Measuring Systemic Risks and Inefficiencies in Agriculture: The Indian Story

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Abstract: Agricultural risk is usually presented in the literature at the individual farm level and as a measure of price or yield volatility over time. I argue that risks borne by individual farms are in part a symptom of systemic risks evident within the sector as a whole. These risks are better captured, I show, through a measure of spatial volatility of crop yields and as an "in-time" measure. Lower levels of systemic risk reflect higher levels of efficiency - in terms of a rational allocation of resources across spatially separated production units. Finally, over time, improvements in or worsening of efficiency is measured with long term trends in the level of systemic risks observed for various crops. I use crop yield data for 734 farming districts in India to compute a *coefficient of variation* measure to capture a yearly systemic risk for four major crops – rice, wheat, maize, and cotton. The long-term trends for these crops suggest that Indian agriculture remains highly inefficient some fifty years after the green revolution. State policy has compounded these inefficiencies by seeking to compensate individual risks while neglecting the broader systemic risks.

Key Words: Risk, Agriculture, coefficient of variation

1. Agricultural Risk Analysis: What are we Missing?

Agricultural risk analysis is conventionally conducted in the literature at the *micro level* of an individual farm and employs measures of price or yield volatility confronted by the farmer over time (Just and Pope, 2003). In addition, a very small number of studies assess the joint impact of multiple risks on farm-household welfare. Thus, Komarek, Pinto, and Smith (2020) find that only eighteen, out of a total of 3283 peer-reviewed studies, published since 1974, considered all five of the major risk types – production, market, institutional, personal, and finance – that impact the farmer. However, even when these are considered jointly, at the individual farm level, they fail to capture the broader, systemic risk and inefficiency that afflicts the agricultural sector as a whole. In addition, unlike the inherent, or "natural" risks the literature associates with agricultural production, distribution, markets, and prices, the source of systemic risk that I highlight in the case of Indian agriculture below has been exclusively institutional. This includes various laws, policies, and state interventions that hamper the ability of the farm-household to respond to the more naturally occurring risks in agriculture. As a result, conventional risk-analysis has often missed a significant, negative welfare result that I attribute to the persistence of systemic risk in agriculture. This is its potential to trap individual farmers within a "low-return-high-risk" status-quo. I use the case of Indian agriculture to highlight the problem of systemic risks and how one may go about trying to measure it.

2. Systemic Risks in Indian Agriculture: Explaining the Ongoing Farmer Protests

Farmers – predominantly from the two Indian States of Punjab & Haryana -- have been protesting against three new agricultural laws passed by the government in an attempt to liberalize Indian agriculture. The first law will allow farmers across India to sell their produce outside of state owned and managed markets

[1]; the second will make it easier for farmers to contract with private agribusinesses[2]; a third law eases the restrictions on exports of food-grains that Indian farmers have been subject to under the so-called Essential Commodities Act[3]. Taken together, these three laws could be interpreted as an attempt by the government to address systemic risks in Indian agriculture.

So why are farmers from the two states that benefitted the most from the productivity and income gains brought about by the Green Revolution protesting the new laws[4]? One claim that my research makes is that policies that aggravate systemic risks for Indian agriculture as a whole – such as minimum price supports and purchase guarantees; overly generous electricity, water, and fertilizer subsidies - have also ended up disproportionately rewarding a small section of Indian farmers, especially the rice and wheat farmers in Punjab and Haryana. That is, these farmers have the most to lose from a change in the status quo that the farm laws are expected to bring about.

3. Famines: The Long History of Systemic Risks in Indian Agriculture

The problem of systemic risks in Indian agriculture has not gone unnoticed. The long history of droughts and famines in India had challenged the administrators in British India who formulated the Indian Famine Codes as a way to track and respond to regional outbreaks of famine. The entire country was seen as being susceptible to famine risks, given the common occurrence of droughts. However as recent geophysical research (Mishra, et. al. 2019) confirms, while the occurrence of soil-moisture droughts affects the entire landmass of the Indian subcontinent, the likelihood of famine in a particular region and within a specific drought period has been a function of crop yields or productivity, provision of common goods such as irrigation, transportation, and state policies that impact food supplies within the economy.

Florence Nightingale in her extensive public campaigns and writings on the experience of famines in India bemoaned the observed lack of sufficient irrigation, transportation, and low productivity that afflicted farming districts throughout the nineteenth century[5]. That is, Nightingale realized that the actual famine risks that individual farmers end up bearing were the result of *systemic risks and inefficiencies* evident within the agricultural sector as a whole.

More recently, economists have highlighted key institutional differences between North and South Korea to explain why North Korea continues to suffer crop failures and recurring famines[6]. While agricultural production in the two countries enjoy the same "natural conditions" and productivity in the two economies immediately after the Korean War was perceived as being at similar levels, the North Korean agricultural sector suffered a secular decline in agricultural production, beginning in the mid-1980s, nearly a decade before the North Korean Famine that began in 1994 and continued until 1998.

4. Capturing Systemic Risks and Inefficiency with an All-India Risk-to-Return Measure

A persistent feature of Indian agriculture has been the unusual extent of regional diversity found in crop yields or productivity and land use across the country. The British used state and district level yield data

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[1] Farmer's Produce Trade and Commerce (Promotion and Facilitation) Act, 2020.
[2] Farmers (Empowerment and Protection) Agreement of Price Assurance and Farm Services Act, 2020.
[3] Essential Commodities (Amendment) Ordinance, 2020.
[4] 2020-2021 Indian farmers' protest *Wikipedia*. Accessed October 1, 2021:
https://en.wikipedia.org/wiki/2020%E2%80%932021_Indian_farmers'_protest
[5] Vallée, G. (2006).
[6] See Yoon, Y. (2013) and Haggard, S. and Noland, M. (2009).

to track famine risks and incidence across the country. The first Agricultural Census of India published in 1970, and coinciding with the early years of the green revolution in India, devoted an entire chapter highlighting the "regional diversities" captured in the statistics on crop yield, acreage, land use, access to irrigation, fertilizer use, etc.[7] The observed regional variation in agricultural productivity is an important component of systemic risks that defines Indian agriculture and I try and capture it using a *coefficient of variation measure* based on spatial and "in-time" volatility of crop yields for four major crops – wheat, rice, maize, and cotton.

Using official crop production statistics for some 734 districts in India I have computed the median district level yield (in tons-per-hectare) for each of the four major crops - rice, wheat, maize, and cotton - along with the geographic variability of this yield (i.e. risk) across all reporting districts for each year from 1966 to 2018. Together, it provides a *coefficient of variation* (CV) measure of district level crop yields or productivity which when translated as a "*risk-to-return*" measure for the Indian agricultural sector as a whole it captures the yearly *systemic risk* confronted by Indian farmers.

5. Interpreting the Systemic Risk Measure for Indian Agriculture: Causes and Impact

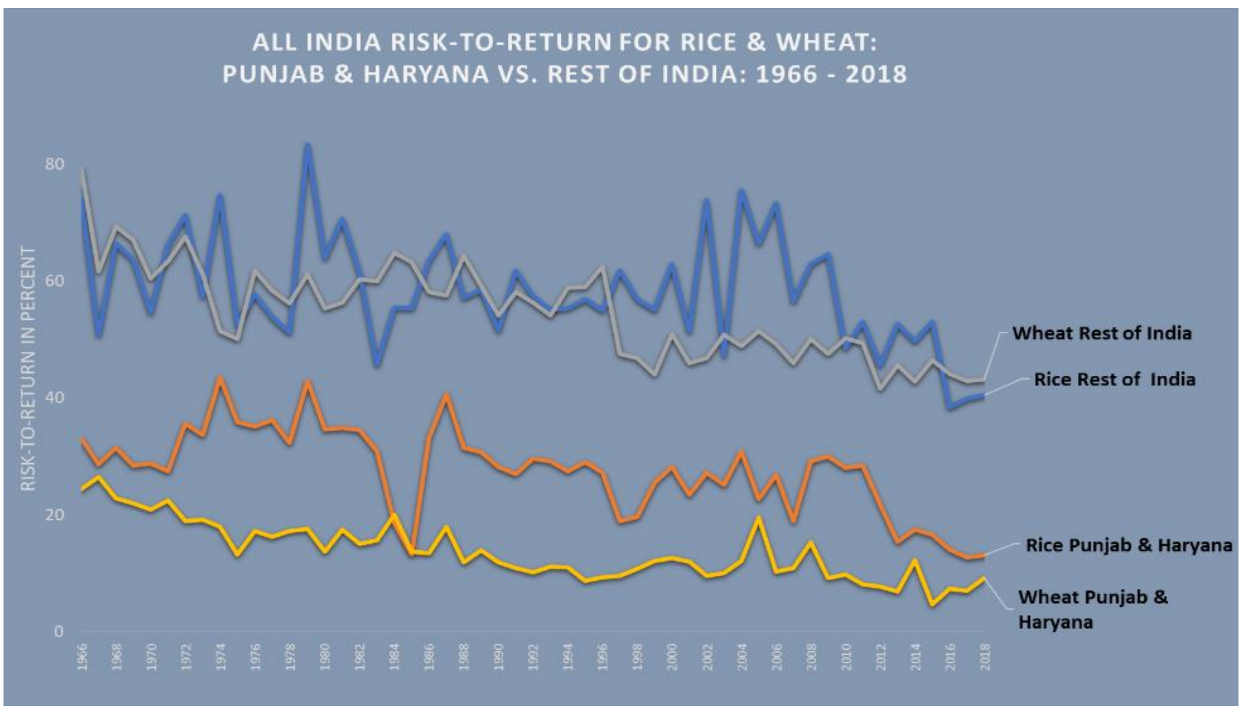

Figure 1: All-India Risk-to-Return for Rice & Wheat: Punjab & Haryana Vs. Rest of India, 1966-2018.

Data Sources: The All-India Risk-to-Return measure was computed by the author combing two data sources. (1) The Crop Production Statistics Information System, Ministry of Agriculture & Farmers Welfare, Government of India, New Delhi. https://aps.dac.gov.in/APY/Index.htm for the 1997-2018

[7] Government of India, Ministry of Agriculture & Irrigation (Department of Agriculture).1975. Accessed on June 13, 2021: https://agcensus.nic.in/document/ac/airac7071_compressed.pdf

years. (2) The Tata-Cornell Institute for Agriculture and Nutrition, District Level Database http://data.icrisat.org/dld/ for the 1966-1996 years.

As the graph in Figure 1 illustrates, outside the two states of Punjab and Haryana, where the green revolution took root some fifty years ago, wheat and rice growing districts in the rest of India continue to suffer from both, lower average yields and far higher variability of yield across districts. The large gap in rice and wheat yields that opened up between the states of Punjab and Haryana and the farm districts in the rest of the country remains far from being closed - some five decades after the green revolution took root in these two states.

The persistence of low average productivity combined with relatively high levels of yield variability across the farming districts suggests the persistence of *inefficiencies* within the agricultural sector - in terms of its inability to more rationally allocate resources across spatially separated production units in ways that could narrow the observed yield gap across the rice and wheat growing districts. There are three main sources of such persistent inefficiencies that are widely acknowledged in the policy literature, and which lend urgency to the cause for reform of existing agricultural laws[8]:

5.1 Restrictions on Resource Mobility

Various state policies have restricted resource mobility within the agricultural by creating a fragmented market for agricultural land, labor, technology, and produce. The same policies have made entry and exit out of agriculture difficult. As a result while the contribution of agriculture to GDP since independence has dropped by two-thirds from around 54% in 1947 to barely over 17% in 2018, the share of the working population dependent on agriculture has remained relatively high at just over 50%.

5.2 Failures in Public Goods Provision

Provision of basic public goods, especially irrigation, remains highly uneven. State policies have also discouraged agribusiness investments in modern infrastructure including in storage, transportation, and distribution contributing to the fragmented nature of the agricultural markets in India.

5.3 Overuse of Resources with Subsidies

Three, heavy state subsidies for water, electricity, fertilizers, and credit have contributed to both overuse of common resources and encouraged inefficient farming practices.

[8] OECD/ICRIER (2018).

6. So, why are the Punjab and Haryana Farmers Protesting the 2020 Farm Laws?

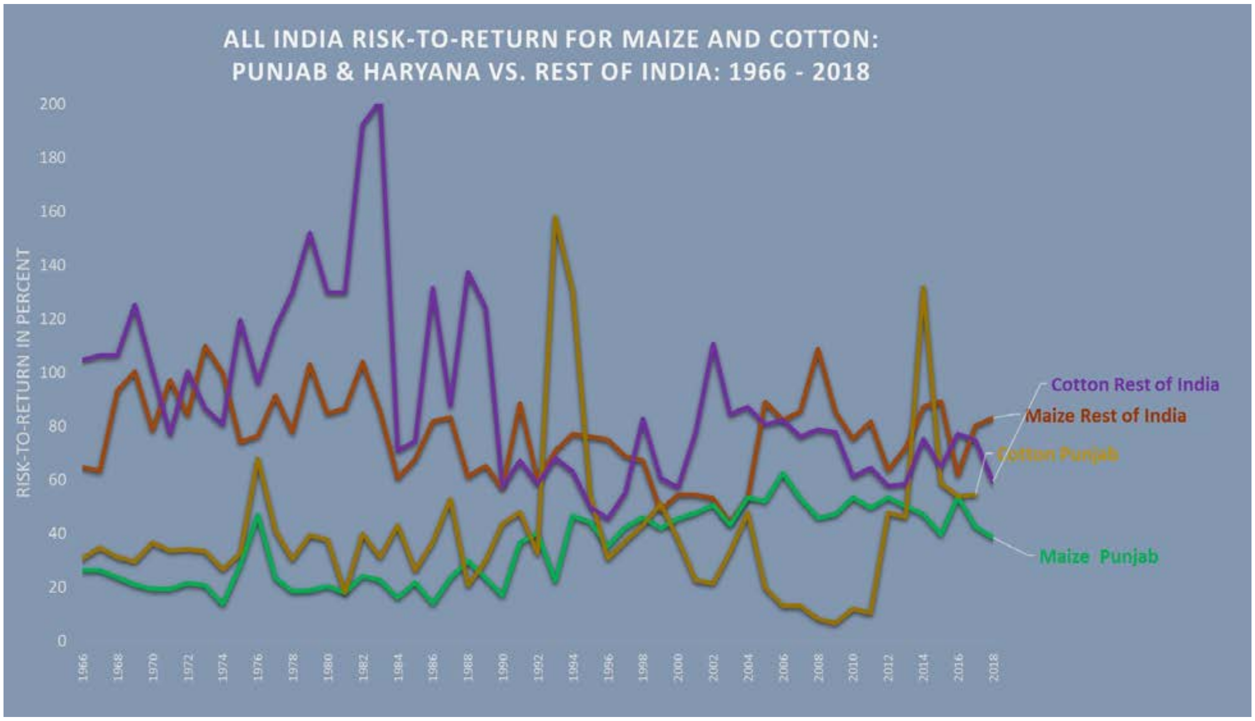

Figure 2: All-India Risk-to-Return for Maize and Cotton: Punjab & Haryana Vs. Rest of India, 1966-2018

Data Sources: The All-India Risk-to-Return measures for maize and cotton was computed by the author combing two data sources. (1) The Crop Production Statistics Information System, Ministry of Agriculture & Farmers Welfare, Government of India, New Delhi. https://aps.dac.gov.in/APY/Index.htm for the 1997-2018 years. (2) The Tata-Cornell Institute for Agriculture and Nutrition, District Level Database http://data.icrisat.org/dld/ for the 1966-1996 years.

The various input subsidies and minimum price guarantee procurement schemes provided by the State, far from addressing the problem of systemic risks in Indian agriculture, have worked to worsen the overall levels of productivity and risk in agriculture, generating adverse effects for all stakeholders – through the degradation of water resources, soil, health, and climate. At the same time, these policies have tightened the risk-trap farm households find themselves in.

Thus, as is evident in Figure 2 above, outside of rice and wheat, the risk-to-return levels are even higher in the case of maize and cotton, including for Punjab. It is no surprise then that the farm households of Punjab and Haryana fear both, the loss of state support for rice and wheat and the higher risks implied by a switch to other crops.

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