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Input subsidies, public investments and agricultural productivity in India

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Abstract

The fund allocation in agricultural sector in India is heavily tilted toward input subsidies provision; however, researchers seem to favor investment expenditure instead. The present paper seeks to compare the usefulness of input subsidies as compared to investment with regard to agricultural productivity so that policy makers hit the right tool and avoid less productive state expenditure. We investigated a total of four regression models using autoregressive and distributed lag cointegration in a time series framework covering period from 1983 to 2019. The first model considers all input subsidies in aggregate form, and the rest three models take input subsidies in disaggregate forms, namely fertilizer subsidy, irrigation subsidy and power subsidy, respectively. It is observed from the results that input subsidies still contribute more than what public investment does to agricultural productivity. It is also found that power subsidy is the most effective component of input subsidies followed by fertilizer subsidy. Hence, government expenditure on input subsidies is justified on the ground that it ensures all farmers to have access to affordable agricultural inputs. Targeted subsidies combined with adequate investment in agricultural infrastructure could deliver long-term agricultural development in India.

Keywords Input subsidies, Investments, Agriculture, ARDL, India

JEL Classification Q140, Q180

Introduction

In the early sixties, India faced severe back-to-back droughts leading to acute shortages of food grains in the country [23]. At that point in time, significant structural bottlenecks in the agricultural system were identified. Policymakers acknowledge the fact that even the PL480[1] program could only provide a short-term solution, which necessitated a long-term agricultural development plan so that the country can be made self-sufficient as far as supply side of food security is concerned. For this, the productivity growth of agriculture was the primary requirement. Consequently, Jha committee in the year 1964 recommended the adoption of an integrated approach to agricultural development called the "Green Revolution" as a long-term solution to food security, which was thought to be achieved through using imported HYV seeds, applying chemical fertilizers, and timely and adequate irrigation to the farm lands. This comprehensive approach was supposed to augment farm productivity and make a significant dent in the crisis facing the sector. It was reported that at market rates, India's marginal and small farmers, who make up more than three-fourths of all farmers, were unable to utilize the optimal quantity of essential inputs like water and fertilizer [12, 25]. Therefore, provisions were made

[1] In 1954, India imported substantial food grains from the USA under the program known as PL-480. The intuition of this US-led program was that importing countries, notably lower-income countries facing food shortages, could make payments in domestic currencies.

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for fertilizer, irrigation, and power subsidies to increase those inputs' consumption beyond the suboptimal level. The economic rationale for providing input subsidies was manifold, stimulating agriculture's growth rate, inducing private investment, protecting farmers' incomes, and eventually ensuring food security [9, 12]. Thus, a massive amount of expenditure on subsidy provision has been made since then by the government of India, which still keeps on rising extensively [1, 2, 5].

Input subsidies such as fertilizers, power, and irrigation subsidies are made to increase agricultural productivity by reducing production costs and increasing yields. The impact of input subsidies on agricultural productivity in India has been a topic of debate among researchers. On the one hand, some studies have found that input subsidies have a positive effect on productivity [3, 8, 21]. Besides input subsidies, farm investments are also a key policy instrument that the government uses to promote agricultural development in India. Input subsidies involve providing farmers with subsidized inputs such as seeds, fertilizers, and pesticides, while public farm investments involve investing in public goods such as irrigation infrastructure, research and development, and extension services. For instance, a study by Birthal et al. [6] found that irrigation investments had a positive impact on crop yields in India. Similarly, a study by Gulati and Bathla [10], Bathla [4] and Bathla [5] found that investment in agricultural research and development had a positive impact on agricultural productivity. However, a study by Fan et al. [8] found that irrigation investments had a limited impact on agricultural productivity in India due to poor maintenance and management of irrigation systems. In order to look at the resource allocation criteria, policy makers need to know which component of public expenditure is more effective, is it subsidies or investment? Recent studies suggest that public farm investments have a more significant impact on agricultural productivity than input subsidies. For example, Gulati and Sharma [11], Akber et al. [3] and Zafar and Tarique [27] find investment to be far more effective for overall agricultural development in case of India.

The objective of this research paper is to examine the effect of input subsidies and public farm investments on agricultural productivity in India. This study is motivated by the following reasons. First, we aim to investigate whether increasing public farm investments would be a better strategy for promoting agricultural productivity than increasing input subsidies. By providing insights into the trade-off between input subsidies and public farm investments with regard to agricultural productivity in India, this research paper aims to contribute to the ongoing debate on the most effective policies for promoting agricultural development. Second, this study also looks at which component of input subsidies (for example, fertilizer subsidy, irrigation subsidy and power subsidy) is contributing more to productivity growth of agriculture so that policy makers hit the right tool. Third, the present study considers lags in the model in autoregressive distributed lag (ARDL)[2] framework. The advantage of using ARDL method is that it does not necessitate the selection of same lags for all the variables; rather, different lag lengths may be chosen for different variables. Additionally, it yields both short-run and long-run effect in a single equation framework. The findings of this study will be of interest to policymakers, development agencies and researchers working in the field of agricultural development in India.

The paper is organized into six sections. The second section presents a conceptual framework of the relationship investigated in this study. The third section critically analyzes the trend of input subsidies vis-a-vis public farm investment. The fourth section explains in detail about data and methodology. The fifth section outlines research outcome and discussions. The final section provides a brief summary along with appropriate policy suggestions.

Conceptual framework

It is reasonable to explain the linkages between public expenditure (disaggregated into input subsidies and investment) and productivity growth in Indian agriculture. Agricultural input subsidies have been a major policy tool for promoting agricultural productivity in India. The subsidies are aimed at reducing the cost of inputs such as fertilizers, irrigation and power, which are critical for productivity growth. Fertilizers are essential for increasing agricultural productivity by providing nutrients to the soil, which improves the yield of crops. However, fertilizers can be expensive, especially for small farmers. The government of India provides a subsidy on fertilizers to make them more affordable for farmers. This subsidy reduces the cost of fertilizers for farmers, enabling them to use more fertilizer on their crops. This increased use of fertilizers can lead to higher crop yields and increased productivity in agriculture. Similarly, irrigation is crucial especially in areas with low rainfall. This subsidy encourages farmers to invest in irrigation, which can increase crop yields and productivity. Irrigation subsidies can also improve the quality of crops and reduce the risk of crop failure due to drought. And, power subsidy also aims at making provision of water for irrigation purpose. Availing electricity supplies at market price is

[2] For additional details regarding the application of ARDL model in the context of agriculture, refer to Ikpesu and Okpe [15], Samal et al. [22] and Oyelami et al. [19]

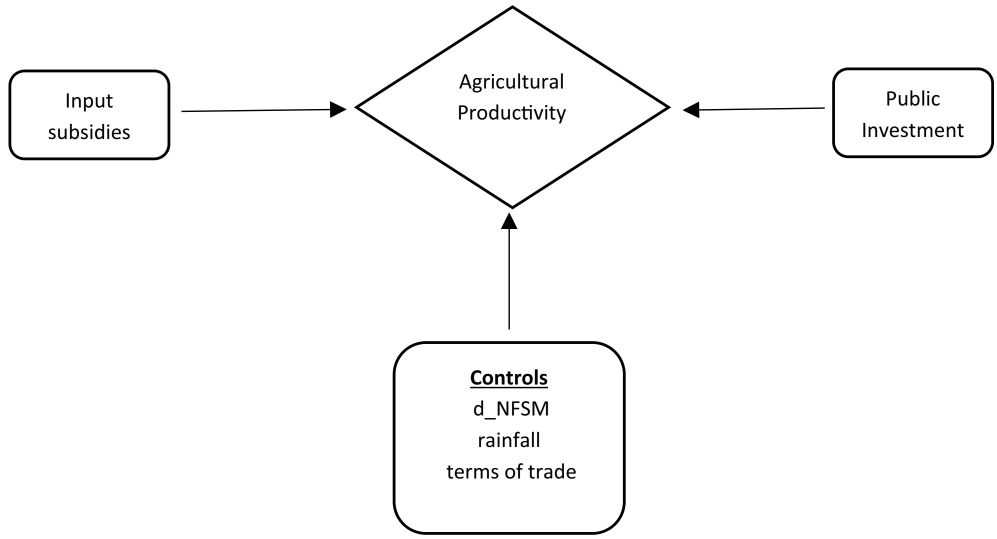

Fig. 1 Conceptual model. *Source*: Author(s)

not affordable to the majority of farmers, and hence, government of India provides subsidies on power to make it affordable. This subsidy helps farmers to reduce their electricity bills, which can be a significant expense for small farmers. The availability of affordable electricity can increase agricultural productivity by enabling farmers to provide sufficient water to the field as and when required. In conclusion, fertilizer subsidy, irrigation subsidy and power subsidy are important policies that can contribute to productivity growth in agriculture in India. These subsidies can reduce the cost of inputs, encourage investment in irrigation and enable farmers to use modern agricultural technology, all of which can increase crop yields and productivity.

On the other hand, public farm investments in India have played a significant role in promoting agricultural productivity growth. These investments have been directed toward various areas such as irrigation, research and development, extension services, rural infrastructure and credit availability. Irrigation investments have been particularly important as they have increased the availability of water, which is essential for crop production. Additionally, investments in research and development have led to the development of new crop varieties and technologies that are more resistant to pests and diseases, have higher yields and are more efficient in their use of water and other inputs. Investments in rural infrastructure such as roads, markets and storage facilities have also improved the marketing and distribution of agricultural products, increasing access to markets and reducing post-harvest losses. Moreover, public investments in credit availability have increased access to credit for small and marginal farmers, who otherwise face difficulties in obtaining credit from formal sources, enabling them to invest in agricultural inputs and technologies.

Overall, public farm investments have contributed significantly to productivity growth in Indian agriculture by improving the availability of critical inputs, increasing access to markets and credit and promoting the development of new technologies. However, the effectiveness of these investments can be limited by factors such as poor implementation, inadequate maintenance and weak institutional capacity. Therefore, it is crucial to ensure that public farm investments are well-targeted, adequately financed and supported by robust institutional and policy frameworks to maximize their impact on agricultural productivity growth in India. The conceptual model investigated in this paper is explained through Fig. 1.

Trends of input subsidies and public investment in India

The amount allotted for input subsidies was more than triple that in the early 1980s, averaging 738 billion in the 2000s. In 2013–14, electricity and fertilizer subsidies accounted for about 80 percent of the entire sum allotted for input subsidies, while irrigation made for just 13 percent of the total [5]. Due to a rise in the electricity price and a shift in government priorities, input subsidies dramatically decreased in the middle of the 2000s; however, they quickly regained, mainly in reaction to the food crisis of 2007–2008. According to Gulati and Narayanan [12], input subsidies alone accounted for 2.1 percent of India's total GDP and 8.8 percent of its agricultural GDP between 1980 and 1995. During the last three and a half decades, the rise of subsidies at constant prices has been enormous. At 2011–12 prices, the sum

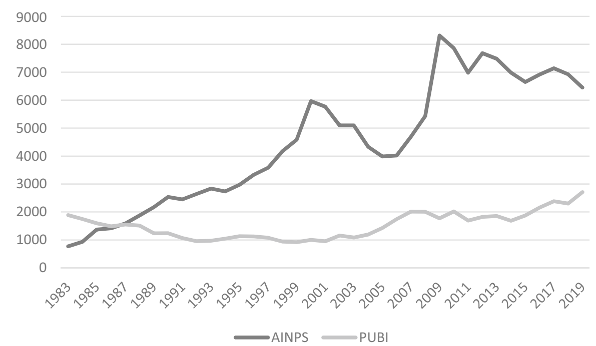

Fig. 2 Trend of per hectare input subsidies and public investment at 2011–12 prices. *Source*: Author(s)

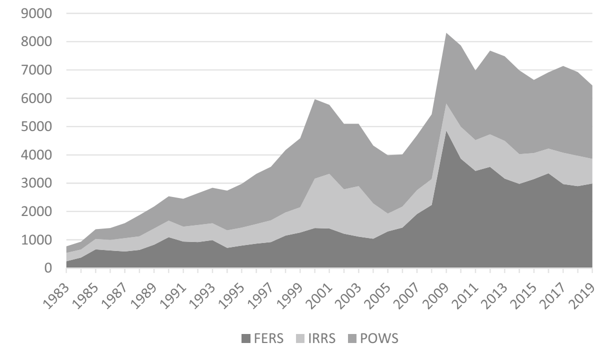

Fig. 3 Trend and composition of per hectare disaggregate input subsidies. *Source*: Author(s)

of three key input subsidies (fertilizer, electricity and irrigation) increased from 492 billion in 1991–92 to 1513.21 billion in 2018–19, an increase of more than thrice. During the same time span, public investment increased from 198 billion in 1991–92 to 460 billion in 2018–19. Consequently, input subsidies have expanded far faster than public agricultural investment. They were approximately identical in size in 1981–1982 [12], but the difference rapidly widened over time, owing in part to a stall in public investment throughout the 1990s and a deterioration in the marginal efficiency of irrigation investment.[3] So, it remained lower than subsidies from 1994 onwards though the gap was not initially wider till 2005. But after 2005, the gap between the two became explosive. It is observed that in the year 1983 per hectare aggregate input subsidies were 769 crores and the figure for public investments during the same time were around 1887 crores, more than double. But the trend reverses, and we see from Fig. 2a that since 1987 input subsidies started rising and leave public investment far behind and the gap continue to widen. In 2019, aggregate expenditure on input subsidies on per hectare basis is roughly around 6453 crores (approximate figure includes extrapolation) while public farm investment are just 2711 crores, less than half of the expenditure on subsidies. Figure 3 shows the trend of disaggregate input subsidies in the form of fertilizer subsidy, irrigation subsidy and power subsidy over the time period 1983 to 2019.

Researchers believe that increasing subsidies comes at the expense of squeezing out investment as the cause for decreased investment. Gulati and Narayanan [12] argue, “the burgeoning subsidies compete for scarce resources and impinge upon governments’ ability to invest in key areas. Increasing subsidies, in short, crowd out public investment”. Crowding out of public investment is apparent in irrigation projects, where numerous major and medium irrigation projects have been postponed owing to a lack of sufficient money. Therefore, expanding public investment in agriculture is crucial due to the significance of agricultural growth and the potential for public–private complementarity.

[3] The fall in public investment in irrigation was linked to a number of external factors, including rising irrigation expenses, the influence of the environmentalist movement and the federal nature of the Indian state, which led to inter-state river conflicts [4, 17, 24]. It might also be attributed to a sharp decline in total capital investment, with agriculture and irrigation bearing the brunt of the decline.

Data and methodology

Model specification and estimation

For empirical analysis, we develop the following four models in natural logarithmic form.

$$\begin{aligned} \mathrm{LAGRY}_t = & \alpha_0 + \alpha_1 \mathrm{LAINPS}_t + \alpha_2 \mathrm{LPUBI}_t + \alpha_3 \mathrm{LRAIN}_t \\ & + \alpha_4 \mathrm{LToT}_t + \alpha_5 \mathrm{d\_NFSM}_t + e_t \end{aligned} \tag{1}$$

$$\begin{aligned} \mathrm{LAGRY}_t = & \beta_0 + \beta_1 \mathrm{LFERS}_t + \beta_2 \mathrm{LPUBI}_t + \beta_3 \mathrm{LRAIN}_t \\ & + \beta_4 \mathrm{LToT}_t + \beta_5 \mathrm{d\_NFSM}_t + e_t \end{aligned} \tag{2}$$

$$\begin{aligned} \mathrm{LAGRY}_t = & \Upsilon_0 + \Upsilon_1 \mathrm{LIRRS}_t + \Upsilon_2 \mathrm{LPUBI}_t + \Upsilon_3 \mathrm{LRAIN}_t \\ & + \Upsilon_4 \mathrm{LToT}_t + \Upsilon_5 \mathrm{d\_NFSM}_t + e_t \end{aligned} \tag{3}$$

$$\begin{aligned} \mathrm{LAGRY}_t = & \theta_0 + \theta_1 \mathrm{LPOWS}_t + \theta_2 \mathrm{LPUBI}_t + \theta_3 \mathrm{LRAIN}_t \\ & + \theta_4 \mathrm{LToT}_t + \theta_5 \mathrm{d\_NFSM}_t + e_t \end{aligned} \tag{4}$$

All the variables are notified as: AGRY for agricultural productivity, AINPS for aggregate input subsidies, FERS for fertilizer subsidy, IRRS for irrigation subsidy, POWS for power subsidy, PUBI for public farm investment, RAIN for annual rainfall, TOT for index of terms of trade and d_NFSM for dummy for national food security mission. All the variables are expressed as per hectare except terms of trade. These are transformed into natural log so that relativeness effectiveness of the variables can be compared. The intuition behind selecting four separate models is to look at the effects of input subsidies in aggregate as well as in disaggregate forms. All the disaggregate input subsides such as fertilizer subsidy, irrigation subsidy and power subsidy are included in three separate equations as Eqs. (2), (3) and (4), respectively, because these are highly correlated and combining them in one equation will create multicollinearity issue.

All the variables are first tested for stationarity so that appropriate time series model can be applied. On investigation, we found that variables are having different order of integration (see Table 2). Following this, we used autoregressive distributed lag (ARDL) approach developed by Pesaran et al. [20] to estimate the specified models. Comparing the ARDL technique to other conventional cointegrating approaches reveals a number of benefits. First, if the series are integrated at $I(0)$, $I(1)$, or a mixed of both, it can measure the correct parameters. The ARDL approach may also concurrently estimate the long-run and short-run parameters.

We write our Eqs. (1), (2), (3) and (4) into ARDL framework referred to as unrestricted error correction models (UECM) as follows:

$$\begin{aligned}\Delta \mathrm{LAGRY}_t = {} & \alpha_0 + \sum_{i=0}^{p} \alpha_{1i} \Delta \mathrm{LAGRY}_{t-i} + \sum_{i=0}^{p} \alpha_{2i} \Delta \mathrm{LAINPS}_{t-i} + \sum_{i=0}^{p} \alpha_{3i} \Delta \mathrm{LPUBI}_{t-i} \\ & + \sum_{i=0}^{p} \alpha_{4i} \Delta \mathrm{LRAIN}_{t-i} + \sum_{i=0}^{p} \alpha_{5i} \Delta \mathrm{LToT}_{t-i} + \sum_{i=0}^{p} \alpha_{6i} \Delta \mathrm{d\_NFSM}_{t-i} \\ & + \theta_1 \mathrm{LAGRY}_{t-1} + \theta_2 \mathrm{LAINP}_{t-1} + \theta_3 \mathrm{LPUBI}_{t-1} + \theta_4 \mathrm{LRAIN}_{t-1} \\ & + \theta_5 \mathrm{LToT}_{t-1} + \theta_6 \mathrm{d\_NFSM}_{t-1} + \mu_{1t}\end{aligned} \tag{1a}$$

$$\begin{aligned}\Delta \mathrm{LAGRY}_t = {} & \psi_0 + \sum_{i=0}^{p} \psi_{1i} \Delta \mathrm{LAGRY}_{t-i} + \sum_{i=0}^{p} \psi_{2i} \Delta \mathrm{LFERS}_{t-i} + \sum_{i=0}^{p} \psi_{3i} \Delta \mathrm{LPUBIt}_{t-i} \\ & + \sum_{i=0}^{p} \psi_{4i} \Delta \mathrm{LRAIN}_{t-i} + \sum_{i=0}^{p} \psi_{5i} \Delta \mathrm{LToT}_{t-i} + \sum_{i=0}^{p} \psi_{6i} \Delta \mathrm{d\_NFSM}_{t-i} \\ & + \lambda_1 \mathrm{LAGRY}_{t-1} + \lambda_2 \mathrm{LFERS}_{t-1} + \lambda_3 \mathrm{LPUBI}_{t-1} + \lambda_4 \mathrm{LRAIN}_{t-1} \\ & + \lambda_5 \mathrm{LToT}_{t-1} + \lambda_6 \mathrm{d\_NFSM}_{t-1} + \mu_{2t}\end{aligned} \tag{2a}$$

$$\begin{aligned}\Delta \mathrm{LAGRY}_t = {} & \gamma_0 + \sum_{i=0}^{p} \gamma_{1i} \Delta \mathrm{LAGRY}_{t-i} + \sum_{i=0}^{p} \gamma_{2i} \Delta \mathrm{LIRRS}_{t-i} + \sum_{i=0}^{p} \gamma_{3i} \Delta \mathrm{LPUBI}_{t-i} \\ & + \sum_{i=0}^{p} \gamma_{4i} \Delta \mathrm{LRAIN}_{t-i} + \sum_{i=0}^{p} \gamma_{5i} \Delta \mathrm{LToT}_{t-i} + \sum_{i=0}^{p} \gamma_{6i} \Delta \mathrm{d\_NFSM}_{t-i} \\ & + ¥_1 \mathrm{LAGRY}_{t-1} + ¥_2 \mathrm{LIRRS}_{t-1} + ¥_3 \mathrm{LPUBI}_{t-1} \\ & + ¥_4 \mathrm{LRAIN}_{t-1} + ¥_5 \mathrm{LToT}_{t-1} + ¥_6 \mathrm{d\_NFSM}_{t-1} + \mu_{3t}\end{aligned} \tag{3a}$$

$$\begin{aligned}\Delta \mathrm{LAGRY}_t = {} & \mathrm{a}_0 + \sum_{i=0}^{p} \mathrm{a}_{1i} \Delta \mathrm{LAGRY}_{t-i} + \sum_{i=0}^{p} \mathrm{a}_{2i} \Delta \mathrm{LPOWS}_{t-i} + \sum_{i=0}^{p} \mathrm{a}_{3i} \Delta \mathrm{LPUBI}_{t-i} \\ & + \sum_{i=0}^{p} \mathrm{a}_{4i} \Delta \mathrm{LRAIN}_{t-i} + \sum_{i=0}^{p} \mathrm{a}_{5i} \Delta \mathrm{LToT}_{t-i} + \sum_{i=0}^{p} \mathrm{a}_{6i} \Delta \mathrm{d\_NFSM}_{t-i} \\ & + \sigma_1 \mathrm{LAGRY}_{t-1} + \sigma_2 \mathrm{LPOWS}_{t-1} + \sigma_3 \mathrm{LPUBI}_{t-1} + \sigma_4 \mathrm{LRAIN}_{t-1} \\ & + \sigma_5 \mathrm{LToT}_{t-1} + \sigma_6 \mathrm{d\_NFSM}_{t-1} + \mu_{4t}\end{aligned} \tag{4a}$$

Table 1 Descriptive statistics. *Source*: Author(s)

Statistics	AGRY	AINPS	FERS	IRRS	POWS	PUBI	RAIN	TOT
Mean	10.28	4480.52	1725.40	879.64	1875.47	1523.55	46.47	88.31
Median	10.38	4329.52	1214.35	844.17	2061.72	1512.45	46.56	84.20
Maxima	14.33	8314.32	4859.32	1930.30	3065.96	2711.25	61.71	109.62
Minima	6.24	769.84	241.15	283.75	231.95	920.60	36.56	74.28
Std. Dev	2.16	2230.11	1191.45	410.27	895.48	472.66	5.20	10.77
Skewness	0.12	0.03	0.86	0.85	− 0.46	0.49	0.48	0.77
Kurtosis	2.04	1.75	2.57	3.27	1.92	2.40	3.93	2.22
JB Stat	1.49	2.39	4.90	4.57	3.13	2.08	2.76	4.63
Prob	0.47	0.30	0.08	0.10	0.20	0.35	0.25	0.09

To test the joint significance of the lagged variables, F-test is commonly applied. However, in a bound testing procedure, Pesaran et al. [20] and Narayan [18] independently describe a unique set of critical values for a certain significance level. In each scenario, the lower and upper bounds are derived from the assumption that all variables are $I(0)$ and $I(1)$, respectively. If the calculated F-statistic exceeds the upper critical bound, the null hypothesis of non-cointegration is rejected. If the test is inconclusive because it falls within the limitations, the error correction term might be used to establish co integration.

The next stage is to compute the error correction model as follows after it has been shown that the variables have a long-term relationship:

$$\begin{aligned} \Delta \text{LAGRY}_t =& \alpha_0 + \sum_{i=0}^{p} \alpha_{1i} \Delta \text{LAGRY}_{t-i} + \sum_{i=0}^{p} \alpha_{2i} \Delta \text{LAINP}_{t-i} + \sum_{i=0}^{p} \alpha_{3i} \Delta \text{LPUBI}_{t-i} \\ &+ \sum_{i=0}^{p} \alpha_{4i} \Delta \text{LRAIN}_{t-i} + \sum_{i=0}^{p} \alpha_{5i} \Delta \text{LToT}_{t-i} + \sum_{i=0}^{p} \alpha_{6i} \Delta \text{d\_NFSM}_{t-i} \\ &+ \eta \text{ECT}_{-1} + \mu_{2t} \end{aligned} \tag{1b}$$

$$\begin{aligned} \Delta \text{LAGRY}_t =& \psi_0 + \sum_{i=0}^{p} \psi_{1i} \Delta \text{LAGRY}_{t-i} + \sum_{i=0}^{p} \psi_{2i} \Delta \text{LFERS}_{t-i} + \sum_{i=0}^{p} \psi_{3i} \Delta \text{LPUBI}_{t-i} \\ &+ \sum_{i=0}^{p} \psi_{4i} \Delta \text{LRAIN}_{t-i} + \sum_{i=0}^{p} \psi_{5i} \Delta \text{LToT}_{t-i} + \sum_{i=0}^{p} \psi_{6i} \Delta \text{d\_NFSM}_{t-i} \\ &+ \tau \text{ECT}_{-1} + \mu_{2t} \end{aligned} \tag{2b}$$

$$\begin{aligned} \Delta \text{LAGRY}_t =& \gamma_0 + \sum_{i=0}^{p} \gamma_{1i} \Delta \text{LAGRY}_{t-i} + \sum_{i=0}^{p} \gamma_{2i} \Delta \text{LIRRS}_{t-i} + \sum_{i=0}^{p} \gamma_{3i} \Delta \text{LPUBIt}_{t-i} \\ &+ \sum_{i=0}^{p} \gamma_{4i} \Delta \text{LRAIN}_{t-i} + \sum_{i=0}^{p} \gamma_{5i} \Delta \text{LToT}_{t-i} + \sum_{i=0}^{p} \gamma_{6i} \Delta \text{d\_NFSM}_{t-i} \\ &+ \varphi \text{ECT}_{-1} + \mu_{3t} \end{aligned} \tag{3b}$$

$$\begin{aligned}\Delta \text{LAGRY}_t = a_0 + \sum_{i=0}^{p} a_{1i} \Delta \text{LAGRY}_{t-i} + \sum_{i=0}^{p} a_{2i} \Delta \text{LPOWS}_{t-i} + \sum_{i=0}^{p} a_{3i} \Delta \text{LPUBIt}_{t-i} \\ + \sum_{i=0}^{p} a_{4i} \Delta \text{LRAIN}_{t-i} + \sum_{i=0}^{p} a_{5i} \Delta \text{LToT}_{t-i} + \sum_{i=0}^{p} a\gamma_{6i} \Delta \text{d\_NFSM}_{t-i} \\ + \omega \text{ECT}_{-1} + \mu_{4t}\end{aligned} \tag{4b}$$

where all the notations are as mentioned and the value of the coefficient of term ECT refers to the long-run equilibrium speed of adjustment following a short-term shock.

Data description

The analysis is based on annual time series data from 1983 to 2019. Selection of the time period is guided by the availability of data in the public domain. Data for agricultural productivity are calculated as sum total of all crop production which includes food crops and commercial crops divided by their respective area. Source of their data is Handbook of Statistics on the Indian economy. Data of aggregate input subsides are calculated as the sum of fertilizer subsidy, irrigation subsidy and power subsidy. Fertilizer subsidy is taken from Fertilizer Statistics of India. Irrigation and power subsidy is taken from Gulati and Narayanan [12] and Gulati and Banerjee [13] only up to year 2014–15 and the data for remaining years are extrapolated. Data for annual rainfall and TOT are taken from Indian Meteorological Database and Agricultural Statistics at a glance, respectively. Data for input subsidies are deflated using Wholesale Price Index at 2011–12 prices. We have performed the descriptive analysis of the data and look at the long-term trends so that initial clue about the nature of data can be observed. The descriptive statistics is presented in Table 1, and long-term trends are observed in Fig. 4. These statistics and graphs are based on actual data which do not undergo any logarithmic transformation. We find that some variables have relatively larger values even after expressing them in intensive form- per hectare. In such case it is suggestive to take natural logarithm of the variables which rescales the underlying data and make it easy for the purpose of comparison, interpretation and analysis.

Results and discussions

We start with the estimated results of unit root tests which is reported in Table 2. We have applied two tests of stationarity, namely augmented Dickey–Fuller tests developed by Dickey and Fuller [7] and Kwiatkowski et al. [16] in short known as KPSS test. The advantage of exposing the variables with two tests of unit root is to get robust outcome with regard to stationary of data series. Using both the tests (Table 2), we observe that no variables are integrated of order two and hence we proceed with the estimation of long-run and short-run results with ARDL approach.

The next step is to go for bound testing procedure. We have selected maximum of two lags using AIC criteria. The specified models as per Akaike Information Criteria are ARDL (1, 2, 0, 0, 2) for model 1, ARDL (2, 0, 2, 0, 2) for model 2, ARDL (2, 0, 0, 0, 2) for model 3 and ARDL (1, 1, 0, 0, 2) for model 4. By using the bounds test for all the four models, we get the following results reported in Table 3.

We found that the model 1 has the F statistic value equal to 6.04 which is greater than the higher critical bound that is 4.37 at 1% level of significance. It implies that the long-run relationship exists among the variable. Similarly, Model 2 and Model 4 generate F statistic value 3.58 and 8.2, respectively, which are greater than the upper critical bound confirming cointegration. Here in Model 3 the F statistic value is equal to 3.04 which is greater than the lower bound and smaller than the upper bound suggesting the inconclusive results about the cointegration. Now for confirming the cointegration, we make decision through error correction term in Table 4. We discover that the error correction term lies between 0 and 1, which is highly significant; this suggests that variables are cointegrated in the long run.

After confirming the long-run relationship among the variables, the next step is to calculate the long-run and short-run coefficients of the variables presented in Table 4. We find that in Model 1, PUBI, ToT and AINPS have positive impact on AGRY at 10%, 5% and 1% level of significance with coefficient value 0.11, 0.33 and 0.22, respectively. One percent increase in expenditure on input subsidies leads to 0.22 percent increase in agricultural productivity on an average. The same effect in case of public farm investment is 0.11. This reveals that input subsidy is more effective than investment in terms of productivity growth of agriculture. Hence subsidies still contribute more than what public investment does to agricultural productivity. This contradicts with the finding of Zafar and Tarique [27] who finds opposite evidence. This could be due to the fact that the present study investigates different sets of data (1983–2019). It also opposes several key findings in this context including those of Fan et al. [8], Gulati and Terway [14] and Bathla et al. [5]. This could be attributed to the underestimation of public investment data, as the data used in the analysis are provided by National Account Statistics which only captures investment made in irrigation projects and ignores all other crucial public expenditure such as research and development, extension services and rural

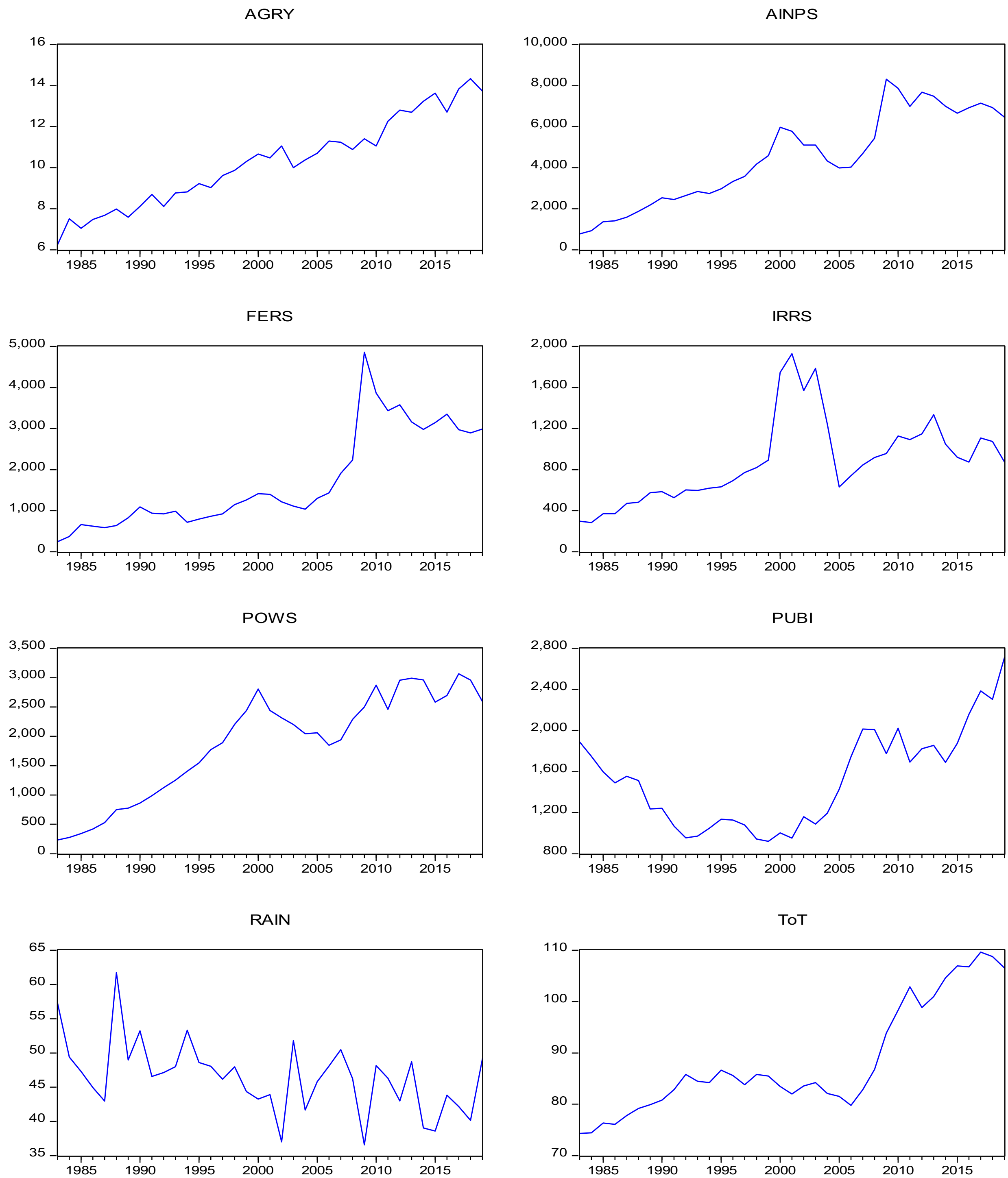

Fig. 4 Long-term trend of variables. *Source*: Author(s)

Table 2 Unit root tests

Variables	ADF		KPSS	
	Level	1st difference	Level	1st difference
LAGRY	−0.80	−11.22***	0.72	0.28***
LPUBI	−0.25	−5.04***	0.37	0.44***
LTOT	−0.37	−4.27***	0.64	0.11***
LAINPS	−3.44**	−4.31***	0.68	0.39***
LFERS	−2.37	−5.38***	0.69	0.19***
LIRRS	−2.22	−5.07***	0.57	0.17***
LPOWS	−4.93***	−3.7***	0.61	0.58***

For KPSS test, asymptotic critical values are taken from Kwiatkowski et al. ([16], Table 1). Andrews (automatic) bandwidth are selected for optimal number of bandwidths using Bartlett Kernel spectral estimation method. Some values are not reported so as to avoid redundancy

***, ** means rejection of null hypothesis at 1% and 5% level of significance respectively

infrastructure. Finally, RAIN has negative effect on AGRY at 5% level of significance with coefficient value 0.18. This could be attributed to the fluctuations and uncertainties associated with monsoon in India. This is consistent with the findings of Tandon and Aggarwal [26]. Therefore, it is suggestive that besides water subsidies, government also invests adequately in irrigation infrastructure which can serve agriculture sector in the long run and check over dependency on monsoon.

Table 3 Results of cointegration test

Models	F Statistics	Critical Bounds	Decision
Model 1	6.04	3.29–4.37***	Cointegration
Model 2	3.58	2.56–3.49**	Cointegration
Model 3	3.04	2.56–3.49**	Inconclusive
Model 4	8.2	3.29–4.37***	Cointegration

Critical bounds are taken from Narayanan [18] and reported at 1% (***) and 5% (**) level of significance

Models 2, 3 and 4 consider input subsidies in disaggregate form which yield impact of fertilizer subsidy, irrigation subsidy and power subsidy respectively on agricultural productivity in India. We observe that the coefficient of fertilizer subsidy, irrigation subsidy and power subsidy are 0.15, 0.06 and 0.18, respectively, where irrigation subsidy comes out to be insignificant. It could be due to the extrapolation technique used to get the data for last 6 years. Interestingly, power subsidy comes out to be the most productive subsides being provided to farmers in India followed by fertilizer subsidy. This advocates that more needs to be spend on power subsidies. This is also conceivable in Indian context where unavailability of water on time has always remain a severe problem because of over dependency on monsoon. Making provision of adequate and timely water facilities to the field is

Table 4 Long-run and short-run results

Variables	Model 1	Model 2	Model 3	Model 4
Long Run				
LPUBI	0.11 (0.06)*	−0.11(0.08)	−0.07(0.13)	0.17(0.05)***
LRAIN	−0.18(0.08)**	−0.30(0.15)*	−0.33(0.25)	−0.22(.07)***
LTOT	0.33(0.15)**	0.70(0.23)***	0.96(0.29)***	0.37(0.01)***
LAINPS	0.22(0.03)***	–	–	–
LFERS	–	0.15(0.05)**	–	–
LIRRS	–	–	0.06(0.08)	–
LPOWS	–	–	–	0.18(0.02)***
Short Run				
D(LAINPS(−1))	−0.10(0.05)*	–	–	–
D(LPUBI(−1))	–	0.14(0.08)*	–	–
D(LTOT(−1))	−0.73(0.27)**	−0.56(0.29)*	−0.52(0.28)*	−0.59(0.23)**
d_NFSM	0.02(0.009)**	0.03(0.01)**	0.06(0.01)***	0.02(0.002)**
ECT_{-1}	−.83(0.12)***	−.51(0.10)***	−.36(0.07)***	−.88(0.11)***
Diagnostic	***p* value**	***p* value**	***p* value**	***p* value**
JB statistic	0.48	0.46	0.42	0.59
BG LM tests	0.20	0.22	0.13	0.06
BPG test	0.53	0.95	0.94	0.36
RAMSEY	0.60	0.16	0.07	0.09

Figures in brackets are standard errors. *, ** and *** indicate rejection of the null hypothesis at the 10%, 5% and 1% significance levels, respectively

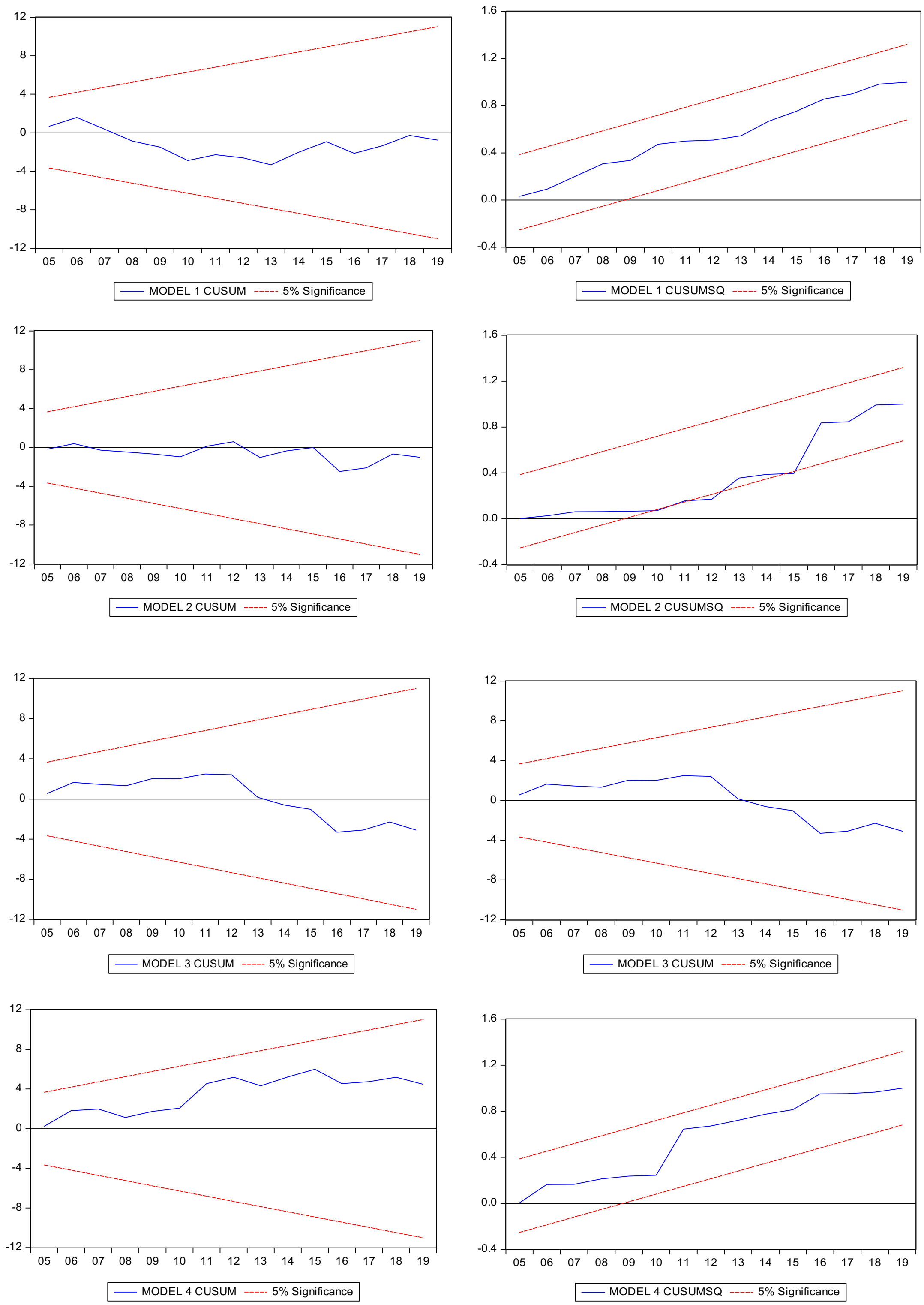

Fig. 5 Stability test. *Source*: Author(s)

something Indian agricultural fields is crying out over a long period of time.

Furthermore, we examine the short-term dynamics and error correction mechanism of the model in Table 4. In Models 1, 2, 3 and 4, the coefficient of the error correction term is extremely significant and equivalent to −0.83, −0.51, −0.36 and −0.88, indicating that about 83%, 51%, 36% and 88%, respectively, of any short-run disequilibrium is corrected within one year. Finally, the BG LM serial correlation test, BPG heteroscedasticity test, RAMSEY reset functional form test and JB normality test are also applied and presented in Table 4 for consistency and stability of the estimated models. Besides, stability tests using CUSUM and CUSUMSQ are performed (Fig. 5) and find that all the estimated parameters are stable over time.

Conclusion and policy suggestions

The present paper seeks to figure out the impact of input subsidies on agricultural development in case of India. It is also attempted to compare the effectiveness of input subsidies vis-a-vis investment with regard to agricultural productivity. The article also figures out which component of input subsidies is the most effective for productivity growth in case of India so that policy makers hit the right tool and avoid less productive state expenditure. We investigated a total of four regression models using autoregressive and distributed lag (ARDL) cointegration in a time series framework covering period from 1983 to 2019. The first model considers all input subsidies in aggregate form and compares its effectiveness with those of public investment. The rest three models take input subsidies in disaggregate forms, namely fertilizer subsidies, irrigation subsidies and power subsidies, respectively. In all the models we find the existence of cointegration which means that there exists long-run stable equilibrium relationship among the variables. It is observed that input subsidies still contribute more than what public investments do. It is also found that power subsidies is the most effective component of input subsidies as far as agricultural productivity is concerned followed by fertilizer subsidies.

This research finding will be of interest to policymakers, development agencies, farmers and researchers working in the field of agricultural development in India. Some crucial suggestions based on the findings are discussed here. First, government expenditure on input subsidies is justified to ensure that all farmers have access to affordable agricultural inputs such as fertilizers, seeds, water and pesticides. Second, focusing on targeted subsidies that benefits the smallholder farmers who are most in need of assistance. This can be achieved by developing a system to identify and register farmers and using data analytics to determine the appropriate level of support required for each farmer. Third, improvement in access to affordable credit so that farmers invest in agricultural inputs, equipment and technology. The government should work with financial institutions to develop financial products that are tailored to the needs of farmers, such as interest free loans to marginal farmers, flexible repayment schedules and crop insurance. Fourth, investing in extension services to provide farmers with the knowledge and skills required to adopt modern farming techniques and to access markets for their produce. This can be achieved by recruiting and training more extension officers, developing effective communication strategies and leveraging technology such as mobile phones and the internet to disseminate information. Fifth, investment in rural infrastructure such as roads, irrigation systems and storage facilities to improve access to markets, reduce post-harvest losses and increase the profitability of farming. Finally, government should encourage the adoption of sustainable farming practices that promote soil health, conserve water and protect the environment. This can be achieved by providing training and education to farmers, promoting the use of organic fertilizers and pesticides and investing in research and development of sustainable farming techniques. However, it is important that these subsidies are designed and implemented effectively and are complemented by other policies and programs that support sustainable and inclusive agricultural development.

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SZ collected the data, analyzed and interpreted the results of the study and wrote the paper. MA wrote methodology section, reported results and revised the manuscript. MT drafted the initial manuscript, formulated the problem and supervised the present research.

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