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# REVIEW ON METHODOLOGY FOR SUPPLY RESPONSES OF AGRICULTURAL CROPS

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## ABSTRACT

*Past studies revealed weak supply response for Indian agriculture. There are no recent reliable estimates to see if the response has been improved after the introduction of economic reforms introduced in early 90s in India. This study reviews methodology adopted by different scholars in the estimation of supply response for both food and non food crops. Supply response studies show some variations in the research conducted by different scientists in India and outside the countries. Many studies hypothesized that acreage response underestimates supply response and farmers respond to price incentives partly through intensive application of other inputs given the same area, which is reflected in enhanced yield. Theoretically, food crops reveal less response than non-food crops. It raises questions such as whether the constraints are properly identified by the policies or if the impact of reform is yet to be felt in order to make a prominent impact on response parameters. Therefore, the review will fill the gaps that have been yet addressed by the researchers in a study related to supply responses in agriculture and this will also help in improving the methodology and selection of reliable variables for study on supply responses.*

## INTRODUCTION

There are broadly two frameworks adopted by many researchers in the literature to conduct supply response analysis: (a) Nerlovian expectation model which facilitates the analysis of both the speed and level of adjustment of actual acreage towards desired acreage and (b) Supply function derived from the profit maximizing framework. The second approach involves joint estimation of output supply and input demand functions. This requires detailed information on all the input prices. Moreover the agricultural input markets are not functioning in a competitive environment in India, particularly land and labour markets. Market intervention in delivering material inputs to the farmers is a common practice. It is difficult to get information on price at which the inputs are supplied to the farmers.

The pioneering work of Nerlove (1958) on supply response enables to determine short run and long run elasticities; it is commonly used by many scientists due to flexibility in nature. Some of the important contributions on the methodology of panel data dynamic models are Nerlove (1971), Anderson and Hsiao (1981) Chamberlain (1984), Arellano and Bond (1991).Also,various studies attributed problems in measurement of variables and the methodologies used for estimation as reasons for highly varying elasticities even within a region. If we peruse the literature starting from Nerlovian (1958) model of supply response,

improvement in the specification was attempted by introducing competing crops concept where relative prices were introduced instead of absolute prices. The next stage of development was the introduction of risk and uncertainty in the model. Behrman (1968) introduced standard deviation of price and yield measured from previous three years' data. This was criticized for the fact that the Nerlovian price expectation model is not consistent with changing variance of the subjective probability distributions. Nowshirvani (1971) modeled farmers' land allocation decision that accounted for uncertainties in prices and yields. Incorporating risk, Nowshirvani has found that area-price response turned out to be negative, implying stabilization schemes may sometimes be more effective policy instrument than price in bringing about area shifts among crops. Many scholars use relative profitability rather than relative price, the reason being that it explains farmers' choice behavior in a better way. However profit calculation has its own measurement problem such as identifying proper imputation methods for own inputs and appropriate type of costs to compute profits and problems related to common costs. Moreover price is a direct policy instrument and hence the results are handy for policy purpose. During the last five decades, a large volume of literature on supply response indicated that the response is much weaker. Non-price factors seem to dominate over price factors in farmers' decision making.( Krishna, 1962; Narain, 1965; Askari and Cummings, 1976; Gulati and Kelly, 1999). Despite the introduction of reform process in early nineties in India, some of the constraints that Indian farmers are facing in responding to the market incentives are more than expectation. However, there is no firm evidence so far, which supports this hypothesis. Is it because the policies are still not able to identify and target the proper constraints or is it due to the nature of specification and methodology used in the literature? Or is it that the time lag of the response to liberalization is still longer so that the impacts are yet to be seen fully? Keeping this in the background, this paper will examine the literature from the viewpoint of (a) methodology and specification of model, (b) relevance issues. Following this, this paper attempts to study the supply response of major crops such as cereals, pulses, oilseed and commercial crops like fish. There are many arguments to support the notion that farmers in less developed countries do not respond to economic incentives like price and income. The numerous studies available for India at the crop level have more or less arrived at the same result that the supply response is less elastic. Reasons cited for poor response varied from factors to factors such as constraints on irrigation, infrastructure etc.

There are varying results of various degree of response. Two sets of explanation were offered to why the results vary and also what have been overlooked in the process. The first is the conceptual problems in identifying correct price and climate variables. The second set of problems arises in the formulation of empirical model. For instance, the specification of supply function, viz. lagged price of single lag or distributed lag, failure to recognize identification problem, improper choice of competing crops, failure to identify the correct set of non market factors etc and all these contribute to varying results. In short, it may be true that the farmers are responding to incentives subject to the constraints but the result has not been clearly documented by many researchers.The importance of non- price factors has drawn adequate attention in the literature like rainfall, irrigation, market access for both inputs and output and literacy. One of the reasons for a low response to prices in backward regions is the limited access to input and product markets or high transaction costs associated

with their use. Limited market access may be either due to absence of proper road links or the distances of markets from roads. However even those studies, which tried to incorporate some of these attributes could not gain much in terms of level of response. Many studies, which provided estimates for India, have mostly used time series aggregated data. This type of data set conceals variations across states and agro climatic regions. The state specific characteristics and its contribution for the varying supply response would provide better information for drawing inferences at the national level. Panel data have a distinct advantages for providing regional and temporal variations for dynamic models. Very few scholars have worked with panel data in supply response analysis.Ahn and Schmidt (1995), Arellano and Bond (1991), Surekha (2005) developed a non-linear autoregressive distributed lag models to study supply response for rice. He criticized the standard methods saying that most of the structural form parameters are either non linear functions or ratios of reduced form parameters and as a result the structural form parameters do not possess finite moments. As a method to overcome this problem, Surekha used an alternative estimation method based on Bayesian paradigm, which takes care of the problem stated above. Using the two stage Bayesian estimator, he found a large value for supply response as compared to the estimated derived from standard least square method. This seems to have explained the low supply response estimated by many empirical studies. Study by Kumar *et al.* (1997) is one of the few, which used pooled cross section- time series data across regions of India for pre reform period. Joint estimation of area, yield and input demand in recursive block system has been adopted by employing Zellner's SUR estimation technique. Expected revenue has been used as a price incentive indicator. The dynamic response has been estimated within a static framework by including lagged dependent variable. Gulati *et al.* (1999) analysed supply response using pooled data. They identified 23 crop zones in the Indian SAT. By utilizing cross-sectional district data covering the period 1970-71 to 1990-91, the estimates were derived zonewise for various crops. The study found that non-price factors mostly explain shift in cropping pattern. Brauw et al.(2003) studied both flexibility and supply responsiveness of Chinese farmers using pooled cross section, time-series data for the period 1975-1995. Supply responsiveness of Chinese farmers has been studied by introducing a new concept of degree of flexibility in the adjustment of quasi-fixed factors. They adopted simultaneous estimation of input demand and output supply following Gallant's (2011) method of non-linear three stage least square estimation simultaneously for two quasi fixed inputs and three outputs. Nahatkar et.al (2006) studied the issues concerning growth in area, production, productivity and supply responses of soyabean in different districts in Malwa plateau of Madhya Pradesh using time series data of 1990-91 to 2002-03 and observed that coefficient of lagged area under soyabean was positive and have high significant impact on current area under soybean in Indore, Ujjain, Dewas and Rajgarth districts.The dynamic value function specified by Epstein (2012) has been utilized by many scientists. They used dummy variable representing early reform period and late reform period. From the findings, it is confirmed that land and labour are less flexible for adjustment in the early reform period and the flexibility has significantly increased in the late reform period where market is fully liberalized. By introducing a period dummy-price interaction term, most study allowed the price response to change between early reform and late reforms periods.the result of the study revealed that farmers increased their speed of adjustment between early and late reforms periods. The practical example of study has been confirmed that gradual reform

process has worked to the advantage of Chinese agriculture. Gulati *et al* (1999) and Kumar *et al.* (1997) are the few which used pooled cross section- time series data across regions of India. There is a dearth of studies on supply response at both pre and post reform era. This study aims to fill up this gap related to relevancy and methodology on supply responses in agriculture. It can be inferred from Table 3 that the yield increase has mainly occurred in 70s and 80s due to the impact of technological changes. In 90s during the period after liberalization, the yield increase for commercial crops like oilseeds and sugarcane is not up to the expected level due to liberal import policies in oilseeds and has negative impact on domestic growth of area and productivity of oilseeds except soybean in central India. Past Studies show that the region wise pattern of Southern and Western regions are more diversified over the years and the shifts have taken place mainly in favour of oilseed crops; especially in Tamil Nadu, crop diversification from rice to groundnut and sugarcane is significant in 80s. In Karnataka area shifts occurred in favour of fruits and vegetables. Climatic conditions and government supported programs favoured this crop.

**Table 1.** Supply Response Coefficient for Different Crops in Different Countries

| **Researchers** | **Periods** | **Crops** | **Supply Response Coefficients** | | **Country** |
|---|---|---|---|---|---|
| | | | Short Run | Long Run | |
| Addison(1976) | 1946-58 | Bean | +1.56 | - | UK |
| Aromdee ( 1970) | 1951-65 | Rice | +0.23 | +0.25 | Malaysia |
| Askari(1970) | 1922-38 | Linseed | +0.25 | - | Phillipines |
| Bacha(1968) | 1939-64 | Rice | +0.07 | -0.82 | Colombia |
| Bateman(1966) | 1914-64 | Cotton | +0.38 | +0.42 | Ghana |
| Behraman(1974) | 1937-63 | Rice | +0.08 | +0.16 | Thailand |
| Behrmam(1965) | 1947-64 | Cocoa | +0.15 | +0.20 | Ivery coast |
| Bromdee(1973) | 1951-65 | Wheat | +0.50 | +0.24 | USA |
| Colman(1970) | 1951-65 | Maize | +0.23 | +0.26 | Sudan |
| Cooley&Decaria (1964) | 1955-66 | Wheat | +0.33 | +0.41 | UK |
| Cumming(1974) | 1953-72 | Rice | +0.08 | +0.04 | Iraq |
| Cumming(1974) | 1961-71 | Rice | +0.66 | +1.15 | Japan |
| Eddie(1968) | 1944-64 | Wheat | +0.50 | - | Peru |
| Federick(1973) | 1948-67 | Wheat | +0.38 | +0.23 | Nigeria |
| Freire(1965) | 1947-66 | Flax Seed | +0.42 | +0.75 | Canada |
| Ghoshal(1973) | 1950-72 | Cotton | -0.49 | +0.50 | Liberia |
| Guise(1968) | 1947-64 | Rice | +0.37 | +0.85 | Australia |
| Harik(1978) | 1950-72 | Rice | +0.66 | +1.15 | Iraq |
| Jones(1962) | 1946-61 | Wheat | +0.63 | - | France |
| Jones(1969) | 1952-65 | Wheat | +0.08 | +0.71 | Iraq |
| Klein(1975) | 1930-55 | Tobacco | +2.02 | +4.67 | Brazil |
| Madani(1969) | 1945-65 | Millet | +0.90 | +1.15 | New Zealand |
| Maitha(1973) | 1946-64 | Cocoa | +0.16 | +0.40 | Kenya |

**Table 1.** Supply Response Coefficient for Different Crops in Different Countries (Contd….)

| **Researchers** | **Periods** | **Crops** | **Supply Response Coefficients** | | **Country** |
|---|---|---|---|---|---|
| | | | Short Run | Long Run | |
| Merril(1973) | 1910-41 | Wheat | +0.26 | +1.16 | Philippines |
| Mules(1971) | 1938-58 | Potato | +0.31 | +0.30 | USA |
| Nerlove(1956) | 1967-14 | Rice | +0.12 | +0.18 | USA |
| Nerlovian (1958) | 1923-50 | Rice | +0.09 | +0.37 | USA |
| Olayide(1972) | 1953-72 | Groundnut | -3.36 | -5.18 | Egypt |
| Oni(1964) | 1948-67 | Cotton | +0.03 | +0.04 | Nigeria |
| Oury(1966) | 1871-73 | Wheat | +0.09 | +1.23 | Hungary |
| Powell(1967) | 1942-64 | Rice | +0.37 | +3.65 | Chile |
| Schmitz(1968) | 1909-32 | Barley | +0.47 | +0.93 | USA |
| Stern(1973) | 19346-66 | Rice | +0.84 | - | USA |
| Subotnik(1976) | 1938-72 | Rice | +0.36 | +1.09 | Australia |
| Swift(1969) | 1948-65 | Wheat | +0.57 | - | Argentina |
| Williams(1970) | 1953-64 | Eggs | +0.14 | +0.22 | Jamica |

**Table 2.** Statistical Summary of changes in Cropping pattern and Yield in India

**(Million ha)**

| Crops | 1960-61 | 1970-71 | 1980-81 | 1990-91 | 1995-96 | 2000-01 | 2005-06 | 2010-11 | Annual % change 80s | Annual % change 90s |
|---|---|---|---|---|---|---|---|---|---|---|
| Rice | 22.34 | 22.67 | 23.26 | 22.98 | 22.96 | 24.03 | 25.41 | 28.32 | -0.12 | 0.46 |
| Wheat | 8.46 | 11.00 | 12.91 | 13.01 | 13.41 | 13.84 | 14.10 | 14.68 | 0.08 | 0.64 |
| Coarse Cereals | 29.43 | 27.72 | 24.20 | 19.55 | 16.55 | 16.56 | 15.45 | 13.90 | -1.92 | -1.53 |
| Pulses | 15.42 | 13.60 | 13.01 | 13.28 | 11.94 | 11.40 | 11.11 | 10.38 | 0.21 | -1.42 |
| Food grains | 75.66 | 74.99 | 73.38 | 68.83 | 64.86 | 65.83 | 64.92 | 63.10 | -0.62 | -0.44 |
| Oilseeds | 9.01 | 10.04 | 10.20 | 13.00 | 13.92 | 13.56 | 14.50 | 15.00 | 2.75 | 0.43 |
| Cotton | 4.98 | 4.59 | 4.53 | 4.01 | 4.85 | 4.61 | 4.52 | 3.95 | -1.15 | 1.50 |
| Sugarcane | 1.58 | 1.58 | 1.55 | 1.99 | 2.22 | 2.46 | 2.62 | 2.98 | 2.84 | 2.36 |
| Non-food grains | 24.34 | 25.01 | 26.62 | 31.17 | 35.14 | 34.17 | 34.34 | 35.64 | 1.71 | 0.96 |
| Cropped area (in million hectares) | 152.77 | 165.79 | 172.63 | 185.74 | 186.56 | 186.36 | 192.70 | 195.56 | 0.76 | 0.03 |

**Source:** Agricultural Statistics at a Glance and www.indiastat.com

**Table 3.** States where Gain and Reduction in Area occurred for Major Crops

| **Crops** | **70s & 80s** | | **90s& 20s** | |
|---|---|---|---|---|
| | **Gain** | **Reductiom** | **Gain** | **Reduction** |
| Rice | MP, Punjab, UP and West Bengal | Tamil Nadu | MP, Punjab and UP | AP and Bihar |
| Wheat | All the major producing states | - | All the major producing states | - |
| ***Coarse Cereals*** Maize<br><br>Jowar | MP and Rajasthan<br><br>- | Bihar and UP<br><br>All the major producing states | AP<br><br>- | UP<br><br>All the major producing states |
| Grams | MP, Maharashtra, Rajasthan | UP | MP, Maharashtra | UP |
| Groundnut$ | AP, Gujrat | Maharashtra | - | AP, Gujarat and Maharashtra |
| Rapeseed &Mustard | Rajasthan MP, Haryana and WB | UP | Rajasthan and MP | - |
| Sugarcane | Karnataka and UP | - | AP, Maharashtra, Karnataka, TN and UP | - |
| Cotton | Andhra and Punjab | Gujarat and Karnataka | AP, Gujarat and Maharashtra | Punjab and Karnataka |

**Note:** 70s refer to the period 1970-71 to 1979-80. 80s refer to 1980-81 to 1989-90. 90s refer to 1990-91 to1999-2000 and 10s refer to 2001-2010.

**Table 4.** States which recorded significant increase in Yield

| Crops | 70s | 80s | 90s | 20s |
|---|---|---|---|---|
| Rice | Punjab*, AP | TN*, WB*, UP*, Orissa and Bihar | Bihar*, UP and WB | Bihar*, UP and WB |
| Wheat | Punjab , UP and Haryana | All the major producing states | All the major producing states | All the major producing states |

**Table 4.** States which recorded significant increase in Yield (Contd….)

| Crops | 70s | 80s | 90s | 20s |
|---|---|---|---|---|
| Grams | Maharashtra, Haryana and Rajasthan | Haryana* and Maharashtra | Rajasthan and MP | MP |
| Groundnut | TN* and Maharashtra | Maharashtra, TN, AP and Karnataka | Gujarat* and TN | Gujarat* and TN |
| Rapeseed & Mustard | | Gujarat, Haryana*UP* MP and Rajasthan | | |
| Sugarcane | Maharashtra and TN | Gujarat | Karnataka | Karnataka |
| Cotton | AP*, Maharashtra* and Karnataka* | Karnataka*, TN* Punjab* Gujarat, MP, Maharashtra and Rajasthan | MP* and Gujarat, Maharashtra and Karnataka | MP* and Gujarat, Maharashtra and Karnataka |

**Note:** Significant refers to annual compound growth rate of above 2% and less than 5%, *very significant refers to annual compound growth rate of above 5%.

The idea of yield response to price is further convinced by the earlier discussion in the literature that area function might underestimate actual level of supply response (Tyagi, 1974). The reason attributed is farmers may display response by adopting better technology of production with no change in area or by adopting intensive cultivation by using more or better quality of inputs. Past studies have found that 'rural literacy rate' influences choice of technology ( Mittal and Kumar, 2000).

Many scholars preferred to use a weighted average price index where the relative price is ratio of crop concerned over weighted average of substitutes' prices (Falcon,1964). Narayana and Parikh (1981) found that specifying same coefficients for principal and competing crops might not always provide meaningful results. Gulati *et al*. (1999) corroborated the notion that agro-climatic conditions, land characteristics and farmer's knowledge about the crop along with the price variable simultaneously affect cropping decisions. They found that low degree of risk bearing ability would weaken the acreage – price response if the crops of higher relative profit are more risky. Also the major determining factors at the individual household level may be quite different from the state, zonal or national level.

In addition, the openions of the researchers with the Nerlovian model are varied. The advantages of using pooled cross sectional-time series data set over the others are well known. Such type of data provide valuable information about the diversity of the attributes because the data contain both inter regional and temporal variations. In the context of supply response, the study by Narayana *et al.* (1981) made improvement upon the conventional econometric techniques, and the necessity for improvement arises because of the following

reasons: The traditional Nerlovian model of adaptive expectation does not separate past prices into stationary component and random component. It attaches same weights to both the components for predicting future prices. Narayana *et al*. (1981) deviate from this in two ways. (i) Use expected revenue instead of expected price and (ii) Formulate revenue expectation function for each crop by isolating stationary and random components in past prices and attach suitable weights for both in prediction. The method is based on ARIMA technique combined with BOX-Jenkins procedure for estimations.Also, similar method was applied to analyse farmers' acreage response in Kenya by Narayana and Shah (1982). This study mainly distinguished between the responses of small farmers versus large farmers. Small farmers' area adjustment parameters towards the desired acreage in the case of food crops are much higher than for non-food crops; whereas for large farms, the adjustment towards desired acreage is higher for commercial crops like sugarcane. Application of non-linear models in supply response is also becoming popular.

## CONCLUSIONS

Literature surveyed shows that farmers' response to price is very low in the short run and their adjustment mechanism towards reaching the desired level is slow for agricultural crops. Various discussions on the supply response theme in the academic literature and in the policy arena clearly pointed out that turning attention to removing some of the physical infrastructural constraints as well as credit constraints will go a long way in increasing the supply response. There is still need for incorporating more variables on weather parameter for long term supply responses looking to climatic changes arising due to global warming.

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