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Impact of weather risk on cotton production in Pakistan

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Overview

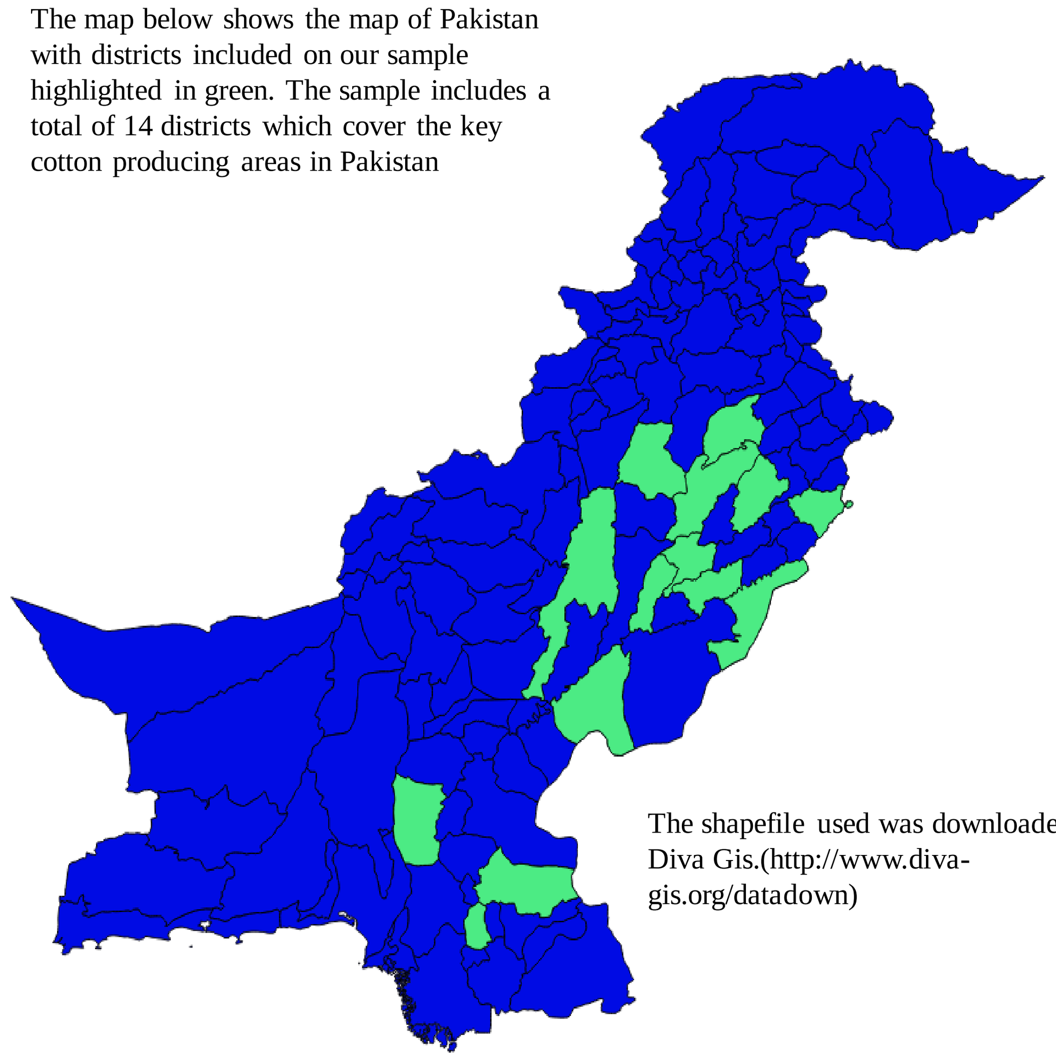
The Indus Basin region in Pakistan was one of the initial regions that adopted the new technologies offered by the Green Revolution. Following this this area saw a significant rise in input intensification and then sharp yield increases (Byerlee & Siddiq, 1994). However low input use efficiency and a decline in the quality of the resource base has emerged as a post Green revolution challenge.(Murgai et al. 2001).Understanding the decision making process of farmers with regards to input use and technology adoption is now an important issue for Pakistani policy makers who need farmers to adopt technologies that are sustainable and efficient with regards to input use.

This paper looks at whether weather risk is a source of significant risk for cotton growers in this region and how it impacts input use decisions. Increasing uncertainty related to production output would lead to a lower level of risk increasing input. We focus specifically on phosphatic fertilizer use as a measure of input use variation.

One of the challenges and possible shortcomings of this analysis is that input and output price factors play a significant role in input use decisions and price risk has not been included here. We justify this exclusion based on the argument that price risk exposure is determined by location and household attributes all of which are part of the unobservable fixed effect that a plot level panel allows us to control for.

Map of districts in available sample

The map below shows the map of Pakistan with districts included on our sample highlighted in green. The sample includes a total of 14 districts which cover the key cotton producing areas in Pakistan



The shapefile used was downloaded from Diva Gis.(http://www.diva-gis.org/datadown)

Date and Model Description

Farmers are modeled as expected utility maximizers (which is the standard despite criticism(Rabin 1997)) and we treat weather variables as the major source of uncertainty. Phosphorous fertilizer is treated as a risk increasing input primarily because while it is known to increase the mean yields(and therefore the returns from the cotton crop) it also increases the expenditure associated with production. This in turn implies that a loss in yields can become even more disastrous when there are weather associated losses of the crop.

The paper utilizes a plot-level panel dataset of production data and household demographic data collected by IFPRI for the production years 2011-12 and 2013-14 covering a total of 942 households and 1380 plots.

The analysis presented in this poster however relies on 161 households and 177 plots for which data for the same plot was available across both rounds.

The flow chart shown below provides a simplified timeline of the cotton production process in the cotton production cycle to help us further identify the weather risks associated with the production process. We identify the possibility of heavy rainfall during picking season as a major source of risk post the application of phosphatic fertilizer through anecdotal information.

We use rainfall data provided by *awhere* which is daily rainfall data from 2008-2013 provided at a pixel level of 9 by 9 km. Weather risk is measured through the standard deviation of rainfall in the relevant region during the month of July when picking is expected to begin in most regions. For the first round in the panel the daily data for the month of July is used from 2008-2011 and for the second rain the data is extended to include observations from 2011-2013

Variable List	Round 1(Kharif 2011)	Round 2(Kharif 2013)
Credit Purchases for season(1=Input in this season for purchased on credit, 0=No inputs in this season were purchased on credit)	0.47	0.56
	0.50	*0.50*
Income from crops for household for the season(PKR)	678972.2	1228003.00
	1378274.00	*3092519.00*
Water Logging/Salinity(1=Water Logging or Salinity reported for this plot for this season,0=No waterlogging/salinity reported for this plot for this season)	0.13	0.10
	-	-
Tractor Hours used on plot for this season(Hours/Acre)	8.79	12.85
	4.37	*18.38*
Seed Cost incurred for this season(PKR)	202.45	189.63
	400.95	*212.76*
Total Labor Hours used this season(Hours)	621.05	1096.03
	354.53	*1289.39*
Farm size of household(Acres)	7.06	7.76
	8.90	*9.40*
Canal Irrigation(No of canal water irrigations on Plot)	6.06	4.12
	6.67	*4.26*
Groundwater Irrigation(No of ground water irrigations on Plot)	7.04	4.96
	6.21	*6.13*
Phosphatic fertilizer used on this plot for this season(Kg/Acre)	35.18	62.75
	34.36	*108.93*

The table provides summary statistics of the variables used in the analysis.
The mean values are in the first row and the standard deviations are in italics below.

Simplified model of irrigated cotton production in Pakistan

Land Preparation. (February-March)
Unpredictable rainfall at this time can mean delays in sowing and greater labor requirement
Method used to prepare land depends on many factors including access to machinery and labor availability affects type of sowing bed prepared

Sowing-(March-April)
Farmer decides what to sow(BT/non-Bt),when to sow(early/late) and how to sow (Either manual sowing in ridges or using drill machine).
Phosphatic fertilizer is applied at the time of sowing

Germination-Emergence-(April 4-9 days after sowing)-
Extreme temperatures during this time can reduce germination rate
Average crop water requirement is 45 mm

First square-Flowering. (May-June-60-70 days after sowing)
Average crop water requirement is 400 mm. Water requirement is the most critical during this stage

Flowering-Boll Opening (June,5-9 days after flower forms)-
Average crop water requirement is 200 mm.

Boll Opening-First Picking (July-August,125-135 days after sowing)-
Leaves form in this stage
Average crop water requirement is 170 mm
Heavy Rains here can cause boll shedding.(yield losses)

Multiple Pickings –
(September-October). Higher cotton prices generally mean delayed taking down of the crop.

Results and Discussion

The regression model used is taken from Honore (1992) which allows for the use of censored data to in a fixed effect regression. The model developed by him is y(i,t) = max(0,x(i,t)*b + a(i) + u(i,t)), where a(i) is the unobserved effect.

We can see that the standard deviation of rainfall has a significant negative impact on phosphorous use amongst farmers which indicates that increased uncertainty prevents optimal input use. This study helps provide insights into smallholder farmers behavioral response to weather risk, which can help governments identify policies to encourage adaption to climate change and mitigate its impacts. A potential policy response could be in the form of insurance products that protect farmers from aggregate risks and thereby encourage improved production practices which might require greater financial investment.

Regression Results

Independent Variables	Phosphatic fertilizer used on this plot for this season(Kg/Acre)
Credit Purchases for season(1=Input in this season for purchased on credit, 0=No inputs in this season were purchased on credit)	13.02
	(9.751)
Variation in rainfall for the month of July in area where household is located	***-22.07****
	(12.09)
Income from crops for household for the season(PKR)	2.04e-05*
	(1.22e-05)
Water Logging/Salinity(1=Water Logging or Salinity reported for this plot for this season,0=No waterlogging/salinity reported for this plot for this season)	14.09
	(13.26)
Tractor Hours used on plot for this season(Hours/Acre)	4.554***
	(1.146)
Seed Cost incurred for this season(PKR)	0.000996
	(0.0260)
Total Labor Hours used this season(Hours)	0.00554
	(0.00639)
Farm size of household(Acres)	-1.440
	(1.613)
Canal Irrigation(No of canal water irrigations on Plot)	0.992
	(1.133)
Groundwater Irrigation(No of ground water irrigations on Plot)	-0.314
	(0.663)
Observations	353

It is important to note the coefficients provided in the table above are not marginal effects. Honore (1992) model works so that the coefficients are zero when max(0,x(i,t)*b + a(i) + u(i,t)<0 and b(j) when max(0,x(i,t)*b + a(i) + u(i,t)>0. Honore shows that the marginal impact can be calculated by multiplying the coefficient to the proportion of positive values on the sample. In our case this would suggest (63% are positive responses) that the marginal effect of the rainfall variation on phosphorous use is -13.87.

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