**Migration Letters**

Volume: 21, No: S5 (2024), pp. 838-858

ISSN: 1741-8984 (Print) ISSN: 1741-8992 (Online)

www.migrationletters.com

# Estimating An Export Function For Principal Agricultural Exports Of India

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**Abstract**

*The Prebisch-Singer hypothesis (1950) argues that there was and would continue to be a secular decline in the terms of trade of primary commodity exporters due a combination of low income and price elasticities of demand. This raises the question how India is faring in respect of agricultural exports. Using a double log simultaneous equation model, we estimate an export function for principal agricultural exports from India. A simultaneous equation model works well. The supply side factors like output and rainfall dominate. They have the largest coefficients. This is a good sign for two reasons. One, it takes us away from an over-emphasis on export demand functions. Two, it points to the 'vent for surplus theory'. It would not be an exaggeration to say that India's agricultural exports are supply driven.*

*There are three probable reasons Prebisch-Singer hypothesis may still hold true- low price elasticity, high standard error implying volatility in agricultural export prices and secular decline in export competitiveness. It is, however, heartening to note that export competitiveness of non-traditional agricultural exports does not appear to have declined. A corollary of the aforementioned is a concerted effort towards promotion of exports of non-traditional commodities. However, SPS (Sanitary and Phytosanitary Measures) imposed by the North act as formidable non-tariff barriers.*

***Keywords**: Agriculture, Aggregate Supply and Demand Analysis, Prices, Agriculture in International Trade, Simultaneous Equation Models*

JEL Classification: Q1, Q11, Q17, C30

## 1. Introduction

The Prebisch-Singer hypothesis (Prebisch (1950)) argues that there was and would continue to be a secular decline in the terms of trade of primary commodity exporters due a combination of low inc[1]ome and price elasticities of demand. This decline has resulted in long term transfer of income from poor to rich countries that could be combated only by efforts to protect domestic manufacturing industries that have come to be known as "import substitution" in the literature on development economics. The Prebisch-Singer hypothesis has lost some of its relevance in the last 30 years, as exports of simple manufactures have overtaken exports of primary commodities in most developing countries outside of Africa. For this reason, much of the recent research inspired by the Prebisch-Singer hypothesis focuses less on the relative

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prices of primary products and manufactured goods, and more on the relative prices of simple manufactures produced by developing countries and complex manufactures produced by advanced economies (Cuddlington 1992; Ardeni, et al, 1992; Sapford, 1985).

Perhaps an implicit assumption behind the prediction of a secular decline in the terms of trade of primary commodities in future was that nature of primary export commodities will remain unchanged. However, the hypothesis was formulated in the late 1940s and a number of significant changes have occurred: First, **while the share of agriculture has come down in India, and second, the nature of primary export has changed as well (Bhatia et.al, 2021). Thus, in the current context it would be highly simplified to say the developing would be primary producers and exporters.**

Export potential from developing economies is not restricted to traditional primary exports. In recent years many new agro-products are being exported from India and other developing countries. Due to emergence of disembodied technological revolution, the role of information technology, new techniques of production (High Yielding Varieties (HYV)), new techniques of marketing, new quality standards, etc., the export of bulk raw material and food items along with other natural products like spices may not hold the sway, in the years to come. Floriculture, sericulture, pisciculture, mushrooms farming, apiary, horticulture, animal husbandry & dairy farming are emerging as components of primary exports from agriculture and allied (Shinoj and Mathur, 2008; Saxena and Nath, 2012: Ramesh et al. 2017). They have high value added and are characterized by stable prices. These products cater to the well-off sections of society. The demand mainly emanates from the North and is siphoned through the supply chains that feed the gigantic modern retail business. **This leads one to ask whether there has occurred a fundamental change in the character of agricultural production and export.**

## 2. Objective of the study

- To estimate the Export function for Principal Agricultural Commodities in India
- To understand the Fundamental Changes in the character of Agricultural production and export.

- To study the trends in Revealed Comparative Advantage of traditional and Non-traditional agriculture products exported from India.

## 3. Research Gap

Estimation of demand and supply function of exports is highly country specific. This is because for every country, the tradeoff between production for domestic market and export is different depending on the size of the domestic market. This leads every country to follow unique policies relating to trade and thus results of estimation of export and demand function cannot be easily generalized across countries. However, there may be common methodological issues. **This paper dwells upon such methodological issues and attempts to arrive at a better framework for estimating an export function for principal agricultural exports from India.**

After having considered a number of works, the important issues relate to:

- Whether to estimate an export demand function or a supply function or both.
- Whether to use Unit Value Realization or value of exports.
- How to measure price (or price indices)? Wholesale price index or commodity prices?

- Whether to estimate with the help of quantity or value of exports.
- How to deal with the famous ‘identification problem.’
- What should be the model specification? Linear or Log-linear?
- Policy importance of the inherent price elasticities.
- The selection of variables.
- Primary products have decreasing returns to scale or increasing costs. What are the implications?
- Regular government intervention in the export of primary goods.

We may not be able to address all these issues but shall in the process of estimating an export function try to remove many of the problems arising out of these methodological issues.

**The interest has waned in the estimation of such a function for agricultural exports because it is believed that the future lies in service exports and non-traditional manufactures. In the light of the above-mentioned trends the present paper intends to revisit this area.**

In Section 4, we have laid out the details of data and methodology. The results are given in Section 5. Limitations have been summed up in sections 6. Finally, the contributions of the study are mentioned in section 7.

The extant literature dwells upon the estimation of export demand functions. The interest has waned in the estimation of such a function for agricultural exports because it is believed that the future lies in service exports and non-traditional manufactures. In the light of the above mentioned trends the present paper intends to revisit this area.

**4. Data & Methodology**

In the following section we have outlined the details of data and methodology.

**4.1 Data:**

The analysis involves two sets of variables - demand determinants and supply determinants. Demand determinants for estimation of agricultural export include world Gross Domestic Product (WGDP), Nominal Exchange Rate (NER), Price of agricultural exports (P) and subsidy granted (SUB). Supply determinants for estimation of agricultural exports include Rainfall (RAIN), Primary output (OUT), Credit flow to agricultural sector (CR) and Price of agricultural exports (P). Various statistical tools have been employed for the analysis. As one of our objectives is to find out India’s Agricultural export competitiveness, we also need data on the share of agricultural exports in total exports for India as well as the entire world. Since the aforementioned is not readily available, data on agricultural exports and total exports has been used to find out appropriate share and ascertain India’s agricultural competitiveness.

**4.2 Data Source**:

The required data for analysis has been collected from secondary sources. Data related to world gross domestic product (WGDP), Total world export, India total export, India agricultural export, World agricultural export have been collected from the online database of UNCTAD[2]. Data related to Rainfall, subsidy granted to agricultural sector and credit flow to agricultural sector have been collected from online database of INDIASTAT. Data related to Nominal Exchange Rate and primary output has been collected from the Handbook of Statistics (RBI). Data related to quantity, price and value of principal commodities have been collected from online database of Food and Agriculture Organization (FAO). The relevant period for our analysis is 1991 to 2022. We have converted all variables to Logarithmic form. (Data for 2020, 2021, and 2022 are interpolated due to COVID 19 impact).

**4.3 Discussion on Variables**:
Brief explanation of variables and their expected behavior has been mentioned in the table below:

**Table 1: Descriptions of Variables**

| **Variable** | **Form** | **Name** | **Supply/ Demand Determinant** | **Expected Sign** |
|---|---|---|---|---|
| World GDP[3] | Logarithmic | LN(WGDP) | Demand Determinant | +ve |
| Nominal Exchange Rate[4] | Logarithmic | LN(NER) | Demand Determinant | +ve |
| Primary output[5] | Logarithmic | LN(OUT) | Supply Determinant | +ve |
| Price[6] | Logarithmic | LN(P) | Supply Determinant and Demand Determinant (both) | +ve/-ve |

[2] **United Nations Conference on Trade and Development** (UNCTAD) is a permanent intergovernmental body established by the United Nations General Assembly in 1964.

[3] The world GDP is the combined gross domestic product of all the countries in the world, i.e., value of goods and service produced domestically by all the nations together. Total GDP has been used as a measure of the strength of external demand which is the first drive for exports. For the aforementioned reason, GDP per capita which is used often to ascertain the standard of living does not appear to be an appropriate measure.

[4] Nominal exchange rate (Nominal Effective Exchange Rate) is an indicator of external competitiveness. It’s a weighted average rate at which country’s currency exchanges for a basket of foreign currencies. It’s a rate of home currency in terms of basket of foreign currency. Our index is based on export weights and defined as the number of units of the domestic currency that can purchase a unit of a given basket of foreign currency. It is considered in order to account for the purchasing power of the currencies. The Basket Represent 31 countries and Euro Area.

[5] Primary output describes value added by the primary sector to GDP. It helps us to gauge the marketable surplus of agricultural products which can be exported, given a steady level of consumption of primary commodities domestically due to a stable consumption pattern.

[6] Price is the internationally traded price of the principal agricultural commodities from India. It is an important element as it affects both demand and supply function of agricultural export.

| | | | | |
|---|---|---|---|---|
| Agricultural Subsidy [7] | Logarithmic | L(SUB) | Demand Determinant | +ve |
| Rainfall[8] | Logarithmic | LN(RAIN) | Supply Determinant | +ve |
| Credit flow[9] | Logarithmic | LN(CR) | Supply Determinant | +ve |

Source: The authors

The extant studies largely concentrate on demand function. Very often these functions are estimated with the help of demand being regressed on domestic export price, world export and world income. Viramani (1991) has estimated the inverse supply function for manufacturing exports, where growth rate of price is regressed on the growth rate of other variables such as average wholesale price index (WPI), quantity of export and rainfall. Why rainfall is a determinant of industrial exports needs some explanation. In terms of external variables Mukherjee (1992) has chosen to use World Trade instead of World Income. In such cases there may be a problem of endogeneity. Even with world income we find that there is a problem of endogeneity.

**4.4 Methodology: -** Our methodology has five steps:

a) Growth Analysis
b) Revealed Comparative Advantage (RCA) analysis
c) Unit Root Testing
d) Methodology of Estimating Export Function

**a) Growth Analysis**

Growth Analysis is an important statistical tool to estimate the rate at which the various factors (variables) is increasing or decreasing over a period of time. It gives us an approximate idea of the stationarity of variables. To proceed with our research, the log of factors was regressed against time. The expression for Growth Equation is as follows:

$$Y = e^{\alpha + \beta t} \quad \text{…. (1)}$$

Taking log of both sides and adding an error term;

$$\text{Log } Y = \alpha + \beta t + \mu t \quad \text{…. (2)}$$

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It is the level of price that captures the price effect. It also reflects the cost-price structure. In time series analysis the price is an ex-post price and an equilibrium price. Thus, *a priori* it is neither a supply price nor a demand price

[7] It is a form of financial or in-kind support extended to an economic sector. It directly promotes exports because of price of the indirect price effect.

[8] In developing country agricultural production directly related to performance of rainfall so better rainfall can cause better agricultural production. This in turn would lead to better marketable surplus, given that consumption patterns are stable. The surplus production being generate over and above normal production and in relation to normal consumption.

[9] Credit flow expected to promote export if the credit is been directed to such production which is mainly being exported.

In the above equation, log has been taken for the independent variable. The intercept term is represented by α whereas the growth rate of dependent variable has been estimated with the help of β. The time horizon of the study is from 1991 to 2022.

Actual and Predicted Analysis
As the result of Growth Analysis comes in the form of actual and predicted graph, it will be easy for the user to find out where the variables are departing from the expected value. The analysis reflects the variability and the time of its occurrence.

**b) Revealed Comparative Advantage (RCA) Analysis**

Revealed comparative advantage (RCA) is an index used in international economics for calculating the relative advantage or disadvantage of a certain country in a certain class of goods or services as evidenced by trade flows. It is based on Ricardo's theory of comparative advantage.

It most commonly refers to an index introduced by Béla Balassa (1965):

RCA = (Eij / Eit) / (Enj / Ent) …. (3)
where:
E= Exports
i = Country index
n= set of Countries
j= Commodity index
t= Set of commodities

A comparative advantage is "revealed" if RCA>1. If RCA is less than unity, the country is said to have a comparative disadvantage in the commodity or industry. **To study the performance of Agricultural exports, Revealed Comparative Advantage (RCA) is calculated**. It was estimated to examine the comparative advantage of India's agricultural exports using the method suggested by Béla Balassa (1965). The concept of revealed comparative advantage (Balassa 1965, 1977, 1979, 1986) pertains to measure the relative trade performance of a countries in particular commodities. **It based on assumption that pattern of trade depends on the inter - country differences in relative Price as well as in non-price factors.**
However, in order to arrive at an informed view regarding agricultural exports, we have classified commodities as traditional Agricultural commodities and non-traditional Agricultural commodities. The purpose of this classification is to get a clearer picture of export competitiveness of both types of agricultural commodities exports. Thus, in our study we have estimated the RCA index for three categories. Firstly, for overall agricultural exports; secondly for traditional agricultural exports and thirdly for non-traditional agricultural exports.

Overall agricultural exports

Accordingly, the RCA of India in Agriculture products was estimated by using following equation:

RCA= Sit/ Swt ... (4)
where,
$S_{it}$ = Share of agricultural exports in India's total export; and

$S_{wt}$= Share of agricultural exports in the total world export.

In order to know the competitiveness of India's traditional agricultural exports and non-traditional agricultural exports, following equations have been used: -

Traditional Agricultural Exports

RCA= $S_{Tit}$ / $S_{twt}$... (5)
where,
$S_{Tit}$ = Share of Traditional Agricultural export in India's total export; and
$S_{twt}$ = Share of Traditional Agricultural export in the total world export.

Non-Traditional Agricultural Export

RCA= $S_{NTit}$ / $S_{NTwt}$ ... (6)
where,
$S_{NTit}$ = Share of Non-Traditional Agricultural export in India's total export; and
$S_{NTwt}$ = Share of Non-Traditional Agricultural export in the total world export.

Major heads included in traditional and non-traditional agricultural Products are as follows:

**Table 2: Traditional and Non-traditional agricultural Products**

| Non-Traditional Agricultural Products | Traditional Agricultural Products |
|---|---|
| Animal husbandry* | Rubber pulp |
| Dairy* | Cereals* |
| Poultry* | Tobacco |
| Horticulture* | Oil seeds |
| Pisciculture* | Silk |
| Beverages* | Cotton |
| Wood and wood pulp | - |

* All these agricultural products are subject to severe Sanitary and Phytosanitary measures. Source: The Authors

Growth analysis of export competitiveness
In order to ascertain the trend in export competitiveness, particularly to observe the annual growth rate at which export competitiveness increases or decreases, we have used semi-log equation as follows: -

$$Y = e^{\alpha + \beta t} \quad \text{…. (7)}$$

Taking log of both sides and adding an error term;

$$\text{Log } Y = \alpha + \beta t + \mu t \quad \text{…. (8)}$$

where,
Y= RCA index for Agricultural export
t= time (1991-2022)
a= intercept
b= annual growth rate of Agricultural export competitiveness

We have also regressed RCA index for traditional agricultural exports and RCA index for non-traditional Agricultural export with the help of following semi-log equation: -

Log (RCA IdxT) = α + βt + μt …. (9)
Log (RCA IdxNT) = α + βt + μt …. (10)

**c) Unit Root Testing**
To examine whether two time-series are co-integrated with each other, we have to test the stationarity of the series. Unit root test is used to confirm the stationarity of a sequence. We have used both Augmented Dicky-Fuller (ADF) test as well as the Phillips-Perron (PP) test to ascertain whether a sequence is stationary or not. ADF test is based on the assumption that errors are statistically independent and have a constant variance. While relaxing these assumptions we can use an alternative test namely PP test which allows the disturbances to be weakly dependent and heterogeneously distributed.

**d) Methodology of Estimating Export Function**
In a time-series, **estimate of export function reflects the equilibrium export ex-post measure interaction of supply and demand function.** In the cross section, we may be able to capture partial effect along with the relevant sign with the restriction implied by demand and supply function respectively. However, in case of time series estimate, the primary condition of measurement at a point of time with respect to demand especially is not possible. This is obviously the failing of the measurement techniques which do not permit restrictions on the time effects. Moreover, **individual estimates of export demand and export supply are incomplete since they suffer from a single equation bias.**
**The solution therefore is to estimate a simultaneous equation which is our case has been done with the help of the above mentioned two stage procedures. Since price and quantity both are being determined simultaneously.** It stands to reason that both the equation is mutually measured as reduced from equation.

The logic is that under equilibrium, quantity demanded is equal to quantity supplied. Incidentally, when this happens, there is a single equilibrium price. Given the fact that under equilibrium there is no separate supply price and demand price, interpretation of the ex-post export price assumes importance. In this context, an identification problem arises because there are no separate estimates of the supply price and demand price. This is reflected in the estimate that we have obtained in the case of respective demand and supply function.

Most of the coefficients are not significant since they suffer from two problems: -

- Single bias problem
- Identification problem

Specially, while the supply function shows significant low and positive price elasticity, the demand function shows low positive and not significant elasticity of demand. This could partly have to do with the fact that demand and supply have not been measured in terms of quantity. **It is important to understand that there is choice between implementing demand and supply function in quantitative terms as opposed to value terms.**

Secondly, **as the interest lies in estimating an aggregate export function, both quantity and price have to be aggregate. Most of the works have taken what appears to be the**

**simpler route of taking wholesale price index (WPI) and taking the total export both of which again are too aggregative.** The relation of two aggregate variables is unlikely to give precise result, especially, when the focus is on distinguishing between traditional agricultural export and non-traditional agricultural export. The total export measure would include both. The problem lies here. Any estimate of the agricultural export function would be biased in favor of principal agricultural export because they from the major portion of export. Having said that, **it is not justified to use wholesale price index (WPI) because agricultural commodity's price (not agricultural export price) would be based on domestic price and not the export price. Secondly their weight in the wholesale price index (WPI) would not be large and significant.**

We have chosen to measure agricultural export in value terms which is the logical alternative where commodities having different measurements units have to be collapsed into one measurement unit. Correspondingly we have constructed a price index which is different from unit value realization because it is based on the ideal Fisher Price Index that is not influenced by base year or the effect of recent year. We hope through this framework we may arrive at a better estimate and a better relationship between price as well as demand and supply.
**Other studies have not included some of the most logical variables such as subsidy, agricultural output, and agricultural credit and so on**. On the demand side, there is question of whether nominal exchange rate (NER) should be employed or real exchange rate (RER). The relevance of real exchange rate (RER) can be justified if export is measured in quantitative terms but the problem is that in the case of principal agricultural export it can't be measured in quantitative terms.

Another problem is in the case of developing countries the Marshall-Lerner condition is very important factor whose implication can be measured only in value terms. In further analysis this would have implication for balance of payment.

Hence it stands to reason that nominal exchange rate (NER) is relevant variable in this context. Subsidy, it is expected will directly promote export because of a price effect. Similarly, credit flow is expected to promote export if the credit is directed to such production which is mainly being exported. Rainfall can be explained in terms of surplus production being generated over and above the normal production and in relation to normal consumption. Hence on the supply side, rainfall, credit flow and output are all likely to augment supply with a given consumption pattern jointly and severally and this factor leads to export surplus. Therefore, this supports "Vent for surplus" theory. In this respect it can be seen that a single equation estimate of supply of export does not bring out the true picture. On the demand side, world GDP would be a major determinant of demand because given the inequalities the major part of demand for primary products would be in the form of imports from developed countries.

We first estimate two aggregate demand and supply functions and demonstrate their inability to capture the behavior of agricultural exports. Then, with the help of a two-stage least square estimation procedure, we estimate a simultaneous equation model of the 'Export Function for Principal Agricultural Exports of India'. We have used Hayashi and Sims (1980) methodology for solving the simultaneous equation model. It is 2SLS procedure.

This is done in four steps:

- Estimating an inverse demand equation;
- Obtaining the pre-determined export price;
- Plugging it into the export function; and

- Finally estimating the 'Export Function'.

Such a function is neither uniquely a demand function nor a supply function. It is an ex-post aggregate agricultural export function.

Individual Functions of Supply and Demand

In order to estimate export function, we have classified our set of variables into two board categories, namely, demand determinants and real determinants.

Two models have been used. The first model has been used to determine the relationship between agricultural exports and demand determinants with the help of the following expression: -

$(AX)_t = e^{\alpha 1}. WGDP_t^{\beta 11}.NER_t^{\beta 12}.SUB_t^{\beta 13}. P_t^{\beta 14}$ ……. (11)

The logarithmic form of the expression is as follows:
$Ln\ AX_t = \alpha_{1\ +} \beta_{11}\ Ln\ WGDP_t + \beta_{12}\ Ln\ NER_t + \beta_{13}\ Ln\ SUB_t + \beta_{14}\ Ln\ P_t + \mu_{t1}$......... (12)
Where AX = Agricultural export
$\alpha_1$ = intercept
t = (1990-91 to 2021- 2022)
$\mu_{t1}$ = error term
WGDP= World gross domestic product
NER= Nominal exchange rate
SUB = Agricultural subsidy
$P^i$ = Price Index (Fisher's) of Principal Agricultural Exports

Similarly, our second model has been used to determine the relationship between agricultural exports and supply determinants with the help of the following expression: -
$(AX)_t = e^{\alpha 2}. RAIN_t^{\beta 21}.OUT_t^{\beta 22}.CF_t^{\beta 23}. P_t^{\beta 24}$ ……. (13)

Logarithmic form of the above expression is as follows:
$Ln\ (AX)_t = Ln\ \alpha_{2\ +} \beta_{21}\ Ln\ RAIN_t + \beta_{22}\ Ln\ OUT_t + \beta_{23}\ Ln\ CF_t + \beta_{23}\ Ln\ P_{t\ +} \mu_{t2}$ .......... (14)
Where AX = Agricultural export
$\alpha_2$ = intercept
t = (1990-91 to 2020- 2022)
$\mu_{t2}$ = error term
RAIN= Rainfall
OUT= Primary output
CF= Credit flow to agricultural sector
P = Price Index (Fisher's) of Principal Agricultural Exports

**Inverse Demand Equation**

In general, an inverse demand equation is of the form:
P = f (Q)……… (19)
In the context of this article, such an equation is necessitated by the requirement of solving the simultaneous equation model. The above two individual supply and demand equations need to be solved simultaneously. Under equilibrium, Qd=Qs and Ps=Pd (supply price and demand price) are equal. Thus, Value of Export Demand would also be equal to the Value of Export Supply. In the above two SS and DD equations, price appears on the right-hand side. Since

price and value of exports are endogenous (determined jointly) the estimation procedure suggested by Hayashi and Sims (1982) involves estimation of a reduced form inverse demand equation. This is obtained by equating quantity demanded and quantity supplied. In other words, there is a single price (equilibrium) determined jointly by all the exogenous variables in the system. On estimation as an OLS equation, it yields a predicted value or the pre-determined Price of Argo-exports (P^). Since it is pre-determined, it does not contain an error term. This predicted price from the inverse demand equation can be plugged into the reduced form Export Function. This is the final equation that we are seeking. In the final form it is neither uniquely a supply function nor is it uniquely a demand equation. It can best be described as an 'ex-post Aggregate Export Function' for principal agricultural exports from India.

Reduced Form Equations

Inverse Demand Equation:

$(P)_t = e^{\alpha 31}. WGDP_t^{\beta 31}.NER_t^{\beta 32}.SUB_t^{\beta 33}. RAIN_t^{\beta 34}.OUT_t^{\beta 35}.CF_t^{\beta 36}$ ……… (20)

Taking log both the side and adding error term

$Ln (P)_t = \alpha_1 + \beta_{31} Ln WGDP_t + \beta_{32} Ln NER_t + \beta_{33} Ln SUB_t + \beta_{34} Ln RAIN_t + \beta_{22} Ln OUT_t + \beta_{23} Ln CF_t + \mu_{t3}$……… (21)

Export Function

$(AX)_t = e^{\alpha 41+D2+D2T}. NER_t^{\beta 41}. SUB_t^{\beta 42}.P_t\wedge^{\beta 43}. RAIN_t^{\beta 44}.OUT_t^{\beta 45}$……… (22)

In the final equation there was an endogeneity problem with World GDP. Also, credit flow to agriculture was not significant. Thus, the above equation was estimated along with dummies for slope and intercept to capture the effect of global financial crisis.

By taking log of both sides and adding dummies along with an error term we arrive at the final export equation:

$Ln (AX)_t = \alpha_{41} + \beta_{41} Ln NER_t + \beta_{42} Ln SUB_t + \beta_{43} LnP_t^{\wedge} + \beta_{44} Ln RAIN_t + \beta_{45} Ln OUT_t + D2 + D2T + \mu_{t3}$……… (24)

In the following section we will analyze the results.

**5. Results**

The first step in any analysis is to study the growth rates and patterns of the underlying variables. Given below are the annual growth rates estimated from a set of semi-log equations.

**Table 3: Growth Rate Analysis**

| Variable | Growth rate | P-value |
|---|---|---|
| Dependent Variable | | |
| LN(AX) | 14.8% | 0.00% |
| Supply Determinant | | |
| LN(RAIN) | (-)0.235% | 43.27% |
| LN(OUT) | (-)2.893% | 0.00% |
| LN(CRT) | 21.90% | 0.00% |
| LN(P) | (-)2.8% | 41.40.% |
| Demand Determinant | | |
| L(WGDP) | 5.5181% | 0.00% |
| LNER | 3.22% | 0.00% |

| | | |
|---|---|---|
| LN(P) | (-)2.8% | 41.40% |
| LN(SUB) | 13.7035% | 0.00% |

Source: The authors

Rainfall and price both do not have significant growth rates. In the case of rainfall since there are vagaries of monsoon this is expected. The standard error would be high. Price is not the price of a single commodity but a hybrid price generated as an index number through developing a Fisher's Index. Thus, even in this case the variability may be very high. So, once again the standard error would be high. Falling rainfall may be a sign of global warming. But the sign of price is ambiguous as is for a basket of commodities. It may be dominated by one or two principal commodities like tobacco for which the demand is going down. Nevertheless, both these variables do not show significant negative trends. Thus, the sign of all variables can be treated as positive. This helps in the final analysis.

**Table 4: Revealed Comparative Advantage of Indian Agricultural Exports**

| Export | Traditional Exports | Non-Traditional Exports | Total Exports |
|---|---|---|---|
| RoG | -0.021 | -0.016 | -0.023 |
| P-Value | 0.002 | 0.223 | 0.001 |

Source: The authors

As per revealed comparative advantage (RCA), **India's agricultural exports do not appear to be competitive. Their indices of competitiveness are collectively less than one. On closer observation it can be seen that there is a secular decline in overall agri-export competitiveness and that of traditional argi-exports**. In the case of non-traditional exports, the trend bears a negative sign but is not significant.

**Testing for Unit Root**

**Table 5: Unit Root Result for Demand and Supply Determinant**

| | **ADF test statistic (with trend and intercept)** | | | | **P-P test statistic (with trend and intercept)** | | | |
|---|---|---|---|---|---|---|---|---|
| | **Level** | **Order of Integrated** | **First Difference** | **Order of Integrated** | **Level** | **Order of Integrated** | **First Difference** | **Order of Integrated** |
| LN(AX) | -1.87 | I(1) | -4.34*** | I(0) | -2.09 | I(1) | -4.43*** | I(0) |
| LN(OUT) | -1.96 | I(1) | -6.13*** | I(0) | -2.14 | I(1) | -6.10*** | I(0) |
| LRAIN | -3.14 | I(1) | -6.42*** | I(0) | -3.06 | I(1) | -7.41*** | I(0) |
| LCF (Credit | -1.75 | I(1) | -7.95*** | I(0) | -2.48 | I(1) | -8.23*** | I(0) |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| LNER | -2.45 | I(1) | -4.48*** | I(0) | -2.53 | I(1) | -4.97*** | I(0) |
| LWGDP | -3.49* | I(1) | -4.74*** | I(0) | -2.05 | I(1) | -3.29* | I(0) |
| LSUB | -3.99** | I(0) | | | -2.64 | I(1) | -4.47*** | I(0) |
| LP | -1.75 | I(1) | -4.74*** | I(0) | -1.91 | I(1) | -4.56*** | I(0) |

Note: *** Significant at 1% level, ** Significant at 5% level, and * Significant at 10% level (ADF and PP) Test critical values at 1% level -4.324, 5% level -3.580, and 10% level -3.225

Source: The authors

**Table 6: Agricultural Export Supply**

| Regression Statistics | |
|---|---|
| Multiple R | 0.963 |
| R Square | 0.928 |
| Adjusted R Square | 0.907 |
| Standard Error | 0.187 |
| Observations | 32 |

ANOVA

| | Df | SS | MS | F | Significance F |
|---|---|---|---|---|---|
| Regression | 5 | 7.811784 | 1.562357 | 44.20515 | 3.75E-09 |
| Residual | 19 | 0.600836 | 0.035343 | | |
| Total | 26 | 8.41262 | | | |

| | Coefficients | Standard Error | t Stat | P-value |
|---|---|---|---|---|
| Intercept | 17.735 | 137.092 | 0.129 | 0.898 |
| Year | -0.009 | 0.070 | -0.129 | 0.898 |
| Output | 1.149 | 1.054 | 1.090 | 0.290 |
| Rainfall | 0.926 | 0.468 | 1.978 | 0.064 |
| Credit_flow | 0.661 | 0.385 | 1.717 | 0.104 |
| PRICE | 0.086 | 0.042 | 2.054 | 0.0556 |

Source: The authors

To check the presence of a unit root in variables, two prominent methods used are Augmented Dickey-Fuller (ADF) and Phillips Perron (PP). The null hypothesis is that series contain no unit root. The result of analysis helps us in deciding not to reject the null hypothesis in the case of all variables. It means that all variables are non-stationary at level I (1). Similarly, unit root analysis was conducted at first difference. As critical value is higher than the calculated value, we can conclude that at first difference, variables are stationary. Further, as all the variables are non-stationary, we decided to use 2SLS Procedure.

The supply is falling although the trend is not significant. The elasticities are low and where they are greater than one (Output) they are not significant. But the signs are all right. However, this is a single equation. Therefore, it suffers from 'single equation bias'. It is drawn from a simultaneous equation framework.

**Table 7: Agricultural Export Demand**

| Regression Statistics | |
|---|---|
| Multiple R | 0.984 |
| R Square | 0.970 |
| Adjusted R Square | 0.961 |
| Standard Error | 0.121 |
| Observations | 32 |

ANOVA

| | Df | SS | MS | F | Significance F |
|---|---|---|---|---|---|
| Regression | 5 | 8.161174 | 1.632235 | 110.3537 | 2.42E-12 |
| Residual | 19 | 0.251446 | 0.014791 | | |
| Total | 26 | 8.41262 | | | |

| | Coefficients | Standard Error | t Stat | P-value |
|---|---|---|---|---|
| Intercept | 77.471 | 91.654 | 0.845 | 0.409 |
| Year | -0.052 | 0.051 | -1.030 | 0.317 |
| W_GDP | 2.454 | 0.575 | 4.268 | 0.001 |
| NER | 0.160 | 0.285 | 0.563 | 0.580 |
| Subsidy | 0.001 | 0.197 | 0.008 | 0.993 |
| PRICE | 0.037 | 0.030 | 1.231 | 0.234 |

Source: The authors

Just like the supply, the demand is also falling although the trend is not significant. The elasticities are low and most often not significant. But where it is greater than one (World GDP) it is an exception. But the signs are all right. Only in the case of price the sign is not negative. However, this is a single equation. Therefore, it suffers from 'single equation bias'. It is drawn from a simultaneous equation framework.

**In general, therefore, the idea of estimating two separate equations for supply and demand suffers from both conceptual and measurement problems. We, therefore, need to set-up a simultaneous equation model.**

We have used Hayashi and Sims (1982) methodology for solving the simultaneous equation model. It is 2SLS procedure.

This is done in four steps:

- Estimating an inverse demand equation;
- Obtaining the pre-determined export price;
- Plugging it into the export function; and
- Finally estimating the 'Export Function'.

We first estimate an inverse demand function of the kind P= f (Q/Value and all other exogenous variables in the system). All exogenous variables must be included on RHS.

**Table 8: Inverse Demand Equation**

| Regression Statistics | |
|---|---|
| Multiple R | 0.622 |
| R Square | 0.3881 |
| Adjusted R Square | 0.102 |
| Standard Error | 0.928 |
| Observations | 32 |

ANOVA

| | Df | SS | MS | F | Significance F |
|---|---|---|---|---|---|
| Regression | 7 | 8.194434 | 1.170633 | 1.359118 | 0.291152 |
| Residual | 17 | 12.91978 | 0.861318 | | |
| Total | 26 | 21.11421 | | | |

| | Coefficients | Standard Error | t Stat | P-value |
|---|---|---|---|---|
| Intercept | 664.322 | 805.503 | 0.824 | 0.422 |
| LN(PO) | -4.139 | 6.765 | -0.611 | 0.549 |
| LN(RAIN) | -6.452 | 3.917 | -1.647 | 0.120 |
| LN(CRT) | -3.047 | 2.331 | -1.306 | 0.210 |
| LN(WGDP) | 16.039 | 5.782 | 2.774 | 0.014 |
| LN(NER) | 6.861 | 3.101 | 2.212 | 0.042 |
| LN(SUB) | -1.643 | 2.242 | -0.732 | 0.475 |
| Year | -0.435 | 0.429 | -1.012 | 0.327 |

Source: The authors

Since this is an intermediate equation, we do not have to analyze it overtly. Only the world GDP and the nominal exchange rate dominate the equation. The signs of all the insignificant variables are alright. The inverse demand equation is not complete by itself and therefore the partial regression coefficients of such as equation are not very reliable but it is interesting to note that signs are indicative of output, rainfall, credit and subsidy. All bear a negative sign because greater price leads to fall in output. Speculative price is low, especially, because agricultural products are perishable. Credit flow also plays a similar role. Greater availability of credit is likely to reduce cost of production. This enables producer to offer lower prices and price decreases. Similar effect is observed for subsidy which leads to lower price.

The inverse demand function shows the world GDP has single largest influence on price. It bears a positive sign and is statistically significant. It means if demand rises as World GDP rises, there is an increase in agricultural export. NER has a positive sign, is statistically significant and is the second most important variable in terms of magnitude. Due to depreciation in NER, exports become cheaper which leads to higher demand.

**Table 9: Agricultural Export Function**

| Regression Statistics | |
|---|---|
| Multiple R | 0.989 |
| R Square | 0.980 |
| Adjusted R Square | 0.968 |
| Standard Error | 0.109 |
| Observations | 32s |

ANOVA

| | Df | SS | MS | F | Significance F |
|---|---|---|---|---|---|
| Regression | 8 | 8.244829 | 1.030604 | 85.99043 | 1.43E-10 |
| Residual | 16 | 0.167791 | 0.011985 | | |
| Total | 26 | 8.41262 | | | |

| | Coefficients | Standard Error | t Stat | P-value |
|---|---|---|---|---|
| Intercept | -334.117 | 97.595 | -3.423 | 0.004*** |
| Pre-PRICE | 0.167 | 0.0431 | 3.880 | 0.001*** |
| Output | 3.150 | 1.055 | 2.983 | 0.009*** |
| Rainfall | 1.583 | 0.380 | 4.166 | 0.001*** |
| NER | -1.470 | 0.353 | -4.153 | 0.001*** |
| Subsidy | 0.563 | 0.316 | 1.779 | 0.096* |
| Year | 0.165 | 0.048 | 3.379 | 0.004*** |
| D2 | 135.742 | 83.847 | 1.618 | 0.127 |
| TD2 | -0.067 | 0.041 | -1.619 | 0.127 |

Source: The authors

Note: *** Significant at 1% level, ** Significant at 5% level, and * Significant at 10% level

All variables except NER are positive and highly significant. Even the dummies for crisis show good results. This speaks volumes for the 2SLS technique that has been employed. World GDP had to be eliminated because it was endogenous to exports. This means we may question the small country argument. Credit, however, was dropped because it was not significant. The crisis dummy shows a big bubble at 2007 (D2). But there is a decline at the rate of almost 7% after crisis. A caveat is that both are significant only at the rate of 15%.

The main question is about the behavior of the price variable. The sign is positive and significant. If the sign of price is positive, then it is good because any improvement in general price of agro-export will lead to an improvement of value of agro exports. Since the coefficient is significant, it shows that the price elasticity is low and hence, the ECLA (Economic Commission for Latin America) argument still holds good (Prebisch, 1950). It is perhaps a consequence of the fact that all principal exports from the basket are only traditional agro-exports.

The basket of commodities, however, is restricted to traditional exports. This implies that given the sign of the price elasticity of exports, the value of elasticity happens to be rather low. The implication is that if the price level rises by one percent, the value of export will rise 0.16%. By inference, there are three significant implications.

On the positive side, it shows that India does not have to sell its agro commodities "cheap" so as to gain in terms of value of export. In other words, the decline in terms of trade argument for agro exports per se does not seem to hold good. However, this needs to be read along with the actual growth rates of the underlying variables. It has been estimated that the price index has been falling at the rate of 2.8% per annum, although it is not statistically significant. At best there is ambiguity about the price effect and at worst, it shows both a secular decline in price of agro exports which, along with a positive coefficient of price elasticity would lead to a fall in the value of agro export. Therefore, in the net, though not with certainty, there are three signs that Prebisch-Singer hypothesis still holds.

These signs are:

- low price elasticity
- high standard error implying volatility in agro export prices
- secular decline in export competitiveness.

The positive sign suggests potential for agro exports, provided that the secular trend can be reversed. This would be possible only if the necessary condition is met, i.e., the composition of the basket of commodities has to change in favor of non-traditional exports. Secondly, it has to have a significant weightage in the basket of exports. Thirdly, **it would be necessary to establish the condition that would support non-price competition and more buoyant elasticity. This could happen only if high value added agro exports are promoted so as to displace agro export in the traditional export.**

The supply side factors like output and rainfall dominate. They have the largest coefficients. This is a good sign. One, it takes us away from the over-emphasis on export demand functions. Two, it points towards the 'vent for surplus theory'. It would not be an exaggeration to say that India's agricultural exports are supply driven. This is the advantage of estimating a simultaneous equation model. In the state of equilibrium, it allows judgment about the underlying factors, whether supply or demand.

## 6. Limitations of the study

The study suffers from the following limitations: -

1) value of agricultural exports is affected by lagged agricultural export supply and relative price has significant impact on it. This may form the subject for more analysis; and

2) Closer examination of the time-frame examined in the study may reveal more structural changes which may be considered for endogenous and exogenous structural break analysis.

**7. Contributions of the Study**

- The manuscript has attempted to provide a framework that enables estimation of agricultural export function. Individual estimates of export demand and export supply are incomplete since they suffer from a single equation bias. The solution therefore is to estimate a simultaneous equation which in the case of the manuscript has been done with the help of the two stage least square procedures.

- The result indicates that Price coefficient is significant and low. Hence, the authors believe the ECLA (Economic Commission for Latin America) argument still holds good (Prebisch, 1950).

- The manuscript demonstrates that as the price level of agricultural commodities rises by one percent, the value of export rises only 0.06 percent. Therefore, India does not have to sell its agro-commodities "cheap" to gain in terms of value of export.

- Supply side factors have larger positive coefficient compared to Demand side factors. This suggests that it is not advisable to emphasize on export demand function at the cost of export supply function. This also validates the 'vent for surplus theory'.

- As the export competitiveness of non-traditional agricultural exports has not declined, we should move towards exporting them.

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**a)** [i] **Constructing Price Index using Fisher's Index**

To estimate the Agricultural export function, we need to estimate price of exports first. In order to proceed, Fisher price index has been used.

The Fisher's price index is a weighted index for measuring the price of a basket of goods and/or services. The procedure involves drawing weights from both *base period* and the *terminal* (*current)* period. It is defined as the geometric mean of the Laspeyre's price index (which only uses the base period basket) and the Paasche's price index (which only uses the terminal period basket). For this reason, the Fisher price index (named after American economist Irving Fisher) is also known as the "ideal" price index.

The choice of a price index formula (Laspeyre's, Paasche's or Fisher's) in a particular case is partly determined by the data available.

*Laspeyre's index*

$$P_L = \frac{\sum(p_t \cdot q_0)}{\sum(p_0 \cdot q_0)} \quad \text{………} (15)$$

This compares the price of the old basket of goods $q_0$ for the old and new prices.

*Paasche's index*

$$P_P = \frac{\sum(p_n \cdot q_n)}{\sum(p_0 \cdot q_n)} \quad \text{………} (16)$$

This compares the price of the new basket of goods $q_n$ for the old and new prices.

Fisher's index

$$P_F = \sqrt{P_P \cdot P_L} \quad \text{………} (17)$$

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Fisher index has been used as it takes away the limitation of other two indices. Laspeyre's uses the quantity of old basket of goods as a weight whereas Paasche's use current basket of goods as weights. However, the Fisher's index shows combined effect of both the indices.

Agricultural commodities used in the analysis are as follow: - Tea, Rice milled, cashew nut shelled, cakes of soya bean, coffee(green), tobacco (unmanufactured), oil of castor seeds, onion (dry), buffalo meat, sesame seed, cake of rapeseed. The period of study is 1991-2022. Following formula used to calculate price index for 1990-91: -

$$P_{1990\text{-}91} = \sqrt{\frac{\varepsilon P91Q90}{\varepsilon P90Q90}} \times \sqrt{\frac{\varepsilon P91Q91}{\varepsilon P90Q91}} \times 100 \ldots\ldots\ldots (18)$$

Similarly, on the same way price estimation for different years is made and the time series of price for agricultural export is obtained.