, for example, is associated with a decreased role of "push factors" in the occupational choice of households, then there is credible evidence that expansion of irrigation projects is likely to protect household welfare.

2. Background

Most of the India's rural poor depend on agriculture for their livelihood. Arguably, the main source of risk and uncertainty rural household face is the amount of rainfall during the agricultural season. There exist many sources of income risk in a rural economy: input prices, output prices, and yields. The latter is the most direct link between weather variability and income risk, but the other sources of risk might be also related to rainfall.

Crop failure -due to droughts or floods- might lead to asset depletion, poverty, and malnutrition. Even if the extreme outcomes do not materialize, extreme weather events might have a long-lasting negative impact on children health (due to an increase of vector-borne diseases and the indirect income effect of a poor harvest).

[2] Climate can be thought of as the expected distribution of weather. 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 climate variability is expected to show an upward trend.

If insurance markets were complete, capital markets allowed household to save and borrow to smooth income variability, and futures markets gave information on prices, risk would not be a source of concern. But in India as in most regions of the developing world insurance markets are not complete. Therefore, production risk (due to weather) can have a heavy toll on human welfare.

Farmers have adapted to weather uncertainty by changing crops (drought and flood resistant varieties), and to some extent farmers can adjust their practices once uncertainty is revealed (emerging information), for example by increasing fertilizer use or by switching to irrigation wherever possible. However, much of the risk associated with weather variability cannot be addressed by changing farming practices.

Households in rural India have long tried to cope with weather risk. Coping strategies can be divided into *ex-ante* strategies and *ex-post* strategies. *Ex-ante* strategies include: crop insurance, raising livestock, planting crops more resistant to weather shocks with possibly lower yield, within household labor diversification into activities not dependent on weather, investing in irrigation, having spatially diversified but more fragmented landholdings, etc.

Ex-post strategies are used to protect consumption from sharp declines in income. Households have several ways to compensate for shortfalls in income: selling of stored produce, selling household assets, accessing formal and informal credit markets, accessing to public safety nets such as food assistance, accessing to informal safety nets such as transfers from relatives, increasing labor market participation, seasonal migration, etc.

In this paper we empirically analyze the role of labor allocation as an *ex-ante* strategy to diversify weather uncertainty at planting. We hypothesize that in places where weather is more variable (measured by the long-term coefficient of variation of rainfall) households will be more occupationally diversified.

We also test whether the availability of other mechanisms to cope with risk reduces the need to diversify occupations. For instance, irrigation reduces the impact of rainfall on agricultural yields[3]. Therefore we should expect households that have access to irrigation to be less diversified.

To what extent is, labor diversification a good risk-coping strategy? Would agricultural household specialize in agricultural activities in the absence of climate risk? We assume that households would be better off under specialization. Is this a good assumption?

3. Literature

The households' inability to completely smooth consumption in the presence of production and income shocks has been analyzed by Jalan and Ravallion (1999), Kazianga, and Udry (2006). A related literature has shown that a lack of credit institutions leads poor households to invest in less risky income portfolio

[3] To some extent irrigation is dependent on rainfall, especially in minor irrigation works which depend on surface runoff and groundwater recharge. However, to the extent year to year rainfall variation is uncorrelated, groundwater based irrigation can insure against low rainfall events. Similarly, river based irrigation systems depends on precipitations in upstream catchment areas that may be uncorrelated with local precipitation.

when they are faced with productivity shocks. Further, these conservative portfolio choices can perpetuate low-income as risky portfolios on average yield higher returns (Eswaran & Kotwal, 1990) (Rosenzweig & Binswanger, 1993) (Rosenzweig & Wolpin, 1993) (Morduch, 1995).

Studies have investigated the risk-averse behavior of farmers in terms of employment and income variability. However, these studies focused on the variability of off farm employment (Mishra & Goodwin, 1998) and farm revenue (Kanwar, 1999) of owner cultivators as measures of overall income risks.

Others have studied *ex ante* risk strategies of rural poor have focused on consumption smoothing through savings, and conservative cropping choices. For example Darcon and others have looked into the role of precautionary savings, crop choices in smoothing income, and intra-household risk sharing (Dercon S. , 1996) (Dercon & Krishnan, Vulnerability, seasonality and poverty in Ethiopia, 2000) (Dercon & Hoddinott, 2003).

Lanjouw and Lanjouw (1995) conducted an excellent survey of the role of non-farm employment in the rural economy and its growth. They further noted the role of "push" factors such as scarcity of land, and the need to self-insure against weather shocks as possible reasons for off-farm employment diversification (Lanjouw & Lanjouw, 2001), (Lanjouw & Murgai, 2009). Similarly Deininger and Olinto (2001) demonstrated with data from Columbia that though households stand to gain by choosing a single specialized farm based source of income, may choose to diversify into non-farm economic activities to reduce risks. Other than the climatic variability, revenue or income risks include price, pests and disease, input unavailability and other risks. Thus, these studies do not specifically focus on climate risks.

An alternate research strategy is to focus on crop insurance coverage, and changes in premium subsidies. For example, Key, et al. (2006) uses a large increase in US Federal crop insurance subsidies as a natural experiment to identify the importance of crop risks and its effects on off-farm labor supply. Moreover crop insurance may include climatic as well as other risks.

Indian insurers in recent years developed innovative retail index insurance products designed to pay out when realized monsoon rainfall is poor. This type of insurance mitigates low rainfall risks only and does not protect against other types of crop failures. A recent study used randomized controlled trial approach to better understand how such an innovative insurance instrument for hedging low rainfall risks affect agricultural decisions of a sample of Indian farmers (Cole, Giné, & Vickery, 2013). Cole et al find that such innovative insurance may help mitigate low rainfall risks particularly for educated farmers. These farmers choose to plant higher-return higher-risk cash crops when provided with low rainfall insurance. However, they also find that demand for insurance is very price sensitive in India. Further, they conclude that limited financial sophistication of the Indian farmers may allow purchase decisions of high-price low-value insurance products.

We now focus on the studies that have explicitly taken climate risks into account. In one study, Mueller and Osgood (2009) distinguishes between short term shocks and 25 year long term mean and variance of precipitation in Brazil and measures their effects on rural out-migrants' income. They find that households migrating out of rural areas during a short term severe precipitation shock have lower long term income in the urban areas. The study suggests households consider historical distribution of climate when deciding to migrate. They find households living in states with lower rainfall variability are more likely to migrate. Thus, it appears that households do not use migration as an ex ante climate risk mitigation strategy.

Three recent studies have addressed similar issues as the current study and deserve some attention: Menon (2009), Ito and Kurosaki (2009) and Bandyopadhyay and Skoufias (2013). Menon focuses on the effect of rainfall uncertainty, access to credit markets, and physical infrastructure on labor diversification.

In Menon's analysis rainfall uncertainty is a covariate shock, not idiosyncratic. Using individual level data she studies the occupational choice of each household member relative to the occupation of household head (any occupation, agriculture, or self-employed in agriculture). She complements the individual level analysis with a household level analysis of labor shares in agriculture and non-agricultural employment.

Results show that household members are less likely to choose the same occupation as the household head (if the household head is self-employed in agriculture) in districts that have more rainfall uncertainty. Under the SUR model rainfall uncertainty reduces the household labor share in agriculture. Among the policy variables only having access to credit markets mitigates the effect of rainfall shocks. Infrastructure has no effect on labor diversification.

Ito and Kurosaki also focus on rainfall uncertainty as a determinant of ex-ante labor diversification, but they consider the family labor allocation in response to realized shocks. As in the previous paper they consider rainfall shocks as a covariate shock, but the hypotheses are derived from a formal allocation model in which labor is the only household endowment.

They estimate a system of equations of shares of labor allocation in: on-farm activities, agricultural laborer in-kind, agricultural laborer in-cash, and non-agricultural activities. They use cross-sectional data from the India LSMS for the states of UP and Bihar corresponding to the 1997-1998 agricultural season. They focus on farm household.

As Menon, they use the coefficient of variation of monsoon rainfall (expected shock related to ex-ante diversification), and the absolute deviation from normal rainfall in the year of the survey (ex-post shock). They find that higher rainfall variability reduces the labor share on on-farm activities and increase the shares of non-farm activities and in-kind farm work. Results on ex-post diversification due to rainfall shocks are mixed. Access to irrigation reduces the need to diversify away of on-farm activities. Other infrastructure has no impact on labor allocation.

Bandyopadhyay and Skoufias (2013) focus on non-flood prone areas of Bangladesh and study how the intra household diversity in the sectors of economic activities is affected by the *ex-ante* climate variability risks. They find that the push factors of floods in the flood prone areas and rainfall variability in the non-flood prone areas are associated with sectoral diversity within household and it results in measurable welfare losses.

The current study differs from the previous works in three ways. Frist, in geographical scope this study covers a vast area of rural India with diverse agro-ecological zones and different levels of rural infrastructure. The previous studies either covered small countries with specific features such as mountainous Nepal and flood prone Bangladesh, or northern states of India with relatively homogenous agro-ecological features.

Second, Ito and Kurosaki (2009) investigate the effects of ex post weather shocks while controlling for ex ante variability. On the other hand the current study focuses solely on ex ante risks of climate variability and economic, social or infrastructure policies that may mitigate some of the ex-ante risks. In this respect the current study sets itself apart from the huge existing literature that focuses on ex-post weather shocks and extreme events that may have large negative economic effects on rural households.

Finally, the current study incorporates household and plot level irrigation information as a possible source of insurance against ex-ante climate variability. Bandyopadhyay and Skoufias (2013) find in Bangladesh normal riverine flood mitigates some of the ex-ante local climate variability risks in flood prone areas. In principle, access to irrigation can serve the same purpose by pooling risks across time and space. For the first time, the current study measures the net effects of irrigation on mitigating ex-ante climate risks and its effects on rural households' occupational portfolio.

4. Data

The Indian 2002-03 NSS round, Schedule 18.2. The 59th round is nationally representative survey focused on rural and peri-urban household that collects detailed farm-level information including land holdings, stocks of assets (also sales and loss of assets), 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). (Working with the occupation in the last week has two additional problems: (i) observed labor outcome might be due to the realization of a shock rather than to the expected shock, (ii) need to link timing of recent shocks with timing of the survey.)

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 km2.

District level data on three dominant topological types of flat, hilly, and undulating were used from FAO together with total district population information from to take into account some of the district level heterogeneity. We complement the FAO topological data with district-level infrastructure from the

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 matching index. Thus, we use proportion of villages in a district with access to the infrastructure in question as measures of district level measures of 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.

High resolution gridded (on 1 degree latitude by 1 degree longitude cells) daily rainfall data from the India Meteorological Department covering 1951-2003 is based on daily records from more than 1800 weather stations. Normal precipitation and normal variability (coefficient of variation) 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 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, we define occupational focus based not only on the sector but also on the type of occupation (self-employed or wage worker). In this case agricultural focus may occur 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 to be self-employed in agriculture and 0 otherwise .

The second sets of variables are 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 irrigation ratio and the primary plus education of the head of the household.

Table 1: Key variables of analysis with descriptive statistics

Description	N	Mean	S.E.
Non-head member indicators			
"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			
"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			
"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			
"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.

The third sets of variables are village level indicators aggregated from households to measure access to the infrastructure at the village level, such as 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 sets of variables measure 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.

Other than the variables of interests described in Table 1, we control for wide sets of individual members' as well as the head of the households' characteristics augmented with household demographic indicators, and district level infrastructure indicators. The complete list of these variables is in annex Table A1.

5. Methodology

We consider two types of occupational choices made by household members. 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. However, 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.

We hypothesize that occupational choices of working non-head members are based on pull and push factors. As noted above the main sources of push factors in rural India is local variability of rainfall. That is, we expect more non-head members of households to choose occupations unrelated to agriculture. Similarly, in districts where variance of rainfall is high the head and non-head members of the household may diversify between self and wage employment in agriculture.

We take into account the pull factor of occupational diversification by controlling for access to human and physical capital and infrastructure, such as education of the non-head, and the size of land holdings. These factors help households to be "pulled into" high return occupationally diversified portfolio.

We test our estimation models with 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 focus of the non-head members we consider three types of left hand side 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 indicators 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 with 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 for 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.

We note that household level measures of policy action variables have their own sets of problems. In particular, our household measures of credit and irrigation shows 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.

We use linear probability models to estimate the effect of local rainfall variability on thepropability that the non-head household member choses the same occupation as the head. A linear probability model has advantages over a logit or probit regressions. See Mullahy (1990), Klaassen and Magnus (2001), Horrace and Oaxaca (2006) for discussions on 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.

Thus, the indicator of within-household occupational and employment homogeneity is modeled using the following linear probability model specification:

$$Y_{ijd} = \alpha + \alpha_{RV} RV_{d} + \alpha_1 X_{1\,d} + \alpha_2 X_{2\,jd} + \alpha_3 X_{3\,ijd} + \varepsilon_{ijd} \qquad (1)$$

Where Y_{iju} 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 *ex ante* climate risk measure, as coefficient of variation of Kharif season rain over the last 30 years in the district *d*, $X_{2\,d}$, $X_{3\,jd}$, $X_{4\,ijd}$ are exogenous variables specific to member *i*, household *j* and district *d*. These variables include district characteristics like mean Kharif season rainfall, annual average temperature, population, and topological indicators; 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.

The hypothesis that increased ex ante climate risks such as greater variability of local rain will lead to smaller probabilities of non-head members also being in agriculture or being self-employed in agriculture as the head of the household is true if α_1 is negative and significantly different from zero.

Policy actions by the government and the NGOs cannot directly reduce the climate risks. However, extra resources made available through policy actions may help households mitigate the ex ante climate risks without occupational diversification that may lower household welfare. We consider five factors that can be altered by policy action, (a) access to roads, (b) access to communications, (c) access to credit, (d) access to education, and (e) access to irrigation. If households have access to credit then diversification in occupational and employment choices in order to insure welfare against ex ante climate risks may be less urgent as compared with no access to credit. Similarly access to social safety-net may act as an insurance against ex ante climate risks. Finally access to market 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 we use a variant of equation (1):

$$Y_{ijd} = \beta + \beta_{RV} RV_d + \beta_{PA} PA_{jd\,/\,d} + \beta_{RV\times PA}\left(RV_d \times PA_{jd\,/\,d}\right) + \beta_1 X_{1\,d} + \beta_2 X_{2\,jd} + \beta_3 X_{3\,ijd} + e_{ijd} \tag{2}$$

Where $PA_{jd\,/d}$ 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 the *ex ante* climate risk measure, such as coefficient of variation of annual Kharif season rain over the last 30 years in the district *d*. Equation (2) highlights the interaction term between RV_d and $PA_{jd\,/d}$.

The effects of ex ante rainfall variability risks on agricultural focus that are not influenced by policy actions are captured by the β_{RV} and we expect β_{RV} to be negative. For households influenced by policy actions, such that they have access to road, communications, credit, education, or irrigation the additional effects of ex ante rainfall variability risks are captured by β_{RVxPA}. Since we expect the policy actions to reduce the negative effects of ex ante rainfall variability risks on household welfare, we expect β_{RVxPA} to be positive. The net effect of ex ante climate risks and policy action on household welfare is then measured by ($\beta_{RV} + \beta_{RVxPA}$). If ($\beta_{RV} + \beta_{RVxPA}$) 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 agricultural focus.

The policy action of education is different from the other policy actions. 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.

As discussed above, district level policy action variables are not ideal. On the other hand, the corresponding household level measures are may suffer from endogeneity bias and measure utilization as opposed to access. We use the instrument variable approach to take into account the endogeneity issue. To this end we consider three policy action variables measured by household credit, irrigation, and education of the head of the household. The household data did not include any suitable analog of access to paved roads, and post and telegraph services and these policy action variables are dropped from the rest of the analysis.

At the first stage, we estimate the policy action variables as a function of household and district characteristics. We use village level aggregates of the endogenous variable in question where the aggregate excludes the current observation. For example, we use the share of households in the village that had used any types of credit in the past year, where the calculation of the share excludes the current household. Thus, the estimated model of instrumented policy action variables is represented as:

$$Y_{ijd} = \delta + \delta_{RV} RV_d + \delta_{PA} \widehat{PA_{jd}} + \delta_{RV\times PA}\left(RV_d \times \widehat{PA_{jd}}\right) + \delta_1 X_{1\,d} + \delta_2 X_{2\,jd} + \delta_3 X_{3\,ijd} + u_{ijd} \tag{3}$$

$$PA_{jd} = \theta + \theta_{\widetilde{PA}} \widetilde{PA}_v + \theta_1 X_{1\,d} + \theta_2 X_{2\,jd} + \epsilon_{jd} \tag{4}$$

Where $\widetilde{\mathrm{PA}}_{\mathrm{v}}$ is the village level aggregate of the policy action variable PA excluding the household j in district d.

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, we estimate all the models described above with state fixed effects. However, similar arguments can be made for the heterogeneity of the districts as well. One can argue that unobserved characteristics of the districts outweigh the few observed characteristics used in this analysis so far. Even though we cannot measure the primary effects of rainfall variability on occupational choices on non-head members in a district fixed effect model, we can estimate the net interaction effects between rainfall variability and household level policy action variables. Thus, equation (3) and (4) can be rewritten for the district fixed effect estimation as:

$$Y_{ijd} = \delta + \delta_{PA}\widehat{PA_{jd}} + \delta_{RV\times PA}\left(RV_d \times \widehat{PA_{jd}}\right) + \delta_2 X_{2\,jd} + \delta_3 X_{3\,ijd} + u_{ijd} \tag{5}$$

$$PA_{jd} = \theta + \theta_{\widetilde{PA}}\widetilde{PA}_v + \theta_2 X_{2\,jd} + \epsilon_{jd} \tag{6}$$

Our estimation strategy includes a variety of policy action variables and we use different estimation methods to check the robustness of the effectiveness of these variables in mitigating ex ante rainfall variability risks faced by the households.

6. Results

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. 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. Table 2 shows 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.

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.

Columns 1 and 2 relate to the dependent variable “in agriculture.” For all 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 first specification in column 1 and 3 excludes all the policy action variables while the alternate specification in columns 2 and 4 includes them all. The main variable of interest is rainfall variability measured by coefficient of variation of the Kharif season rainfall. As expected, the there exists a negative association between rainfall variability and sectoral focus. 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.

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

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 expected to provide better 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 their interactions on household agricultural focus. 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: 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 (β_{RVxPA})	0.0723	0.0364
	(0.0728)	(0.0874)
(β_{RV}+β_{RVxPA}) = 0	-0.0317	**-0.0576***
F-Stat(β_{RV}+β_{RVxPA})	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 A4.

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 household. 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 (β_{RV}+β_{RVxPA}) = 0. This hypothesis cannot be rejected when agricultural focus is measured by "in agriculture" and is rejected at 10 percent level of significance when agricultural focus is measured as "self-employed in agriculture." However, the district level access to paved road indicators gloss over the within district heterogeneity.

Access to communications may provide new employment as well as 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.

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 (β_{RV}+β_{RVxPA}) = 0 cannot be rejected at 10 percent or better. However, the absence of access to postal service data at the household level does not allow us to compare these results with corresponding household level indicators.

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 (β_{RVxPA})	0.0940	**0.156** **
	(0.0613)	(0.0748)
(β_{RV}+β_{RVxPA}) = 0	-0.0254	-0.0185
F-Stat(β_{RV}+β_{RVxPA})	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 A4.

Access to credit is allows a household to smooth its consumption in case of adverse rainfall and agricultural outcome. Policies that improve access to credit as well as allow households to better utilize credit may thus ameliorate the need for diversification from agriculture within household 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 primary effect of access to banks on agricultural focus of the household is negative. The net effects 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.

Columns (2), (3), and (4) show household measures of credit use out of which columns (3) and (4) shows estimates where the household credit is instrumented by village aggregate of credit. The results are qualitatively similar to those obtained from the district level indicators in columns (1). 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.

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 (β_{RVxPA})	0.205	0.0189	**0.938* **	-0.249
	(0.178)	(0.0218)	(0.493)	(1.918)
(β_{RV}+β_{RVxPA}) = 0	0.109	**-0.0683*** **	0.255	
F-Stat(β_{RV}+β_{RVxPA})	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 (βRVxPA)	0.301	0.00812	**2.183* **	0.381
	(0.225)	(0.0261)	(1.313)	(0.308)
(β_{RV}+β_{RVxPA}) = 0	0.175	**-0.0913*** **	0.640	
F-Stat(β_{RV}+β_{RVxPA})	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 A4. Table A5. And Table A6.

Irrigation has arguably one of the 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 shows 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.

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. Only in specification (column 2) where the household irrigation is not instrumented the null ($\beta_{RV}+\beta_{RVxPA}$) = 0 cannot be rejected at 5 percent level of significance. However, it can be argued that the irrigation variable and its interaction term suffer from endogeneity bias in this specification. Thus, the rejection of the null ($\beta_{RV}+\beta_{RVxPA}$) = 0 in this specification may not be as relevant to the true indicator of the relationships between these factors. On the other hand positive and significant interaction coefficients in district fixed effects instrument variable specifications (column 4) strengthens our hypothesis that household irrigation in combination with local rainfall variability is a significant determinant of agricultural focus of occupation within a household.

Table 6: Interaction between access to irrigation and rainfall variability

	(1) District irrigation ratio	(2) Household Irrigation ratio	(3)	(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 (βRVxPA)	0.0207	**0.0679** **	**0.119*** **	**0.0962***
	(0.0581)	(0.0276)	(0.0369)	(0.0536)
($\beta_{RV}+\beta_{RVxPA}$) = 0	-0.0642	**-0.0673** **	-0.0406	
F-Stat($\beta_{RV}+\beta_{RVxPA}$)	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 (βRVxPA)	0.0310	**0.0794*** **	**0.125*** **	**0.0990***
	(0.0714)	(0.0299)	(0.0390)	(0.0579)
($\beta_{RV}+\beta_{RVxPA}$) = 0	-0.0798	**-0.0652** **	-0.0437	
F-Stat($\beta_{RV}+\beta_{RVxPA}$)	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 A4. Table A5. And Table A6.

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) uses 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: 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 (βRVxPA)	**0.385*** **	**0.0611*** **	-0.00626	**-0.280** **
	(0.0761)	(0.0229)	(0.0710)	(0.130)
($\beta_{RV}+\beta_{RVxPA}$) = 0	**0.190*** **	-0.0314	-0.0824	
F-Stat($\beta_{RV}+\beta_{RVxPA}$)	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 (βRVxPA)	**0.431*** **	**0.0705*** **	0.00191	**-0.300** **
	(0.0905)	(0.0261)	(0.0764)	(0.135)
($\beta_{RV}+\beta_{RVxPA}$) = 0	**0.204*** **	-0.0466	**-0.102* **	
F-Stat($\beta_{RV}+\beta_{RVxPA}$)	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 A4. Table A5. And Table A6.

The estimated coefficients of measures of education policy in columns (1) through (3) are all negative and significant as expected. The estimated coefficients in column (4) have the right sign but they are not statistically significantly different from zero. The estimated coefficients of the interaction between education and rainfall variability are positive and significant in columns (1) and (2), not significant in column (3), and have the wrong sign in column (4).

The null (β_{RV}+β_{RVxPA}) = 0 is rejected at better than 1 percent and 10 percent level respectively for the share of middle schools (column 1) and for household heads' education (column 2), but could not be rejected when the household level measure was instrumented (column 3). Thus, it is not clear that 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.

7. Conclusions

Rain-fed agriculture continues to employ a significant share of rural population in India. We used historical local rainfall variability as a measure of the ex-ante risks faced by rural households and analyzed how historical climatic patterns affects the household sectors of employment portfolio in rural India. The theory suggests if agricultural income is subject to high risks from uncertain rainfall, members of agricultural households may choose to get employed in non-agricultural sectors to hedge against that risk even when the returns from the non-agricultural sectors may be lower than those from the agricultural sector.

We find that high rainfall variability has strong negative effects on the agricultural focus of within household occupational choices. This confirms our hypothesis that local variability in rainfall "pushes" household members towards employment in non-agricultural sector. Data limitations do not allow us measure 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.

Without corrective policy actions mitigating the likely increased rainfall risks due to climate change, exposed households may have no choice but to allocate more labor to low risk low return non-agricultural activities as a means of adaptations to climate change. The most direct approach to avoid the low risk low return outcome is for the policy makers to create a market for rainfall indexed insurance products. In recent years the Government of India has started rainfall insurance schemes in some parts of the country. However, it is too early to conduct national level analysis of the effectiveness of rainfall insurance.

The second direct policy action related to mitigation of ex ante rainfall risks is through expansion of irrigation. India has a sizable irrigation infrastructure at the national level and we were able to measure its effects in combination with rainfall variability on household employment choices. We expected irrigation to be a major source of ex-ante rainfall variability risk mitigating strategy where available. Our results confirm this hypothesis and show that irrigation can be an alternative to the use of occupational diversity as an ex-ante climate risk mitigation strategy for rural households in India.

Finally, policies that improve access to education, credit, roads, and information, such as postal services, are expected to 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 to reduce *ex ante* rainfall risks. If this is the predominant channel through which access to education, information, and markets, affects intra-household employment choices, we would expect households with access to these services to be more focused on 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-return non-agricultural activities, then we would expect the combination of high *ex ante* rainfall risks and access to education, information, and markets, to reduce the household focus on agriculture.

We find that policies that improved access to education, credit, roads, and postal services, appear to increase the agricultural focus of household members. However, the results are not always robust to the various specifications. Thus, it is not clear if 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 when they have access to more of these services.

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Annex Tables

Table A1: All the variables of analysis with descriptive statistics

Description	N	Mean	S.E.
Non-head member indicators			
"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			
"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 indicators			
"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			
"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 an 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 an 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)
(β_{RV}+β_{RVxPA}) = 0	-0.0642	-0.0673	0.190	-0.0314
F-Stat(β_{RV}+β_{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 A5: 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)
($\beta_{RV}+\beta_{RVxPA}$) = 0	0.255	-0.0406	-0.0824	0.640	-0.0437	-0.102*
F-Stat($\beta_{RV}+\beta_{RVxPA}$)	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 A6: 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.

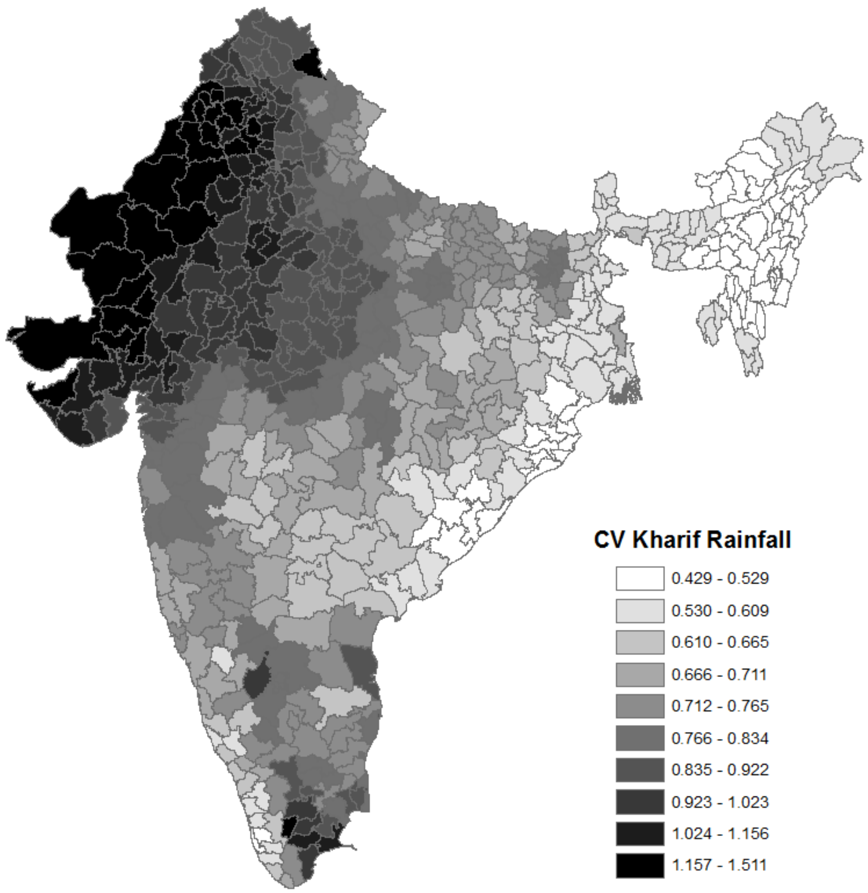

FIGURE 1. Coefficient of Variation of Rainfall (June-October 1960-2000)
Data Source: India Meteorological Department