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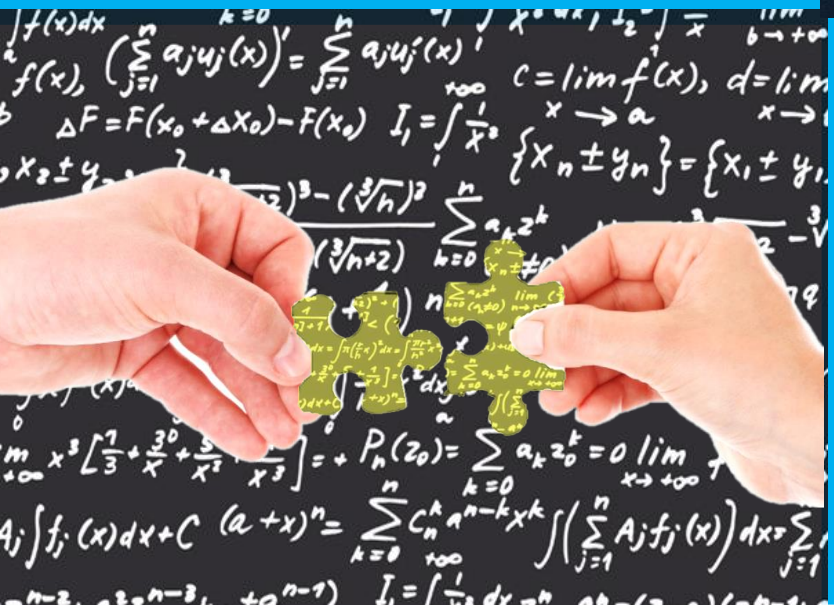
Farmer suicides in India and the weather god



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ASIA-PACIFIC RESEARCH AND TRAINING NETWORK ON TRADE

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ASIA-PACIFIC RESEARCH AND TRAINING NETWORK ON TRADE

WORKING PAPER

Farmer suicides in India and the weather god

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Abstract

This paper examines the reasons for farmer suicides in India. Inability to get the right price, crop failures, and insurmountable debt are the factors that may drive the farmers to take this extreme step. A key factor for farmers being unable to get market prices is inefficient agriculture supply chain management. We find that the reasons for inefficient supply chain management include lack of reforms in the Agricultural Produce Market Committee (APMC) Act, low bargaining power due to small farm size, and lack of warehousing facilities. Crop failures happen because of poor irrigation facilities. Considering agricultural output and rainfall data from four different states in India we find evidence in favor of association between the cyclical component of agricultural output and rainfall data. Understanding this linkage is important from the perspective of formulating demand management policies (read, intervention by the government and central bank).

Key Words: Agriculture output, Beveridge-Nelson Decomposition, APMC Act, Rainfall, India.

JEL Classification: C50, E31, E32.

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1. Introduction

70 per cent of India's population rely on agriculture or related informal sector support.[1] Between 2012 and 2015 over 3000 farmers committed suicides in India. Farmer suicides are therefore a major cause of political contention, despite the fact that they have always occurred and the factors driving these deaths are sometime outside the control of policymakers, including crop failures, inability to get the right price, and insurmountable debt. Nevertheless, when large numbers of suicides occur, it generates heated political debate. The ruling party typically defends its interventions such as farm loan waiver schemes, higher minimum support price (MSP), fertilizer subsidies, and tax free agricultural income, while the opposition parties criticise the government for not doing enough on the ground.

During the fiscal year 2013-2014, contribution of the agricultural and agriculture related allied activities was only 14 per cent of the Gross Domestic Product (GDP), despite providing the livelihood of around 70 per cent of the population (Central Statistical Organization, Government of India, 2014).[2]Some 850 million people still live in rural India. India has around 260 million people living in poverty and 80 per cent of them live in the countryside(World Bank, 2016).

Not only per-capita agricultural income is low, and but at times it is not possible to sustain this low income. Also, agricultural output fluctuates far more than the outputs of the industrial and services sectors. Official output data shows that during the period between 1991-1992 and 2013-2014, the coefficient of variation for agricultural output is 191.34, in comparison to 50.48 for industry, and 22.03 for services sector(Central Statistical Organization, Government of India,

[1] See: http://indiainbusiness.nic.in/newdesign/index.php?param=economy_landing/213/2. Accessed on 09/04/2015.

[2] Year refers to the fiscal year, starting from April for any particular year and ending on March, next year.

2014). This has led to unequal income distribution in India with rural-urban wage gap at 45 per cent in comparison to around 10 per cent for China and Indonesia.

Low and uncertain income are a key driver of farmers' suicides. While crop failures during bad rainfall years can be attributed to less than normal rainfall, a more constant driver of suicides is the low prices they achieve for their produce. Here the blame can squarely be attributed to inefficient agriculture supply chain management. While Dev (2009) attributes lacks of investment in rural infrastructures such as road connectivity (linking village markets to nearby wholesale market) and lack of cold storage facilities as factors prohibiting price discovery for agricultural produce, Kennedy and King (2014) find farmers' indebtedness resulting from crop failures and inability to sell, as reasons for suicides.

World Bank data shows only 35 per cent of India's agricultural land is irrigated (artificial application of water to land or soil).[3] This means the majority (65 per cent) of farming is rain-dependent, most of which happens just a few months over the summer. As Figure 1 shows, likelihood of a farmer committing suicide is more during bad-rain years. To have a meaningful comparison, we standardized rainfall and suicide data with respect to mean and variance, to make them unit free (read, std. rainfall and std. suicide).

Volatile rainfall patterns lead to lower farm income. The median annual wage for a farmer in India is around US $290 which is barely two months' minimum wage in Mumbai – the commercial capital of India. Because of lack of proper irrigation facilities, and weather insurance schemes, farmers' typically get stuck to growing low-value crops such as rice and wheat, although there is an ever increasing demand for high-value stuffs such as fruits, and vegetables.

[3] Available at: http://data.worldbank.org/indicator/AG.LND.IRIG.AG.ZS/countries. Accessed on 09/12/2015.

Productions of the latter variety of crops are prone to lack of rainfall in comparison to the formers.

Figure 1: Rainfall and farmers' suicide

Source: Rainfall Data (https://data.gov.in/keywords/annual-rainfall) and Farmers Suicide Data (http://agrariancrisis.in/2012/02/29/farmers-suicides-data-from-1995-2010-state-wise-gender-deseggregated/).

Subsequently, we test this hypothesis whether farmer suicide rates are strongly and negatively correlated with rainfall data. In the events of drought and floods, there is a likelihood about farmers' facing crop failure. The mechanism of this relationship is driven by the relation between cyclical component of agriculture output (read, volatility of agricultural output) and rainfall. Hence we look for this association in our regression framework.

Additionally, other factors such as lack of reforms to the Agricultural Produce Market Committee (APMC) Act, low bargaining power resulting from small farm size, and lack of warehousing facilities are also responsible for as to why farmers may not get the true market price. In this paper we examine these issues, and discuss possible policy implications that arise from our

findings. The rest of the paper is organized as follows. Section II deals with issues leading to inefficient supply chain management – the main culprit for farmers' inability to command market prices for their outputs. Section III, we look at the effect of rainfall on the cyclical component of agriculture output. Any state related intervention such as building more canals can negate the effect of extreme weather conditions, and in fact can be instrumental for farmers' to realize their targeted revenue. Section IV contains conclusion and policy recommendations.

2. Inefficient supply chain management

In India, if farmers are to sell their produce, they have two options. First is to sell directly to the government. The Central government procures 24 essential food items from the farmers through agencies such as National Agricultural Cooperative Marketing Federation of India Limited (NAFED) and Food Corporation of India (FCI). The second option is to take their produce to the nearby government-designated mandi (market)[4] where in front of state officers they can auction produce to the brokers.

In agriculture, the central government functions as a welfare state. It generally procures these essential items at a higher price and sells these procured items through public distribution system (PDS) at a cheaper price, relative to the market. The basic assumption for the welfare state to function is that the farmers are able to sell all they want to NAFED or FCI collection centers at the MSP. MSP is the minimum price for a product established by the government and supported by payments to producers in the event of the market price falling below the specified

[4] Mandis are the markets in smaller towns and cities to which farmers from nearby villages bring their agricultural produce to sell. In India, mandis have traditionally fulfilled the requirement of aggregation of small quantities of production into larger lots which the wholesaler would procure.

minimum. From the consumer side, low-income people are able to procure these essential items from ration shops at a subsidised rate, thereby making them better-off.

However, in reality things are little different. Typically, MSP is higher than the market price, and one would assume that farmers gain every time the government announces the MSP. However, farmers are seldom able to sell their produce at the MSP. First of all, every village does not have NAFED or FCI outlets. FCI currently procures a major portion of rice and wheat from a few selective states. 70 per cent of rice procurement comes from the Indian States of Punjab, Andhra Pradesh, Chhattisgarh, and Uttar Pradesh while 80 per cent of wheat procurement comes from Punjab, Haryana and Madhya Pradesh. FCI has a minimum presence in other major rice and wheat producing states like Bihar, West Bengal, Assam, and Orissa.[5]And, even if there is an NAFED or FCI outlet, the government may not procure if the farmers bring their produce before/after the dates of procurement.

The government generally announces the dates of procurement, and many times the farmers are not aware of these dates. Worse still, sometimes the government announces procurement dates a month or two after the harvest time, making it impossible for the small farmers to sell their produce at the MSP. In India, as much as 83 per cent of the farmers are smallholders, with less than 1 hectare of landholding (Chand et al, 2011). These smallholder farmers do not have access to cold storage, and have no option but to sell their produce to the middlemen or traders. It is impossible for them to get a space in the state storage facilities without any political connection.

[5] Compared to all-India average of 7340 farmers' suicide committed between 1995 and 2010, only West Bengal has a higher suicides numbering 19331 between 1995 and 2010. The corresponding figures for Assam, Bihar, and Orissa are 3566, 1235, and 4460, respectively. This shows there are other factors in place, particularly, bad weather pattern. This data is available at:http://agrariancrisis.in/2012/02/29/farmers-suicides-data-from-1995-2010-state-wise-gender-deseggregated/. Accessed on 27/08/2016.

What about items such as fruits and vegetables that central government does not typically procure? Here the farmers have the option of taking these products to the nearby government-designated mandi. There are around 7700 government designated mandis spread across India. These middlemen are commissioned licensed agents in the government-designated markets. So that the farmers get a fair price and are not exploited the APMC Act was enacted. Under APMC Act, state government officers are meant to oversee activities related to auctioning such as whether the middlemen give the right price to the farmers, the commodities traded are homogenous in quality, and the markets are equipped with basic infrastructure for taking correct weights and for making payments. In reality, however, these middlemen form a cartel and at the time of auction offer a substantially lower price to the farmers. In addition these middlemen also pass on the mandi fee to the seller. The mandi fee including various charges such as purchase and weighing fee charges: is as high as 13 to 14 per cent of the value of the produce. In contrast, government spending on mandi related infrastructure accounts for only 1 per cent of public spending on agriculture.

Though ideally the buyers should pay for the mandi fees, in reality this price is passed on to the farmers. Typically, smallholder farmers have weak bargaining power. The price realization by these farmers become even less as these mandis have poor infrastructure facilities. Small farmers get affected because of lack of modern grading and sorting process, manual weighing, and measurement errors.

In fact, APMC regulations prevent supermarkets, exporters, and agro-processors to procure fruits, vegetables, and cash crops, directly from the farmers. This prevent contract farming which otherwise can entail better price realization for the farmers. Of course, there is a need for small farmers to form an association so that they have better bargaining power to deal with big

corporates. For example, in Gansu province China, local governments formed marketing associations for the small potato farmers, allowing them to realize better price and eventually increase agricultural productivity.

Corporates can provide credit and insurance coverage for the small farmers. The smallholder and subsistence farmers, constituting 83 per cent of the entire agricultural sector, do not have access to cold storage, or supply of institutional credit. Most of them depend upon village traders, who are also moneylenders, giving them crop loans and pre-harvest consumption loans. The superior bargaining power of the village traders and the middlemen mean that farmers get low prices. Such imperfection in the procurement process leads to inflation. To a certain extent food inflation can be controlled by addressing the inefficiency in agricultural supply chain management.

To correct these problems, there is first a need to increase farmers' bargaining power. Often the needs of the actual users, like consumers, processors and exporters may not coincide with the needs of the farmers. So that the agricultural produce can be procured directly from the farmers, and to make this procurement logically feasible farmers have to get together and supply a minimum quantity of produce. Therefore, it is essential that the farmers form a cooperative on the lines of milk cooperative initiated for AMUL, and sell the produce directly to the procuring agencies. Cooperatives will help in aggregation of the produce and thus make marketing more efficient. These cooperatives should be given trader license in all mandis, so that they can sell directly to the retailers, instead of selling it to the middleman.

Second, there is a need to undertake further reforms. The Task Force on Agricultural Marketing Reforms set up by the Ministry of Agriculture in 2002, Government of India, had suggested promotion of new and competitive Agricultural Markets in private and cooperative sectors to

encourage direct marketing and contract farming programs, facilitate industries and large trading companies to undertake procurement of agricultural commodities directly from the farmers fields, and to establish effective linkages between the farm production and retail chain. Mahindra's Shubhlabh Services, Tata Kissan Kendra, ITC e-Chaupal, Godrej Aadhar, and DSCL Hariyali are all outcomes of such reform measures. The APMC Act was also modified and some states have taken initiatives like direct marketing, private mandis, and contract farming. The idea behind direct marketing is to eliminate the middlemen so that the farmers can enter into a direct selling agreement with the corporate.

However, the reform measures undertaken by various states have been ineffective as a number of rules and regulations of the amended acts are overly restrictive. For instance, in Uttar Pradesh the APMC license issued to ITC to buy through e-Chaupals is only valid for one year. In both 2008 and 2009, the renewed license was issued after the peak wheat marketing season was over, making it redundant. In Madhya Pradesh, there is a stipulation that the buying point cannot be inside a factory, which leads to increased transaction costs and does not serve the very purpose for which buying points are set up. In Rajasthan, buying points have to be far away from mandis/town limits, making *ChaupalSaagar*(organized retail foray) an unviable proposition. In Gujarat, Premium Farm Fresh Private Limited has 6 licenses for establishing private markets. Each market is designed to have a minimum of 20 collection centers, making a total of 120 collection centers spreading across the entire state. Filling of application separately for each collection center is too cumbersome as it implies submitting 120 separate application forms, deposit securities, bank guarantees, etc. The state should realize this difficulty and issue a "unified license" to the private entity.[6]

[6] For more on this see India Commodity Year Book 2012, Edited By Sanjay Kaul, Ane Books Private Limited, India.

Problems such as the ones stated above will continue to persist without further modification and harmonization of the APMC Act across states. It is interesting to note that the states that are vehemently opposing FDI in multi-brand retail are yet to execute any reforms in their APMC Act (see, Box 1). Reforming the APMC Act means farmers can sell their produce directly to the retailers and corporates, bypassing the middlemen. Given that most middlemen in the mandis are also full-time party workers, it is a no-brainer that any further reforms of the APMC Act will negatively impact their payoffs. West Bengal is one such state where, in fact, no reform has been started to amend the APMC Act. Considering potatoes, the margins for the middlemen are almost equal to what the farmers earn for themselves. Put differently, if the farmers were to sell directly to the wholesale buyers they would have realized double the margin in comparison to when they have to sell their produce to the middlemen (Mitra, et al., 2013).

Box 1: Stages of APMC Reforms

	Stage of Reforms	Name of States / Union Territories
1	States/UTs where reforms to APMC Act have been effected for Direct Marketing: Contract Farming and Markets in private/cooperative sectors	Andhra Pradesh, Arunachal Pradesh, Assam, Chhattisgarh, Goa, Gujarat, Himachal Pradesh, Jharkhand, Karnataka, Maharashtra, Mizoram, Nagaland, Orissa, Rajasthan, Sikkim, Uttarakhand and Tripura
2	States / UTs where reforms to APMC Act have been effected partially	(a) Direct Marketing: NCT of Delhi, Madhya Pradesh (b) Contract Farming: Madhya Pradesh, Haryana, Punjab and Chandigarh (c) Private Market: Punjab and Chandigarh
3	States / UTs where there is no APMC Act and hence not requiring reforms	Bihar, Kerala, Manipur, Andaman and Nicobar Islands, Dadra and Nagar Haveli, Daman and Diu, and Lakshadweep
4	States / UTs where APMC Act already provides for reforms	Tamil Nadu
5	States / UTs where further action is required for the reforms	Meghalaya, Haryana, Jammu and Kashmir, West Bengal, Puducherry, NCT of Delhi and Uttar Pradesh

Source: Ministry of Agriculture and Farmers Welfare, Government of India (2016)

Box 2: Stages of APMCS Reforms

Stages of APMC Reforms	Bihar	Punjab	Uttar Pradesh	West Bengal
Establishment of private market yards by a person other than market committee	0	1	0	0
Direct Purchase of agricultural produce from agriculturist by processor	0	1	1	0
To promote and permit e-trading	0	0	0	0
Establishment of private market yards by a person other than market committee	0	0	0	0
Contract farming provision	0	1	0	0
Single point levy of market fee	0	1	0	0
Single registration/ license for trade in more than one market	0	0	0	0
	0	4	1	0
Scores	**0**	**0.571429**	**0.142857**	**0**

Source: Ministry of Agriculture and Farmers Welfare, Government of India (2016)

Note: In absence of a well informed apriori, as to which one of these constituent elements of APMC reforms has more weightage, we assume equal weightage for each one of these factors.0 implies no reforms is undertaken with respect to that constituent element of the APMC Act, whereas 1 implies reforms is complete.

For the States of Bihar, Punjab, Uttar Pradesh, and West Bengal[7]a correlation analysis between number of suicides and reforms in the APMC Act suggests a statistically significant negative coefficients (t-statistics is -3.35).Negative correlation coefficient between lack of reforms of APMC Act and farmers' committing suicides implies that the states which have undertaken reforms are less likely to witness farmers' suicides. Lack of reforms in the APMC Act, make agricultural market rigid and prohibit price discovery. Inability to get the correct price is a reason for farmers' committing suicides.

[7] These are the states for which agricultural income and matching rainfall data are available, and hence considered for the analysis.

Table 1: Correlation between farmers' suicides and reforms in the APMC Act.

Correlation	SUICIDES	APMC Act
SUICIDES	1	
APMC Act	-0.47 (-3.35)	1

Source: Authors' Calculation. t-statistics is in the parenthesis.

Reforming the APMC Act will require political will, something that various states government has to initiate. Some of the states such as Punjab, Tamil Nadu, Karnataka, and Himachal Pradesh, which has undertaken reforms in the APMC Act has already seen better price realization for their farmers. Reforming APMC Act is essential and equally important are government interventions, particularly when lack of rainfall lead to crop failures. In the next Section we look at how volatile rain patterns affect agricultural output.

3. Association between rainfall and the cyclical component of output

Whenever we talk about demand management policy, that is, fiscal and monetary policy, we are basically focusing on how to minimize output fluctuation around its trend (potential) level, also known as output gap. From the policy perspective managing the output gap is important. Large fluctuations in output for a particular sector with huge employment potential such as agriculture in the case of India, will have an adverse effect on income distribution. Any government related intervention such as building canals may help farmers' to achieve their revenue target.

We hypothesized that for the states with inadequate irrigation facilities, farmers will experience a more fluctuating income. A preliminary analysis of correlation coefficients indicate a statistically significant negative correlation between rainfall data and farmers' suicides (t-statistics is -2.12).

Table 2: Correlation between farmers' suicide and rainfall data

Correlation t-Statistic	Farmers' Suicides	Rainfall Data
Farmers' Suicides	1	
Rainfall Data	-0.32 (-2.12)	1

Source: Authors' Calculation. t-statistics is in the parenthesis.

This implies farmers are less likely to commit suicides during good rainfall years. Intrinsic in this argument arise the necessity to test for the relationship between cyclical component of agriculture output and rainfall, which we do in our regression analysis. We use Beveridge-Nelson decomposition technique to decompose the state agricultural GDP into the trend and cyclical components. And, thereafter we look for association between cyclical component of GDP and rainfall data to examine how inadequate irrigation facilities may lead to volatile agricultural income.

In modeling GDP, the simple model containing a linear time trend is given as follows:

$$y_t = \alpha + \beta t + \varepsilon_t \qquad (1)$$

where y_t is GDP, t stands for time trend, ε_t has zero mean, variance σ^2, and is serially uncorrelated.

Beveridge and Nelson (1981) show that any ARIMA model can be represented as a stochastic trend plus a stationary component where a stochastic trend is defined to be random walk, possibly with a drift.[8]

[8] As state-wise employment data are not available for the period considered, we do not use the Blanchard and Quah (1989) decomposition technique.

$$y_t = \mu t + h\sum_{r=1}^{t}\varepsilon_r + d(L)\varepsilon_t \quad (2)$$

where $h = \sum_{j=0}^{\infty} c_j \Rightarrow h = \frac{\sum_{j=0}^{q}\theta_j}{\sum_{i=0}^{p}\phi_i}$ and $d_i = -\sum_{j=i+1}^{\infty}\psi_j$. We can write equation 3 as

$$y_t = y_t^p + y_t^s \quad (3)$$

where $y_t^p = \mu t + h\sum_{r=1}^{t}\varepsilon_r$ and $y_t^s = d(L)\varepsilon_t$

or

$y_t^p = \mu + y_{t-1}^p + h\varepsilon_t$

$y_t = y_t^p + y_t^s$

where $y_t^p = \mu t + h\sum_{r=1}^{t}\varepsilon_r$ and $y_t^s = d(L)\varepsilon_t$

or $y_t^p = \mu + y_{t-1}^p + h\varepsilon_t$

y_t^p is the stochastic trend component. It is modeled as random walk with a drift μ. y_t^s is the cyclical component. Once we decompose the state agricultural output data into trend and cyclical components, we regress the cyclical component on the state rainfall data with a lag.

Data

We have agricultural GDP data for four different states in India: Bihar, Punjab, Uttar Pradesh, and West Bengal. As we do not have matching rainfall data for other states in India, we limit our analysis to these four states only to study the effect of rainfall on agricultural output. The good part is each one of these four states is diverse in terms of their agriculture produce and in a way capture the essence of agriculture produce at a pan-India level.

For instance, Punjab is a major producer of rice, wheat, and cotton. The major crops for Uttar Pradesh are rice, wheat, pulses, oilseeds, and sugarcane. In West Bengal, the main food crops are rice, wheat, potatoes, tea, and jute. For Bihar, rice, wheat, and pulses, comprise around 77 per cent of the total crop production. In general, for India, the crop growing pattern is more towards growing food crops such as rice and wheat, and less towards growing horticulture crops such as fruits and vegetables. This preference structure is to minimize risk: growing crops that can sustain volatile weather condition.

The data consists of 49 annual observations from 1960-61 to 2009-10 measured in 2004-05 prices. The data used in this study are real agricultural state GDP data measured in millions of Indian Rupees. The data are obtained from *Central Statistical Organisation (CSO)*, Government of India. Data on rainfall are sourced from Indian Institute for Tropical Meteorology, Government of India.

Table 3: Descriptive statistics for agricultural gross domestic product

Agricultural GDP	**Mean**	**Median**	**Standard Deviation**	**Minimum**	**Maximum**
Bihar	68,116	61,679	21,693	35,700	143,594
Punjab	74,971	52,303	61,407	21,713	253,466
Uttar Pradesh	235,501	213,822	170,415	178,188	615,737
West Bengal	110,404	68,494	103,481	48,540	386,464

Source: Central Statistical Organization (CSO).

Note: Figures are in Indian Rupees Million at 1993-94 prices.

Results

To undertake data decomposition first we check for data stationarity using the Augmented Dickey-Fuller (ADF) test, and find evidence of non-stationarity. Specifically, we estimated the regression model as:

$$\Delta y_t = \beta_0 + \beta_1 y_{t-1} + \sum_{j=1}^{n} \alpha_j \Delta y_{t-j} + \varepsilon_t \ ,$$

where: y_t is the logarithm of the agricultural GDP series for each state, and β_1 is the ADF parameter. To determine appropriate specification for the number of lagged GDP terms, we use the standard lag-length diagnostic tests such as the AIC and Schwarz Criterion. The most parsimonious specification is obtained choosing a lag-length of *n* = 3. The partial *t*-statistics on second and third-order lagged output are not statistically significant (*P*-value>0.10). Loss functions, such as AIC and Schwarz Criterion, are roughly minimised in the neighbourhood of *n* = 3. Given the MacKinnon's (1996) critical values of 2.61, we fail to reject the null hypothesis of a unit root at the five per cent level of significance.

Table 4: Augmented Dicker-Fuller (ADF) test results

Statistic / Diagnostic	$y_t^{\,b}$	$y_t^{\,p}$	$y_t^{\,up}$	$y_t^{\,wb}$
ADF Test [a]	1.56	2.45	0.62	1.78
AIC	21.41	21.08	25.34	22.96
Schwarz Criterian	21.43	21.43	25.42	23.17
Durbin Watson	2.12	2.17	2.14	2.12

Note: $y_t^{\,b}$, $y_t^{\,p}$ $y_t^{\,up}$ and $y_t^{\,wb}$ represent the natural logarithm of Agricultural GDP for the States of Bihar, Punjab, Uttar Pradesh and West Bengal.

[a] In absolute value and compared to the MacKinnon (1991) critical value of 2.61 for a 10 per cent level of significance.

Taking first difference of the data, we reject the null hypothesis of a unit root at the one per cent level of significance. The results in Table 4 show that for all the four states, data exhibit unit root, suggesting that these variables are not mean reverting but are I(1) processes. Hence, the agricultural GDP data are non-stationary. To make the data stationary, we take the first difference of the data. For our sample, we examine the autocorrelation and the partial autocorrelation function of the first difference of the log of agricultural output (y_t). They are identified, and estimated as an ARIMA process. The Beveridge-Nelson decomposition is then applied to compute the trend and the cyclical components of y_t. The results of the estimated model for each of the four states are given in Box 3.[9]

Box 3: Cyclical and permanent components of agricultural output

Bihar

Identification: $\Delta y_t = \underset{(0.0087)}{0.0077} - \underset{(0.129)}{0.632}\,\Delta y_{t-1} - \underset{(0.00003)}{0.0797}\,\varepsilon_{t-1} - \underset{(0.086)}{0.792}\,\varepsilon_{t-12} + \varepsilon_t$

Solution:

$$y_t = y_0 + 0.0047 \cdot t + 0.0785\sum_{r=1}^{t}\varepsilon_r + 0.049 \cdot \varepsilon_t + 0.486 \cdot \left(\varepsilon_t + \varepsilon_{t-1} + \varepsilon_{t-2} + \cdots\cdots + \varepsilon_{t-11}\right)$$

Punjab

Identification: $\Delta y_t = \underset{(0.0073)}{0.039} - \underset{(0.107)}{0.679}\,\Delta y_{t-5} - \underset{(0.057)}{0.869}\,\varepsilon_{t-5} + \varepsilon_t$

Solution: $y_t = y_0 + 0.023 \cdot t + 1.113\sum_{r=1}^{t}\varepsilon_r - 0.518 \cdot \left(\varepsilon_t + \varepsilon_{t-1} + \varepsilon_{t-2} + \varepsilon_{t-3}\right)$

Uttar Pradesh

Identification: $\Delta y_t = \underset{(0.0012)}{0.028} + \underset{(0.029)}{0.0448}\,\Delta y_{t-1} - \underset{(0.0391)}{0.0597}\,\Delta y_{t-1} - \underset{(0.025)}{0.96}\,\varepsilon_{t-1} + \varepsilon_t$

Solution: $y_t = y_0 + 0.027 \cdot t + 0.0393\sum_{r=1}^{t}\varepsilon_r + 0.946 \cdot \varepsilon_t$

West Bengal

Identification: $\Delta y_t = \underset{(0.0092)}{0.0388} - \underset{(0.0408)}{0.934}\,\varepsilon_{t-15} + \varepsilon_t$

Solution $y_t = y_0 + 0.0388 \cdot t + 0.066\sum_{r=1}^{t}\varepsilon_r + 0.934 \cdot \left(\varepsilon_t + \varepsilon_{t-1} + \varepsilon_{t-2} + \cdots\cdots + \varepsilon_{t-14}\right)$

Source: Author's Estimations *Note:* Standard errors are in parenthesis.

[9] Estimation was performed using the econometric software package Eviews 7.

The permanent and temporary components can now be easily calculated using the solution to the difference equations given in Box 2. For example, in the case of West Bengal the permanent component of GDP is given as $y_0 + 0.0388 \times t + 0.066 \sum_{r=1}^{t} \varepsilon_r$. "$y_0$" is the log value of West Bengal's agricultural GDP for the fiscal 1960-61, and $t = 1 \cdots 49$. The permanent component of the log output for West Bengal for the year 1960-61 is given as $y^{wb}_{1960/61} + .0388 \times 1 + 0.066\varepsilon_{1960/61}$. Similarly, the permanent component of the log output for West Bengal for the year 1961-62 is given as $y^{wb}_{1960/61} + .0388 \times 2 + 0.066(\varepsilon_{1960/61} + \varepsilon_{1961/62})$. Repeating for each point in the data sets for West Bengal, starting from 1960-61 and ending 2009-10, will yield the trend component. We follow the same rule in calculating the trend components of GDP for other states. In case of Uttar Pradesh and Bihar, involving an *AR (1)* process, we lose two initial observations (one was due to differencing the data and the other was related to the *AR(1)* process). Likewise, in the case of Punjab, 6 initial observations are lost.

Once we estimated the trend component we can easily calculate the cyclical component by subtracting the trend component from the actual data sets. Given that the GDP series for each state is expressed as natural log units, the trend and cyclical components of GDP are also in natural log format.

In the final step, we test for association between the cyclical component of agricultural GDP and rainfall. Agricultural output will increase in the event of normal rainfall, and will fall in the event of sub-optimal rainfall. This is particularly true if there is lack of physical infrastructure – making rainfall the sole driver for agricultural growth.

For estimation, we use Ordinary Least Square (OLS). The dependent variable is the cyclical component of state agricultural GDP, and the independent variable is rainfall. As heavy rainfall

(flood) without proper irrigation facilities may harm crop production (some crops cannot withstand water stagnation) we take into consideration rainfall square as an additional explanatory variable. We estimate:

$$y_j^{tt} = \beta_0 + \beta_1 r_{j\text{-}1}^{t} + \beta_2 r_{j\text{-}1}^{2t} + e_j^t$$

where, y_j^{tt} represents the cyclical component of the agriculture GDP for the state *j* (*j* = Bihar, Punjab, Uttar Pradesh and West Bengal) at time period *t*. For the crops grown in these states, harvest time typically happens during February-March of every year. Therefore, we have taken the lag value for rainfall. That is, the effect of last fiscal year rainfall is expected to have an impact on the current year's harvest. All the variables are expressed in log form. The results are as follows:

Table 5: Effects of rainfall on the cyclical component of agriculture

Cyclical Component	Constant	Independent Variables	
y_j^{tt}	β_0	β_1 (Rainfall)	β_2 (Heavy Rainfall)
Bihar	6.689	0.216*	**0.322*** **
Model diagnostics	(4.173)	(0.078)	**(0.169)**
Adj. R^2 = 0.566			
Punjab	8.556*	0.4112	**0.788**
Model diagnostics	(1.221)	(0.328)	**(0.455)**
Adj. R^2 = 0.163			
Uttar Pradesh	0.566	0.1002*	**-0.0741****
Model diagnostics	(0.226)	(0.033)	**(0.0382)**
Adj. R^2 = 0.623			
West Bengal	**3.822*****	**0.1855***	**0.652**
Model diagnostics	**(1.722)**	**(0.097)**	**(0.462)**
Adj. R^2 = 0.486			

Notes: * Indicates significance at 1per cent level; ** Indicates significance at 5per cent level; *** Indicates significance at 10per cent level. Standard errors are in parenthesis.

From the results, we find evidence about rainfall affecting the cyclical component of agricultural GDP. The results are particularly robust for the states of Bihar, Uttar Pradesh, and West Bengal (significant β_1 s). Interestingly, excessive rainfall has not affected agricultural output in Bihar (significant positive β_2). The case is opposite for Uttar Pradesh, where excessive rainfall has affected crop output (significant negative β_2). Bihar has a higher proportion of agricultural land (4.29 per cent) under coarse cereals in comparison to that of Uttar Pradesh (1.77 per cent). Coarse cereals such as sorghum, pearl millet and silver millet can withstand extreme weather conditions, and are unlikely to get affected by excessive rainfall and drought.

As the model is in log format, the results indicate that for a hundred per cent increase in rainfall the cyclical component of agricultural output has risen by 24 per cent for Bihar, 10 per cent for Uttar Pradesh, and 20 per cent for West Bengal. However, we did not get any statistically significant results for the State of Punjab. One possible reason is that Punjab has relatively developed agricultural infrastructure in comparison to the other three states. Out of total agricultural land of Punjab, around 99 per cent is irrigated through canals or tube wells.[10]This also partly explain why farmers from Punjab are able to grow a lot more non-cereal types crops such as fruits and Zucchini, and also are economically better-off in comparison to its peers. For the other states, Bihar, Uttar Pradesh and West Bengal(with relatively poor irrigation coverage)rainfall seems to be the predominant driver for growth in agricultural output. For example, considering net irrigation area as a percentage of net sown area, we find 85 per cent of the land is irrigated in Punjab, the corresponding figures for Bihar, Uttar Pradesh and West

[10] http://www.punjabdata.com/agriculture-in-punjab.aspx.

Bengal are 48 per cent, 72 per cent, and 43 per cent, respectively (Government of India, 2016).[11]

To check the robustness of our results we did a counterfactual experiment by surveying market managers employed with the wholesale food and vegetable association in Chennai. The survey reveals that in the event of poor harvest and bad rainfall the number of trucks bringing vegetables to the Chennai city wholesale market from neighboring Kerala and Karnataka fall drastically. There is a high correlation between the bad harvest/poor rainfall year and the number of trucks bringing produce to the wholesale market. In fact there are instances of hoarding by big retailers and middlemen during bad harvest years.

[11] Data available at: http://wrmin.nic.in/writereaddata/WatertheResource/statewiseirrigated2079753822.pdf. Accessed on 28/08/2016.

4. Conclusion

This paper's findings suggest a number of policy implications to improve the incomes of smallholder and subsistence farmers, and thereby reduce suicides. First is to rise above party-politics and ensure reforming the APMC Act. This will ensure farmers realize market prices for their outputs.

Second is timely procurement through MSP. Lack of storage, adequate refrigeration and sanitation facilities degrade quality of perishable items, compounding the farmer loss. Growing horticulture crops always yield better returns in terms of income (almost four times more than the food grains), but also require better agricultural infrastructure such as cold storage facilities, better access to credits, etc., factors which are generally not forthcoming.

Third is requirement of training, education, and urbanization. This will facilitate employment opportunities for the 70 per cent of Indians who are still dependent on the agriculture sector, by providing them smooth transition to other sectors such as manufacturing and services. Most of the services and manufacturing related jobs are concentrated in the urban areas. Urbanization is just over 30 per cent in India, in comparison to around 60 per cent for China. Rural people are averse to the ideas of abandoning informal rural safety nets which many a times are based on *caste* related factor.

Fourth, instead of spending on subsidies, investment in rural infrastructure, such as electrification and building canals, will help to mitigate losses due to crop failures. Electrification will help setting up rural based small-scale industry, and canals will reduce dependence on the capricious weather. As our study indicates, fluctuation of agricultural GDP in three major states in India is due to supply-side shocks rather than demand-side factors. For the State of Punjab

we did not find any statistically significant relation between the cyclical component of agricultural output and rainfall. The State government of Punjab has not only initiated reforms in the APMC Act but has also invested heavily in modern storage and transport facilities.

Finally, a better coordination between farmers and KrishiVigyan Kendra (agriculture research institutes set up by Government of India) for proper dissemination of research and rainfall related information. In fact, during January 2016, the Government of India launched Fasal Bima Yojana(Prime Minister Crop Insurance Scheme) with the government paying for bulk of the insurance cover against crops loss on account of natural calamity.[12]So far as welfare of farmers are concerned targeted government interventions such as the crop insurance scheme is expected to yield better results.

[12] Under this scheme, farmers will have to pay a uniform premium of 2 per cent for *kharif*crops (sown during June-July), 1.5 per cent for *rabi* crops (sown during November-December), and 5 per cent for horticulture crops. The remaining share of the premium will be borne equally by the Centre and the respective State governments.

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