CHAPTER VI

ANALYSIS OF EXPORT PERFORMANCE

6.1. Analysis of Growth Rates

In order to assess the export performance of commodities under study, we have calculated compound growth rates and examined its behaviour for the whole period from 1980-81 to 2001-02 and also separately for the sub-periods from 1980-81 to 1990-91 and from 1991-92 to 2001-02.

A compound annual growth rate is worked by using the following equation:

\[ Y_t = a b^t \]

Taking logarithms of the above equation to base 10 gives

\[ \log Y_t = \log a + t \log b \]

i.e. \( Y = A + Bt + u_t \)

where \( Y \) is the dependent variable, \( t \) is the trend, \( A \) and \( B \) are the parameters and \( u_t \) is the error term with the usual classical properties. An estimate of ‘\( B \)’ can be obtained by fitting a linear regression based on the OLS method. The compound annual growth rate is derived as \((\text{Antilog } B - 1) \times 100\). The regression results are furnished in Table – 7.1.

The compound annual growth rate of cashew exports in terms of quantity for the period from 1980-81 to 2001-02 was 6.40 percent. For the first period of 1980-81 to 1991-92, the growth rate was limited to 3.97 percent, whereas during the second period of
Table – 6.1: Regression Results: Time Trend and Estimates of Growth

<table>
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<tr>
<th>Variable</th>
<th>Parameter Estimate</th>
<th>T-stat</th>
<th>P-value</th>
<th>Estimate of ‘g’ as %</th>
<th>R Square</th>
<th>Adj. R</th>
<th>F-ratio</th>
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Source: Computed from Data on Exports of Commodities
1991-92 to 2001-03, the growth rate was higher at 7.05 percent. The export behaviour in terms of value in USD earnings also corroborated the finding. It showed a comparatively better performance in the second period. The overall compound growth recorded six percent and the first sub-period showed a growth rate of 4.20 percent, while the second sub-period registered a growth rate of 6.10 percent. The growth rate in the period of accelerated liberalisation was higher for cashew exports signifying that the policies and measures, and global trade environment were conducive to the export business of the cashew industry.

The analysis of annual compound growth rate of total spice exports in terms of quantity disclosed a similar pattern as in the case of cashew exports. The annual compound growth rate for the whole period recorded 6.96 percent and the first sub-period showed a growth of 3.16 percent and the second period had a better result of 6.08 percent. The results convey that the export of spices in terms of quantity had a better performance in the second period of liberalisation.

The quantity of pepper exports, which is considered to be the pride of exports from Kerala, however, showed a trend of reversal. The overall annual compound growth recorded a low rate of 0.45 percent only. The fist sub-period showed a higher rate of growth at 5.13 percent, whereas the second sub-period showed a negative annual compound growth rate of − 1.44 percent. It is quite plausible that liberalisation measures and external trade factors wrought havoc on the export performance of pepper. In terms of USD values of pepper exports as compiled by the FAO data, the whole period registered a growth rate of 0.02 percent. The first sub-period showed 12.70 percent and the second sub-period performed at a lower rate of 5.09 percent. The quantity based data of FAO also confirmed decelerating trade performance of the commodity in the second period.
The international trade in marine products and fisheries had to face a host of problems during the last decade owing to strict implementation of quality norms and procedures like HACCP (Hazard Analysis and Critical Control Points) and SPS (Sanitary and Phyto-sanitary measures) by the importing countries. The results on growth analysis reveal that the industry could weather the situation by showing a better performance. The overall growth rate of volume of exports for the period from 1980-81 to 2001-02 marked 10.37 percent. The first sub-period showed a growth rate of 4.73 percent and the second period produced better results with a growth rate of 8.79 percent. The export earnings in terms of USD values displayed the same pattern. The overall growth rate marked 9.02 percent, the first period showed 3.84 percent and the second period recorded 7.57 percent annual compound growth rate. It can be inferred that the period of threats and challenges helped the industry brace up to the new environment and could become competitive by quickly adapting to the changed systems.

The export of coir products, the traditional monopoly product of Kerala, exhibited a tendency of comparatively better performance in the latter decade, both in terms of quantity of exports and earnings. The volume of exports displayed annual compound growth rate of 4.98 percent for the entire range of period. The first period recorded a negative growth rate of -1.23 percent. However, the growth rate during the second period was to the extent of 8.38 percent, thus showing positive results. The export earnings in rupee terms displayed a similar trend. The growth rate of the latter period showed 15.47 percent, far exceeding the growth rate of 5.86 percent recorded in the first sub-period. The whole period registered an annual compound growth rate of 16.23 percent. It is to be noted that the coir exports did have comparatively fewer restrictions and hence, the industry could sustain the momentum of trade performance in the changed circumstances.
The exports of cardamom, which is a prime spice product from Kerala, recorded a negative annual compound growth rate of -4.24 percent for the entire period as a whole. The first period marked -16.97 percent, and the second period showed a far better result of 12 percent growth rate. In terms of export-earnings in rupees, the overall growth rate recorded in the whole period was 2.78 percent, the first sub-period performance decelerating at -15.45 percent, and the second period showed a positive growth rate of 20.41 percent.

The exports of tea in dollar earnings had a negative growth rate of -1.52 percent for the whole period. The first period showed a growth rate of 1.09 percent and the second period registered a lower rate of 0.26 percent. The exports of tea in terms of volume as per FAO data showed an overall growth rate of -1.12 percent. The first period growth rate decelerated at -1.29 percent and second period showed a better rate at 0.87 percent.

Thus, better export performance was evident in the sectors like cashew, marine products and coir, in the period of economic liberalisation and in the era of WTO regime. This contrasts with the lacklustre performance in the growth rate of the spices like pepper and plantation commodities like tea and coffee.

Based on the FAO data on pepper exports, in USD value terms, the entire period recorded a growth rate of 0.02 percent. The first period covering 1980-81 to 1990-91 showed annual export growth rate of 12.70 percent and the second period of 1991-92 to 2002-03 recorded a lower growth rate of 5.09 percent. In terms of quantity of exports as tabulated by FAO, the annual compound growth rate for the whole period registered only 0.0002 percent reflecting stagnation in external trade. The first period registered 5.18 percent and second period had a negative growth rate of -2.27 percent.
The USD value of total spice exports recorded an overall growth rate of 5.35 percent for the period from 1980-81 to 2002-03. The first sub-period registered a growth rate of 4.80 percent and for the second sub-period a higher growth rate of 9.63 percent is recorded. The export of tea in terms of quantity showed a negative growth rate of −1.12 percent for the entire period of 1980-81 to 2002-03. The first sub-period recorded a negative growth rate of −1.29 percent compared to second period growth rate of 0.87 percent. The result shows decline in the export of tea in terms of quantity.

6.2. Trend-break Analysis

Trend-break analysis was attempted to show whether major landmark events such as commencement of economic liberalisation in 1991 and implementation of WTO regime in 1995 had resulted in a remarkable and significant break in the trend of trade performance of the export items of major interest to Kerala. This section provides the statistical test for the exogenous structural change for the years 1991 and 1995. The statistical test adopted is a Dummy variable model using semi-log trend function. Trend analysis of log values of volume and earnings of exports was fitted incorporating dummy variables for the years 1991 and 1995 to verify the hypothesis of trend-breaks for these years.

Dummy variable model:

1) \[ \ln Y = a_0 + a_1 t + a_2 D_{1t} + e \]
2) \[ \ln Y = a_0 + a_1 t + a_2 D_{2t} + e \]
3) \[ \ln Y = a_0 + a_1 t + a_2 D_{1t} + a_2 D_{2t} t + e \]

Where \( D_1 = 1 \), for the period 1991-2001,
\[ = 0, \text{ otherwise}; \]
\( D_2 = 1 \), for the period 1995 - 2001,
\[ = 0, \text{ otherwise}; \]
Ln = natural logarithm

Y stands for time series data on volume or value of exports of the commodity for the period 1980-81 to 2001-02. The above dummy variable models were estimated by OLS regression of the annual time series data on volume and values of major export items of Kerala.

Trend-break is positive but not significant in the year 1991 for the volume of exports of cashew kernel. The result is same for the period after 1995. The trend-break analysis in value terms also confirm that though the time-series data showed positive trends, the shifts in trends are not statistically significant below 10 percent level of significance.

Both quantity and volume of exports of coir products recorded positive time trends, and trend-breaks registered by dummy variables were found to be statistically significant (below 10 percent level of significance) for both the years 1991 and 1995.

The trend-break analysis of export of marine products revealed that time trends were positive and statistically significant in terms of both quantity and value of exports for the period from 1980-81 to 2001-02. Trend-breaks were statistically significant for the year 1991 for both the variables - quantity of exports and export earnings. The analysis did not yield significant results for the year 1995. The trend-breaks were found to be significant for both quantity and value above 10 percent level for the year 1995.

The time trends of total spice exports for the whole period - 1980-81 to 2002-03 - showed positive and significant coefficients both for quantity and value of exports. The dummy variable for the year 1991 for value of exports in USD terms showed negativity but statistically not significant. For the year 1995, the volume of exports marked a statistically significant shift in export performance. Both quantity and value of exports exhibited statistically significant trend-breaks, at 10 percent level, for the year 1995.
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<td>8.58</td>
<td>0.00</td>
<td>-</td>
<td>-</td>
<td>-</td>
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<td>1.32</td>
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<td>-</td>
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<td>0.32</td>
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<td>0.00</td>
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<td>0.01</td>
<td>0.94</td>
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<td>0.00</td>
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<td>2.70</td>
<td>0.01</td>
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<td>-</td>
<td>-</td>
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<td>0.00</td>
<td>-</td>
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<td>2.14</td>
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<td>-</td>
<td>-</td>
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<td>0.64</td>
<td>20.16</td>
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<tr>
<td>- V</td>
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<td>1.71</td>
<td>0.10</td>
<td>-</td>
<td>-</td>
<td>-</td>
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<td>2.62</td>
<td>0.02</td>
<td>0.70</td>
<td>26.94</td>
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<td>-1.4</td>
<td>0.18</td>
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<td>0.63</td>
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<td>1.82</td>
<td>0.08</td>
<td>0.13</td>
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</tr>
<tr>
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<td>-0.56</td>
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<td>-</td>
<td>-</td>
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<td>1.41</td>
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<td>- V</td>
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<td>0.02</td>
<td>-</td>
<td>-</td>
<td>-</td>
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<td>0.56</td>
<td>-0.00</td>
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<td>1.19</td>
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<td>0.03</td>
<td>1.25</td>
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<td>0.81</td>
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<td>0.37</td>
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<td>-</td>
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<td>2.54</td>
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<td>0.15</td>
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<td>-</td>
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<td>3.80</td>
<td>0.00</td>
<td>0.48</td>
<td>11.44</td>
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<td>Tea V</td>
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<td>0.16</td>
<td>0.87</td>
<td>-0.33</td>
<td>-2.09</td>
<td>0.05</td>
<td>0.06</td>
<td>0.41</td>
<td>0.69</td>
<td>0.27</td>
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<tr>
<td>- V</td>
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<td>0.59</td>
<td>-0.33</td>
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<td>0.04</td>
<td>-</td>
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<td>0.31</td>
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<tr>
<td>- V</td>
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<td>-1.8</td>
<td>0.09</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>0.08</td>
<td>0.49</td>
<td>0.63</td>
<td>0.16</td>
<td>3.03</td>
</tr>
<tr>
<td>INX INR</td>
<td>0.17</td>
<td>12.1</td>
<td>0.00</td>
<td>0.02</td>
<td>0.91</td>
<td>0.37</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>0.98</td>
<td>595</td>
</tr>
<tr>
<td>- INR</td>
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<td>-</td>
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<td>- CuS</td>
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<td>0.00</td>
<td>0.02</td>
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<td>0.12</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>0.97</td>
<td>381</td>
</tr>
<tr>
<td>- CuS</td>
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<td>0.00</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>0.01</td>
<td>0.26</td>
<td>0.80</td>
<td>0.97</td>
<td>337</td>
</tr>
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<td>- ConS</td>
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<td>11.5</td>
<td>0.00</td>
<td>0.06</td>
<td>5.83</td>
<td>0.00</td>
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<td>0.97</td>
<td>0.35</td>
<td>0.99</td>
<td>1273</td>
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<tr>
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<td>0.00</td>
<td>0.07</td>
<td>11.36</td>
<td>0.00</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>0.99</td>
<td>1916</td>
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<tr>
<td>- ConS</td>
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<td>18.2</td>
<td>0.00</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>0.07</td>
<td>5.92</td>
<td>0.00</td>
<td>0.99</td>
<td>692</td>
</tr>
</tbody>
</table>

Source: Computed from data on exports of respective commodities
The time trends of quantity of exports of pepper though yielded positive values are not statistically significant for the whole period as shown by the low prob-values. The coefficients of dummy variables for the year 1991 and 1995 showed negative values, but are not statistically significant below 10 percent level. The USD values of exports of pepper showed statistically significant at one percent level for the year 1991. The coefficient of the dummy variable also is obviously negative, and significant. The coefficient of the dummy variable for the year 1995, though negative, is not statistically significant as shown by the high prob-value.

Trend-break analysis of pepper exports in terms of volume based on FAO data shows that the coefficient of dummy variables are negative for the years 1991 and 1995, but are not found to be statistically significant below 10 percent level, as indicated by high prob-values. The USD value of pepper exports recorded a statistically significant negative trend-break for the year 1991 as shown by the negative value of the dummy variable with lower probability value (seven percent level of significance). However, the year 1995 showed a positive break with no statistical significance for the coefficient value.

The long-term trend of cardamom exports in quantity registered statistically significant negative values for the whole period from 1980-81 to 2002-03. The coefficient of dummy variable for the year 1991 was negative, but not significant. However, for the year 1995, the dummy variable showed positive and significant value for quantity. In terms of export earnings in rupees, the whole period showed negative trend value, the year 1991 marked negative coefficient for dummy variable and the year 1995 exhibited positive coefficient, but the prob-values were found to be at high levels. The trend value of coffee exports in USD values, though positive, is not statistically significant. The coefficient value
of 1991 dummy, though positive, is not statistically significant. The coefficient value of 1995 dummy variable is both positive and statistically significant below 10 percent.

For Tea exports in USD values, the year 1991 showed statistically significant negative values. But, the year 1995 yielded positive values, but not significant below 10 percent level.

The exports from India as a whole in constant rupee values over the period from 1980-81 to 2001-02 showed positive time trend with statistical significance. The trend equation incorporating dummy variable for the year 1991 shows that the coefficient value of the dummy variable is not significant, though positive, indicating absence of a trend-break. Trend-break analysis using dummy variable for the year 1995 showed a negative coefficient value but without statistical significance as indicated by high probability values.

Time trend of aggregate exports in USD values produced positive values with good statistical significance as shown by low probability value. The coefficient value of dummy variable for the year 1991 and 1995 showed positive values, but with statistical significance above 10 percent level.

The time trend equations based on constant USD (1995 USD) values of exports of goods and services incorporating dummy variables for 1991 and 1995 yielded positive coefficient values with good statistical significance, as indicated by low prob-values.

6.3. Analysis of Export Demand Relationships – OLS Method

Double log linear OLS regression equations were estimated to find interrelationships among variables affecting export demand of the commodities having major export interest to Kerala. Time series data for all variables under investigation were compiled for the period from 1980-81 to 2000-01 from various sources.
The log values of quantity of cashew kernel exports were regressed on the log values of variables like unit value index of cashew (UVEX) (base = 1993 = 100), per capita income of the USA (PIUS), the total international trade in cashew exports (WEX), New York prices of cashew kernels (NYP) and time trend (Eq-I).

\[ Q_t (\text{Cashew}) = f(\text{UVEX, PIUS, WEX, NYP, TIME}) \]

Logarithmic transformation of the model on both sides would give regression equation as follows, with a random disturbance term, \( U_t \), with its usual classical properties.

\[
\log Q_t = a_0 + a_1 \log \text{UVEX}_t + a_2 \log \text{PIUS}_t + a_3 \log \text{WEX}_t \\
+ a_4 \log \text{NYP}_t + a_5 \log T + U_t 
\]

(Eq.1)

Logarithmic transformation is used in the present study because log linear form is proved to be better than a linear form for standard specification and direct estimation of elasticity parameters.

**Table - 6.3: Export Equation for Cashew - I**

<table>
<thead>
<tr>
<th>Regressors</th>
<th>Parameter Estimate</th>
<th>T-ratio</th>
<th>P-values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>0.38</td>
<td>0.10</td>
<td>0.92</td>
</tr>
<tr>
<td>UVEX</td>
<td>-0.88</td>
<td>-2.82</td>
<td>0.01</td>
</tr>
<tr>
<td>PIUS</td>
<td>1.28</td>
<td>1.41</td>
<td>0.18</td>
</tr>
<tr>
<td>WEX</td>
<td>0.40</td>
<td>2.90</td>
<td>0.01</td>
</tr>
<tr>
<td>NYP</td>
<td>0.21</td>
<td>0.85</td>
<td>0.40</td>
</tr>
<tr>
<td>Trend</td>
<td>-0.13</td>
<td>-1.37</td>
<td>0.19</td>
</tr>
</tbody>
</table>

Multiple R 0.95 R square 0.92 Adj R² 0.89 F-ratio 35.11

Source: Computed from data on variables specified

Of the variables only UVEX and WEX were found to be having coefficients with statistical significance with prob-values around 0.01. UVEX produces negative coefficients indicating its inverse relationship to the quantity of exports. WEX, as expected, had a positive coefficient value. PIUS and NYP yielded positive coefficient values showing direct
relationship among these variables and the dependent variable, but were not significant below 10 percent level. Time trend shows an inverse relationship, which is not significant. The values of Multiple R (0.95), R Square (0.92), Adjusted R^2 (0.89) and F ratio (35.14) confirm overall significance of the regression equation. The F-ratio was found significant with low prob-value.

The regression equation was re-cast by excluding the lowest significant variable, NYP, from the above equation. It did not result in any further improvement in the basic relationship explained by the first equation. Nature of relationships and levels of significance remained almost the same, with a small increment in F-ratio.

Log Qt = a0 + a2 log UVINt + a3 log PIUS_t + a4 log WEX_t + a5 log T + Ut (Eq.2)

**Table – 6.4: Export Equation for Cashew - II**

<table>
<thead>
<tr>
<th>Regressors</th>
<th>Parameter Estimate</th>
<th>T-ratio</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
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<td>-0.07</td>
<td>0.94</td>
</tr>
<tr>
<td>UVIN</td>
<td>-0.72</td>
<td>-2.89</td>
<td>0.01</td>
</tr>
<tr>
<td>PIUS</td>
<td>1.33</td>
<td>1.49</td>
<td>0.15</td>
</tr>
<tr>
<td>WEX</td>
<td>0.38</td>
<td>2.82</td>
<td>0.01</td>
</tr>
<tr>
<td>T</td>
<td>-0.13</td>
<td>-1.38</td>
<td>0.18</td>
</tr>
</tbody>
</table>

Source: Computed from data on variables specified

No remarkable changes were observed in the results, except for minor changes in the values of parameter estimates, t-ratios and prob-values. The significance of the regression equation has not improved.

When log values of quantity were regressed by log values of independent variables like UVEX, PIUS and time trend, PIUS turned out to be a major significant variable.

Log Qt = a0 + a1 log UVIN_t + a2 log PIUS_t + a3 log T + Ut (Eq. 3)
The US always continued to be a major export destination for cashew kernels and hence PIUS has a direct positive relationship with cashew exports from Kerala.

The regression equation among total quantity of coir exported and independent variables such as unit value of exports (UVEX) based on 1993 prices, per capita income of the US as a proxy for demand of the OECD countries (PIUS), Nominal Exchange Rate (NEX) and time.

$log Qt = a_0 + a_1 \log UVEX_t + a_2 \log PIUS_t + a_3 \log NEX_t + a_4 \log T + Ut \quad (Eq-4)$

### Table 6.5: Export Equation for Cashew - III

<table>
<thead>
<tr>
<th>Regressors</th>
<th>Parameter Estimate</th>
<th>T-ratio</th>
<th>P-values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
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<td>0.01</td>
</tr>
<tr>
<td>UVIN</td>
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<td>0.14</td>
</tr>
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<td>4.71</td>
<td>0.00</td>
</tr>
<tr>
<td>T</td>
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<td>-0.73</td>
<td>0.47</td>
</tr>
<tr>
<td>Mult R 0.94</td>
<td>R Square 0.88</td>
<td>Adj $R^2$ 0.85</td>
<td>F-ratio 40.17</td>
</tr>
</tbody>
</table>

Source: Computed from data on variables specified.

### Table 6.6: Export Equation for Coir - I

<table>
<thead>
<tr>
<th>Regressors</th>
<th>Parameter Estimate</th>
<th>T-ratio</th>
<th>P-values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
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<td>-0.40</td>
<td>0.69</td>
</tr>
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<td>UVEX</td>
<td>0.08</td>
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<tr>
<td>PIUS</td>
<td>1.14</td>
<td>1.36</td>
<td>0.19</td>
</tr>
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<td>NEX</td>
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<td>3.71</td>
<td>0.00</td>
</tr>
<tr>
<td>Trend</td>
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<td>-3.27</td>
<td>0.00</td>
</tr>
<tr>
<td>Mult. R 0.94</td>
<td>R square 0.88</td>
<td>Adj $R^2$ 0.85</td>
<td>F-ratio 28.34</td>
</tr>
</tbody>
</table>

Source: Computed from data on variables specified.

Except for time trend, all variables represented positive values. Only time trend and NEX produces statistically significant values. PIUS is significant above 10 percent. The values of $R^2$, adjusted $R^2$ and F-ratio denote significance of the regression equation.
The export demand equation was re-cast by including variables such as total production of coir in India (INP), world exports of coir (WEX), into (eq-4) above and excluding UVEX.

\[
\log Q_t = \alpha_0 + \alpha_1 \log \text{INP}_t + \alpha_2 \log \text{WEX}_t + \alpha_3 \log \text{PIUS}_t + \alpha_4 \log \text{NEX}_t + \alpha_5 \log T + U_t
\]

(Eq-5)

Table - 6.7: Export Equation for Coir - II

<table>
<thead>
<tr>
<th>Regressors</th>
<th>Parameter Estimate</th>
<th>T-ratio</th>
<th>P-values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>0.37</td>
<td>0.10</td>
<td>0.92</td>
</tr>
<tr>
<td>INP</td>
<td>0.13</td>
<td>0.31</td>
<td>0.75</td>
</tr>
<tr>
<td>WEX</td>
<td>0.35</td>
<td>1.70</td>
<td>0.11</td>
</tr>
<tr>
<td>PIUS</td>
<td>0.26</td>
<td>0.28</td>
<td>0.78</td>
</tr>
<tr>
<td>NEX</td>
<td>0.66</td>
<td>2.45</td>
<td>0.03</td>
</tr>
<tr>
<td>Trend</td>
<td>-0.31</td>
<td>-2.82</td>
<td>0.01</td>
</tr>
</tbody>
</table>

Mult. R 0.95 | R Square 0.90 | Adj R^2 0.87 | F-ratio 26.67

Source: Computed from data on variables specified

Except for time trend, all variables have positive coefficient values. But only NEX and TIME have significance below 10 percent. R square, adjusted R^2 and F-ratio indicate significance of the regression equation.

The demand equation was remodelled by inclusion of variables like world production of coir products (WDP).

\[
\log Q_t = \alpha_0 + \alpha_1 \log \text{UVEX}_t + \alpha_2 \log \text{WDP}_t + \alpha_3 \log \text{WEX}_t + \alpha_4 \log \text{PIUS}_t + \alpha_5 \log \text{NEX}_t + \alpha_6 \log T + U_t
\]

(Eq.6)

The regression results did not help improve significance of individual coefficients nor the overall significance of the equation.

Export demand equations for the dependent variable, quantity of exports of marine products and independent variables like unit value of exports (UVEX), international price of
fish products (IPR), per capita income of the US as a proxy of world income of the importing countries (PIUS), total quantity of fish production in the country (INQT) and Nominal Exchange Rate (NEX) were estimated by using double log linear regression equations for the period from 1980-31 to 2000-01.

\[
\log Q_t = a_0 + a_1 \log UVEX_t + a_2 \log IPR_t + a_3 \log PIUS_t + a_4 \log INQT_t + a_5 \log NEX_t + U_t
\]  

(Eq.7)

Table 6.8: Export Equation for Marine Products - I

<table>
<thead>
<tr>
<th>Regressors</th>
<th>Parameter Estimate</th>
<th>T ratio</th>
<th>P-values</th>
</tr>
</thead>
<tbody>
<tr>
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<td>-1.20</td>
<td>0.06</td>
</tr>
<tr>
<td>UVEX</td>
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<td>1.01</td>
<td>0.33</td>
</tr>
<tr>
<td>IPR</td>
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<td>1.90</td>
<td>0.08</td>
</tr>
<tr>
<td>PIUS</td>
<td>2.45</td>
<td>2.09</td>
<td>0.06</td>
</tr>
<tr>
<td>INQT</td>
<td>1.68</td>
<td>2.40</td>
<td>0.03</td>
</tr>
<tr>
<td>NEX</td>
<td>0.76</td>
<td>2.67</td>
<td>0.02</td>
</tr>
<tr>
<td>T</td>
<td>-0.72</td>
<td>-3.21</td>
<td>0.00</td>
</tr>
<tr>
<td>Mult R 0.98</td>
<td>R square 0.97</td>
<td>Adj R^2 0.96</td>
<td>F-ratio 86.14</td>
</tr>
</tbody>
</table>

Source: Computed from data on variables specified

Except for time trend, which showed a negative coefficient value, all the independent variables have taken positive coefficient values. All variables excluding UVEX are seen statistically significant below 10 percent level. The regression has resulted in R square value of 0.97 and adjusted R^2 value of 0.96 indicating statistical significance of the regression equation. The F-ratio is found to be statistically significant. The regression equation was recast by excluding the variable NEX from the above equation. The results did not yield any significant changes except for improved prob-values for the coefficient values of independent variables.
The equation was re-cast by replacing the NEX with log values of Real Effective Exchange Rate (REER) series (base- 1993 =100). The coefficient values of REER was found to take on negative values with significance above 10 percent level. There was no substantial change in the nature and significance of the coefficient values of other explanatory variables.

\[
\log Qt = a_0 + a_1 \log UVEX_t + a_2 \log IPR_t + a_3 \log PIUS_t + a_4 \log INQT_t + a_5 \log \text{REER}_t + a_6 \log T + U_t
\]  
(Eq. 8)

<table>
<thead>
<tr>
<th>Regressors</th>
<th>Parameter estimate</th>
<th>T ratio</th>
<th>p-values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>-25.24</td>
<td>-4.36</td>
<td>0.00</td>
</tr>
<tr>
<td>UVEX</td>
<td>0.47</td>
<td>0.86</td>
<td>0.40</td>
</tr>
<tr>
<td>IPR</td>
<td>0.18</td>
<td>3.14</td>
<td>0.01</td>
</tr>
<tr>
<td>PIUS</td>
<td>4.76</td>
<td>4.52</td>
<td>0.00</td>
</tr>
<tr>
<td>INQT</td>
<td>2.63</td>
<td>3.85</td>
<td>0.00</td>
</tr>
<tr>
<td>REER</td>
<td>-0.62</td>
<td>-1.11</td>
<td>0.28</td>
</tr>
<tr>
<td>T</td>
<td>-1.05</td>
<td>-4.14</td>
<td>0.00</td>
</tr>
</tbody>
</table>

| Source: Computed from data on variables specified |

Table – 6.9: Export Equation for Marine Products – II

Demand analysis for pepper exports was aimed at estimating regression equations for the period from 1980-81 to 2000-01. The quantity of pepper exported from India over this period was regressed on by the dependent variables like per capita income of the OECD countries (PIOECD), quantity of domestic production of pepper (INQT), total international trade in exports of pepper (WEX), relative price of Malabar pepper to international price (RMIP) and time trend.

\[
\log Qt = a_0 + a_1 \log \text{PIOECD}_t + a_2 \log \text{INQT}_t + a_3 \log \text{WEX}_t + a_4 \log \text{RMIP}_t + \log T + U_t
\]  
(Eq. 9)
Table - 6.10: Export Equation for Pepper - I

<table>
<thead>
<tr>
<th>Regressors</th>
<th>Parameter Estimate</th>
<th>T-ratio</th>
<th>P-values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>3.12</td>
<td>0.49</td>
<td>0.63</td>
</tr>
<tr>
<td>PIOECD</td>
<td>1.85</td>
<td>0.84</td>
<td>0.41</td>
</tr>
<tr>
<td>INQT</td>
<td>0.05</td>
<td>0.16</td>
<td>0.87</td>
</tr>
<tr>
<td>WEX</td>
<td>-1.32</td>
<td>-1.81</td>
<td>0.09</td>
</tr>
<tr>
<td>RMIP</td>
<td>-1.47</td>
<td>-1.98</td>
<td>0.07</td>
</tr>
<tr>
<td>T</td>
<td>-0.01</td>
<td>-0.05</td>
<td>0.96</td>
</tr>
</tbody>
</table>

Source: Computed from data on variables specified.

The estimation resulted in positive coefficient values for PIOECD and INQT, and negative coefficient values for WEX, RMIP and time trend. The parameter estimates of WEX and RMIP had values statistically significant below 10 percent level. But $R^2$, Adjusted $R^2$ and F-ratio recorded lower values, reducing overall significance of the regression equation.

The demand equation was re-cast by adopting independent variables such as relative price of Malabar pepper to international price, per capita income of the US, international trade in pepper and time trend.

\[
\log Q_t = a_0 + a_1 \log PIOUS_t + a_2 \log RMIP_t + a_3 \log WEX_t + \log T + U_t \quad (Eq. 10)
\]

Table - 6.11: Export Equation for Pepper - II

<table>
<thead>
<tr>
<th>Regressors</th>
<th>Parameter Estimate</th>
<th>T-ratio</th>
<th>P-values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>-31.22</td>
<td>-5.03</td>
<td>0.00</td>
</tr>
<tr>
<td>PIOUS</td>
<td>11.71</td>
<td>7.15</td>
<td>0.00</td>
</tr>
<tr>
<td>RMIP</td>
<td>-0.67</td>
<td>-0.68</td>
<td>0.50</td>
</tr>
<tr>
<td>WEX</td>
<td>-3.03</td>
<td>-4.17</td>
<td>0.00</td>
</tr>
<tr>
<td>T</td>
<td>-0.28</td>
<td>-1.17</td>
<td>0.26</td>
</tr>
</tbody>
</table>

Source: Computed from data on variables specified.
PIUS and WEX produced significant coefficient values. RMIP and trend gave negative coefficients with prob-values above 10 percent level. The explanatory power of the regression equation increased as denoted by $R^2$, adjusted $R^2$ and F-ratio.

When the quantity of pepper exports was regressed on by independent variables like relative price of Malabar pepper to international price, volume of domestic production and time trend, the coefficient values were found to be statistically significant. But the explanatory power of the demand equation was lower as indicated by $R^2$ and Adjusted $R^2$.

$$\log Qt = a_0 + a_1 \log PIUS_t + a_2 \log RMIP_t + a_3 \log T + Ut$$  
(Eq. 11)

### Table - 6.12: Export Equation for Pepper - III

<table>
<thead>
<tr>
<th>Regressors</th>
<th>Parameter Estimate</th>
<th>T ratio</th>
<th>P-values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>3.61</td>
<td>14.88</td>
<td>0.00</td>
</tr>
<tr>
<td>RMIP</td>
<td>-1.32</td>
<td>-2.31</td>
<td>0.03</td>
</tr>
<tr>
<td>INQT</td>
<td>0.26</td>
<td>3.61</td>
<td>0.00</td>
</tr>
<tr>
<td>T</td>
<td>-0.17</td>
<td>-1.99</td>
<td>0.06</td>
</tr>
<tr>
<td>Mult R</td>
<td>0.79</td>
<td>R Square 0.63</td>
<td>F-ratio 9.73</td>
</tr>
</tbody>
</table>

Source: Computed from data on variables specified

The regression equation was re-cast by including PIUS, RMIP, WEX and time trend as independent variables and quantity of pepper exported as dependent variable.

$$\log Qt = a_0 + a_1 \log PIUS_t + a_2 \log RMIP_t + a_3 \log WEX_t + a_4 \log T + Ut$$  
(Eq. 12)

### Table - 6.13: Export Equation for Pepper - IV

<table>
<thead>
<tr>
<th>Regressors</th>
<th>Parameter Estimate</th>
<th>T-ratio</th>
<th>P-values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>1.88</td>
<td>0.43</td>
<td>0.67</td>
</tr>
<tr>
<td>PIUS</td>
<td>1.90</td>
<td>1.65</td>
<td>0.12</td>
</tr>
<tr>
<td>RMIP</td>
<td>-1.35</td>
<td>-1.95</td>
<td>0.07</td>
</tr>
<tr>
<td>WEX</td>
<td>-1.08</td>
<td>-2.11</td>
<td>0.05</td>
</tr>
<tr>
<td>T</td>
<td>-0.02</td>
<td>-0.14</td>
<td>0.88</td>
</tr>
<tr>
<td>Mult R</td>
<td>0.71</td>
<td>R Square 0.51</td>
<td>Adj R$^2$ 0.38</td>
</tr>
</tbody>
</table>

Source: Computed from data on variables specified
The variables RMIP and WEX were found to be negatively related, with prob-values below 10 percent. PIUS had a positive coefficient with significance above 10 percent level. The explanatory power of the regression equation was found lower.

The log values of quantity of tea exports for the period from 1980-81 to 2001-02 were regressed by independent variables like unit value of exports (UVEX), unit value of world exports (UVWDX), per capita income of the US as a proxy of income for the importing countries (PIUS), and time factor.

The coefficient values of UVEX and PIUS were positive, and significant below 10 percent level. The variables UVWDX and time factor generated negative values. The coefficient value of UVWDX had prob-value higher than 10 percent.

\[
\log Q_t = a_0 + a_1 \log UVEX_t + a_2 \log UVWDX_t + a_3 \log PIUS_t + a_4 \log T + U_t \quad \text{(Eq. 13)}
\]

**Table 6.14: Export Equation for Tea - I**

<table>
<thead>
<tr>
<th>Regressors</th>
<th>Parameter Estimate</th>
<th>T-ratio</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>1.88</td>
<td>0.98</td>
<td>0.34</td>
</tr>
<tr>
<td>UVEX</td>
<td>0.71</td>
<td>1.93</td>
<td>0.07</td>
</tr>
<tr>
<td>UVWDX</td>
<td>-0.37</td>
<td>-0.75</td>
<td>0.46</td>
</tr>
<tr>
<td>PIUS</td>
<td>0.78</td>
<td>1.75</td>
<td>0.10</td>
</tr>
<tr>
<td>T</td>
<td>-0.21</td>
<td>-2.98</td>
<td>0.01</td>
</tr>
</tbody>
</table>

Source: Computed from data on variables specified

The demand model was re-cast by substituting world per capita income (WDPI) for US per capita income, other variables remaining the same.

\[
\log Q_t = a_0 + a_1 \log UVEX_t + a_2 \log UVWDX_t + a_3 \log WDPI_t + a_4 \log T + U_t \quad \text{(Eq. 14)}
\]
Both UVEX and WDPI produced positive coefficient values with prob-values around 0.10. UVWDX, however, had negative coefficient value, with prob-value far above 10 percent level.

The demand model was re-cast by incorporating independent variables such as share of India's international trade (SHINT), UVEX and PIUS.

\[
\log Q_t = a_0 + a_1 \log SHINT_t + a_2 \log UVEX_t + a_3 \log PIUS_t + a_4 \log T + U_t \quad (Eq. 15)
\]

### Table – 6.16: Export Equation for Tea - III

<table>
<thead>
<tr>
<th>Regressors</th>
<th>Parameter Estimate</th>
<th>T-ratio</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>0.96</td>
<td>1.21</td>
<td>0.24</td>
</tr>
<tr>
<td>SHINT</td>
<td>-1.08</td>
<td>-9.67</td>
<td>0.00</td>
</tr>
<tr>
<td>UVEX</td>
<td>0.21</td>
<td>2.58</td>
<td>0.02</td>
</tr>
<tr>
<td>PIUS</td>
<td>1.16</td>
<td>6.12</td>
<td>0.00</td>
</tr>
<tr>
<td>T</td>
<td>-0.02</td>
<td>-0.49</td>
<td>0.63</td>
</tr>
<tr>
<td>Multi R</td>
<td>0.96</td>
<td>Adj R^2</td>
<td>0.92</td>
</tr>
</tbody>
</table>

Source: Computed from data on variables specified

The share of world trade is negatively related to the quantity of exports and the coefficient value is found statistically significant. UVEX and PIUS had positive and significant coefficient values. The estimated regression assumes significance as indicated by R Square, Adjusted R^2 and F-ratio.
When demand equation was estimated with independent variables like SHINT, UVEX, UVWDX, PIUS, nominal exchange rate (NEX) and time trend, only SHINT and PIUS were found having coefficient values with statistical significance. The explanatory power of the regression was good.

\[
\log Q_t = a_0 + a_1 \log \text{SHINT}_t + a_2 \log \text{UVEX}_t + a_3 \log \text{UVWDX}_t + a_4 \log \text{PIUS}_t
\]

\[+ a_5 \log \text{NEX}_t + a_6 \log T + \epsilon_t \] (Eq. 16)

Table 6.17: Export Equation for Tea - IV

<table>
<thead>
<tr>
<th>Regressors</th>
<th>Parameter Estimate</th>
<th>T-ratio</th>
<th>P-values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>0.61</td>
<td>0.51</td>
<td>0.62</td>
</tr>
<tr>
<td>SHINT</td>
<td>-1.06</td>
<td>-8.02</td>
<td>0.00</td>
</tr>
<tr>
<td>UVEX</td>
<td>0.24</td>
<td>1.23</td>
<td>0.24</td>
</tr>
<tr>
<td>UVWDX</td>
<td>-0.07</td>
<td>-0.29</td>
<td>0.78</td>
</tr>
<tr>
<td>PIUS</td>
<td>1.24</td>
<td>4.28</td>
<td>0.00</td>
</tr>
<tr>
<td>NEX</td>
<td>-0.02</td>
<td>-0.30</td>
<td>0.77</td>
</tr>
<tr>
<td>T</td>
<td>-0.02</td>
<td>-0.49</td>
<td>0.63</td>
</tr>
</tbody>
</table>

Mult. R 0.97 | R Square 0.94 | Adj R² 0.92 | F-ratio 37.17

Source: Computed from data on variables specified

Aggregated export demand regression equation for India was fitted by OLS method. The export values in current USD (INX), as dependent variable was regressed with the independent variables such as Real Effective Exchange Rate (base-1995 = 100) (REER), unit values indices of exports with base 1995 = 100 (UVINX), OECD per capita income in current USD and time trend.

Table 6.18: Export Equation for Aggregate Indian Exports

<table>
<thead>
<tr>
<th>Regressors</th>
<th>Parameter Estimate</th>
<th>T-ratio</th>
<th>P-values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>-5.96</td>
<td>-3.12</td>
<td>0.01</td>
</tr>
<tr>
<td>REER</td>
<td>1.26</td>
<td>3.12</td>
<td>0.01</td>
</tr>
<tr>
<td>UVINX</td>
<td>1.16</td>
<td>5.54</td>
<td>0.00</td>
</tr>
<tr>
<td>PIOECD</td>
<td>1.38</td>
<td>3.71</td>
<td>0.00</td>
</tr>
<tr>
<td>T</td>
<td>-0.37</td>
<td>-4.32</td>
<td>0.00</td>
</tr>
</tbody>
</table>
| Mult R 0.98| R Square 0.98      | Adj R² 0.97 | F-ratio 174.08

Source: Computed from data on variables specified
\[
\log \text{INX}_t = a_0 + a_1 \log \text{REER}_t + a_2 \log \text{UVINX}_t + a_3 \log \text{PIOECD}_t + a_4 \log T + U_t \\
\text{(Eq. 17)}
\]

The variables REER, UVINX and PIOECD produced positive and statistically significant coefficient values. The explanatory power of the regression was found high with adjusted $R^2$ being 97 percent and F-ratio highly significant.

The log values of annual global import growth rate were added as an explanatory variable to the above model, but the coefficient value was found negative and less significant.

The aggregate export values of goods and services (\text{INX}_{cst}) in constant USD (1995) was regressed by the independent variables such as per capita income of the OECD in constant USD, REER, UVINX and time trend, all variables but time trend showed positive and statistically significant coefficient values.

\[
\log \text{INX}_{cst} = a_0 + a_1 \log \text{PIOECD}_{cst} + a_2 \log \text{REER}_t + a_3 \log \text{UVINX}_t + a_4 \log T + U_t \\
\text{(Eq. 18)}
\]

The regression yielded high explanatory power as denoted by adjusted $R^2$ and F-ratio with very low prob-value. About 96 percent of variation in the dependent variable, INX, was explained by the changes in independent variables.

**Table – 6.19: Export Equation for India’s Goods and Services**

<table>
<thead>
<tr>
<th>Regressors</th>
<th>Parameter Estimate</th>
<th>T-ratio</th>
<th>P-values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>-16.36</td>
<td>-3.82</td>
<td>0.00</td>
</tr>
<tr>
<td>PIOECD</td>
<td>3.50</td>
<td>3.33</td>
<td>0.00</td>
</tr>
<tr>
<td>REER</td>
<td>1.66</td>
<td>3.38</td>
<td>0.00</td>
</tr>
<tr>
<td>UVINX</td>
<td>1.27</td>
<td>4.03</td>
<td>0.00</td>
</tr>
<tr>
<td>T</td>
<td>-0.36</td>
<td>-3.76</td>
<td>0.00</td>
</tr>
<tr>
<td>Multi R</td>
<td>0.98</td>
<td>R Square 0.97</td>
<td>Adj R$^2$ 0.96</td>
</tr>
</tbody>
</table>

Source: Computed from data on variables specified.

6.4. Nonstationarity and Cointegration

6.4.1. Test for Stationarity

Time series data are to be tested for ‘stationarity’ of the variables. It is now recognized that any time-series trend study should also take into account the issue of
whether the error process is stationary around the trend. "Unit root" test is one of the popular tests, which is used to test for the stationarity of the residuals. This is done by fitting a first-order or Auto Regressive AR(1) regression, in that $Y_t$ is regressed on $Y_{t-1}$, i.e., the model takes the form:

$$Y_t = \rho Y_{t-1} + U_t$$

If the co-efficient of $Y_{t-1}$ (i.e. $\rho$) turns out to be 1 statistically, we face 'unit root' problem, i.e., a non-stationary situation. A unit root is an attribute of a statistical model of a time-series where autoregressive parameter is 1. A time-series, which contains unit root, is called 'random walk'. Conversely, a random walk is an example of a non-stationary time-series.

The above equation can also be expressed as,

$$dY_t = (\rho - 1) Y_{t-1} + U_t$$

$$= dY_{t-1} + U_t$$

where $d = (\rho - 1)$ and 'd' is nothing but 'd' which is the first-difference operator.

When a time-series becomes stationary after it is differenced once, the original (random walk) series is integrated of order one, indicated by I(1). Generally for 'd' times, the time-series is integrated of order 'd' or I(d). Consequently, a time-series, which is integrated of, order one or greater, can be called a non-stationary time-series. Hence, process I(0) and a stationary process are synonymous.

Non-stationarity of a time-series can be established by running a regression as in the above equations and compute "p" to know whether it is statistically equal to one or compute "d" to know whether is statistically equal to zero.

If one is estimating a regression model between a pair of variables X and Y, we estimate the following equation:

$$Y_t = a_0 + a_1 X_t + e$$

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Where, $a_0$, $a_1$ are parameters to be estimated and $e_t$ is the random or stochastic term.

The assumptions of the classical regression model require both $(Y_t)$ and $(X_t)$ to be stationary, i.e. the means and variances of the two series are constant over time. In the presence of non-stationary variables, we might get what is called a spurious regression, i.e. a regression with high $R^2$, 't' statistic that appear to be significant, but the results are without any economic meaning. The problem that may arise with the regression model listed above is that the two series may be random walks as they are called in econometrics. The random walks for $(X_t)$ and $(Y_t)$ are written as:

$$X_t = a_1X_{t-1} + e_x$$  (i)

$$Y_t = a_2 Y_{t-1} + e_y$$

where $e_x$, $e_y$ are white-noise processes independent of each other.

In a random walk process, the coefficient $a_1$ and $a_2$ are equal to 1. Such series are said to possess unit roots and are non-stationary. Therefore it becomes essential to test whether the series are stationary or not. Taking the example of the $(X_t)$ series, we shall demonstrate the procedure. The equation for $X_t$ may be generalized to include either constant term or a trend term or both. In order to show the various forms that the equation for $X_t$ may take, we first subtract $X_{t-1}$ from both sides of the equation (i) to yield:

$$X_t - X_{t-1} = a_1 X_{t-1} - X_{t-1} + e_x$$

$$\Delta X_t = \gamma X_{t-1} + e_x$$

Where, $\Delta$ is a first difference operator and $\gamma = (a_1 - 1)$

If the data generating process (DGP) includes a constant term and a trend, then the following modification is made:

$$\Delta X_t = \beta_0 + \gamma X_{t-1} + \beta_1 t + e_x$$

where, $t$, is a trend variable.
The parameter of interest in the above equation is $\gamma$. If $\gamma = 0$, then the $(X_t)$ series contains a unit root. We shall be testing the presence of unit roots employing the ADF testing procedure with the help of EViews software.

6.4.2. Unit Root Tests

Three different regressions can be used to test the presence of Unit Root.

$\Delta Y_t = \beta Y_{t-1} + \epsilon$

$\Delta Y_t = b_0 + \beta Y_{t-1} + \epsilon$

$\Delta Y_t = b_0 + \beta Y_{t-1} + b_2 t + \epsilon$

The difference between the three regressions concerns the presence of deterministic elements $b_0$ and $b_2 t$.

1 – Test if $Y$ is a pure Random Walk

2 – Test if $Y$ is a Random Walk with Drift

3 – Test if $Y$ is a Random Walk with Drift and deterministic Trend

Of the three methods of ‘unit root tests’ namely, Dicky-Fuller (DF), Augmented Dickey-Fuller (ADF), and Phillips-Perron (PP) tests, we have conducted ADF unit root tests on the time-series data and MacKinnan’s critical values are used as benchmarks.

6.4.3. Augmented Dickey-Fuller (ADF) Test

The simple unit root test described above is valid only if the series is an AR(1) process. If the series is correlated at higher order lags, the assumption of white noise disturbance is violated. The ADF and the Phillips-Perron (PP) tests use different methods to control for higher-order serial correlation in the series. The ADF test makes a parametric correction for higher-order correlation by assuming that the $Y$ series follows an AR($p$) process and adjusting the test methodology. The ADF approach controls for higher-order
correlation by adding lagged difference terms of the dependent variable ‘Y’ to the right-hand side of the regression:

\[ \Delta Y_t = \mu + \gamma Y_{t-1} + \delta_1 \Delta Y_{t-1} + \delta_2 \Delta Y_{t-2} + \ldots + \delta_p \Delta Y_{t-p} + \varepsilon_t \]

This augmented specification is then used to test:

\[ H_0: \gamma = 0 \]
\[ H_1: \gamma < 0 \]

6.4.4. Vector Error Correction and Cointegration Theory

The finding that many macro time series may contain a unit root has spurred the development of the theory of non-stationary time series analysis. Engle and Granger (1987) pointed out that a linear combination of two or more non-stationary series may be stationary. If such a stationary, or I(0), linear combination exists, the non-stationary (with a unit root), time series are said to be cointegrated. The stationary linear combination is called the cointegrating equation and may be interpreted as a long-run equilibrium relationship between the variables.

A vector error correction (VEC) model is a restricted VAR that has cointegration restrictions built into the specification, so that it is designed for use with nonstationary series that are known to be cointegrated. The VEC specification restricts the long-run behaviour of the endogenous variables to converge to their cointegrating relationships while allowing a wide range of short-run dynamics. The cointegration term is known as the error correction term since the deviation from long-run equilibrium is corrected gradually through a series of partial short-run adjustments.

As a simple example, consider a two-variable system with one cointegrating equation and no lagged difference terms. The cointegrating equation is:

\[ Y_{2t} = \beta Y_{1t} \]
And the VEC is
\[ \Delta Y_{1t} = \gamma_1 (Y_{2(t-1)} - \beta Y_{1(t-1)}) + \varepsilon_{2t} \]
\[ \Delta Y_{2t} = \gamma_2 (Y_{2(t-1)} - \beta Y_{1(t-1)}) + \varepsilon_{2t} \]

In this simple model, the only right-hand side variable is the error correction term. In the long run equilibrium, this term is zero. However, if \( Y_1 \) and \( Y_2 \) deviated from long run equilibrium in the previous period, the error correction term is nonzero and each variable adjusts to partially restore the equilibrium relation. The coefficients \( \gamma_1 \) and \( \gamma_2 \) measure the speed of adjustment.

6.4.5. Testing for Cointegration

Given a group of non-stationary series, one has to determine whether the series are cointegrated, and if they are, in identifying the cointegrating (long-run equilibrium) relationships. EViews software implements VAR-based Cointegration tests using the methodology developed by Johansen (1991, 1995). Johansen’s method is to test the restrictions imposed by Cointegration on the unrestricted VAR involving the series.

**Johansen’s Cointegration Test**

Consider a VAR of order \( p \):
\[ Y_t = A_1 Y_{t-1} + \ldots + A_p Y_{t-p} + B_t + \varepsilon_t \]

Where \( Y_t \) is a k-vector of non-stationary, \( I(1) \) variables, \( X_t \) is a d vector of deterministic variables, and \( \varepsilon_t \) is a vector of innovations. The VAR can be re-written as
\[ \Delta Y_t = \Pi \Delta Y_{t-1} + \sum_{j=1}^{p} \Gamma_j \Delta Y_{t-j} + B X_t + \varepsilon_t \]

Where, \( \Pi = \left[ \sum_{i=1}^{p} A_i \right] - I \), and \( \Gamma_i = - \sum_{j=1}^{p} A_{i-j} \)
Granger's representation theorem asserts that if the coefficient matrix $\Pi$ has reduced rank $r < k$, then there exist $k \times r$ matrices $\alpha$ and $\beta$ each with rank $r$ such that $\Pi = \alpha \beta'$ and $\beta'Y_t$ is stationary. The 'r' is the number of cointegrating relations (the cointegrating rank) and each column of $\beta$ is the cointegrating vector. The elements of 'x' are known as the adjustment parameters in the vector error correction model. Johansen's method is to estimate the $\Pi$ matrix in an unrestricted form, and then test whether we can reject the restrictions implied by the reduced rank of $\Pi$.

6.4.6. Number of cointegrating relations

In the case of $k$ endogenous variables, each of which has one unit root, there can be from zero to $k-1$ linearly independent, cointegrating relations. If there are no cointegrating relations, standard time series analyses such as the (unrestricted) VAR may be applied to the first-differences of the data. Since there are $k$ separate integrated elements driving the series, levels of the series do not appear in the VAR in this case.

Conversely, if there is one cointegrating equation in the system, then a single linear combination of the levels of the endogenous series, $\beta'Y_{t-1}$, should be added to each equation in the VAR. When multiplied by a coefficient for an equation, the resulting term, $\alpha \beta'Y_{t-1}$, is referred to as an error correction term. If there are additional cointegrating equations, each will contribute an additional error correction term involving a different linear combination of the levels of the series.

If there are exactly $k$ cointegrating relations, none of the series has a unit root, and the VAR may be specified in terms of the levels of all of the series. Note that in some cases, the individual unit root tests will show that some of the series are integrated, but the Johansen tests show that the cointegrating rank is $k$. This contradiction may be the result of specification error.
6.4.7. Cointegration Relations (vector)

Each column of the \( \beta \) matrix gives an estimate of a cointegrating vector. The cointegrating vector is not identified unless we impose some arbitrary normalization. EViews adopts the normalization so that the \( r \) cointegrating relations are solved for the first \( r \) variables in the \( Y_t \) vector as a function of the remaining \( k-r \) variables.

Note that one consequence of this normalization is that the normalized vector, which EViews provides will not in general, be orthogonal, despite the orthogonality of the unnormalized coefficients.

6.4.8. Deterministic Trend Assumptions

The data series may have nonzero means and deterministic trends as well as stochastic trends. Similarly, the cointegrating equations may have intercepts and deterministic trends. The asymptotic distribution of the LR (Likelihood Ratio) test statistic for the reduced rank test does not have the usual \( \chi^2 \) distribution and depends on the assumptions made with respect to deterministic trends. EViews provides tests for the following five possibilities considered by Johansen.

1. Series \( Y \) have no deterministic trends and the cointegrating equations do not have intercepts: \( H_2 (r): \Pi Y_{t-1} + BX_t = \alpha \beta' Y_{t-1} \)

2. Series \( Y \) have no deterministic trends and the cointegrating equations have intercepts: \( H_1^* (r): \Pi Y_{t-1} + BX_t = \alpha (\beta' Y_{t-1} + \rho_0) \)

3. Series \( Y \) have linear trends but the cointegrating equations have only intercepts:

\[ H_1 (r): \Pi Y_{t-1} + BX_t = \alpha (\beta' Y_{t-1} + \rho_0) + \alpha_1 y_0 \]

4. Both series \( Y \) and the cointegrating equations have linear trends:
5. Series have quadratic trends and the cointegrating equations have linear trends:

\[
H^*(r): Y_{t+1}^\prime + BX_t = a (b' Y_{t+1} + \rho_0 + \rho_1 t) + a_1 \gamma_0
\]

\[
H(r): Y_{t+1}^\prime + BX_t = a (b' Y_{t+1} + \rho_0 + \rho_1 t) + a_1 (\gamma_0 + \gamma_1 t)
\]

Where \(a_1\) is the (non-unique) \(k \times (k-r)\) matrix such that \(a' a_1 = 0\) and rank \(\{a, a_1\}\)

These five cases are nested from the most restrictive to the least restrictive, given any particular cointegrating rank \(r\)

\[
H_2(r) \subset H_1^*(r) \subset H_1(r) \subset H^*(r) \subset H(r):
\]

The Johansen Cointegration test on EViews is valid only for nonstationary series.

6.4.9. Number of Cointegration relations

The first part of the table provides the trace test for the number of cointegrating relations. The eigenvalues are present in the first column while the second column gives the LR (Likelihood Ratio) test statistic:

\[
Q_r = -T \sum_{i=r+1}^{k} \log(1 - \lambda_i)
\]

For \(r = 0, 1, \ldots, k-1\) where \(\lambda_i\) is the \(i\)-th largest eigenvalue. \(Q_r\) is termed the trace statistic and is used to test \(H_1(r)\) against \(H_1(k)\).

To determine the number of cointegrating relations \(r\), subject to the assumptions made about the trends in the series, one has to proceed sequentially from \(r = 0\) to \(r = k-1\) until one fails to reject. The first row in the table tests the hypothesis of no Cointegration, the second row tests the hypothesis of one cointegrating relation, the third row tests the hypothesis of two cointegrating relations, and so on, all against the hypothesis of full rank, i.e. all series in the VAR are stationary.

EViews displays the critical values for the trace statistic reported by Osterwald-Lenum (1992), not those tabulated by Johansen and Juselius (1990). Johansen proposed an
alternative LR test statistic known as the maximum eigenvalue statistic, which tests $H_1(\tau)$ against $H_1(\tau + 1)$. The maximum eigenvalue statistic can be computed from the trace statistic as,

$$Q_{\text{max}} = \lambda^T \log (I - \lambda_{\tau+1}) = Q_\tau - Q_{\tau+1}$$

EViews does not provide critical values for the maximum eigenvalue statistic; critical values for this statistic are tabulated in Os erwald-Lenum (1992).

After the results of the Cointegration rank tests, EViews provides the estimates of the cointegrating vector or relations. Although EViews displays all possible $k-1$ cointegrating relations, the most interesting one is the first $r$ estimates, where $r$ is determined by the LR tests.

The cointegrating vector is not identified unless some arbitrary normalization is done. EViews adopts normalization such that the first $r$ series in the $Y_t$ vector are normalized to an identity matrix. The normalized cointegrating relation assuming one cointegrating relation $r = 1$ is given for all the tests. The numbers in parenthesis under the estimated coefficients are the asymptotic standard errors.

6.4.10. Error Correction Model and Granger Causality Test

A principal feature of co-integrated variables is that their time paths are influenced by the extent of deviation from long-run equilibrium. After all if the system is to return to long run equilibrium, the movements of at least some of the variables must respond to the magnitude of the disequilibria. Error correction models for the relationship

$$Y_t = a_0 + a_1 X_t + e$$  (1)
may be specified as follows:

\[ \Delta Y_t = \alpha_1 + \alpha_Y e_{t-1} + \sum_{i=1}^{\lambda} \alpha_{1i} (i) \Delta Y_{t-1} + \sum_{i=1}^{\lambda} \alpha_{12} (i) \Delta X_{t-1} + \varepsilon_{yt} \]

\[ \Delta X_t = \alpha_2 + \alpha_X e_{t-1} + \sum_{i=1}^{\lambda} \alpha_{21}(i) \Delta Y_{t-1} + \sum_{i=1}^{\lambda} \alpha_{22}(i) \Delta X_{t-1} + \varepsilon_{xt} \]

Where, \( e_{t-1} \) are the residuals from \((\cdot)\) and \( \varepsilon_{yt} \) and \( \varepsilon_{xt} \) are white-noise disturbances. The lags on \( \Delta Y_t \) and \( \Delta X_t \) are to be appropriately selected. The coefficients \( \alpha_Y \) and \( \alpha_X \) have the interpretation of speed of adjustment parameters. The larger is \( \alpha_Y \), the greater is the response of \( Y_t \) to the previous period's deviation from long-run equilibrium; if \( \alpha_Y \) is small the lower is the response of \( Y_t \). For the series \( (\Delta Y_t) \) to be unaffected by \( X_t \), \( \alpha_Y \) and all the \( \alpha_{12} (i) \) coefficients must be equal to zero; we would then say that \( X_t \) does not Granger-cause \( Y_t \).

Likewise, for the series \( (\Delta X_t) \) to be unaffected by \( Y_t \), \( \alpha_X \) and all the \( \alpha_{21} (i) \) must be equal to zero; in this case, we would say that \( Y_t \) does not Granger-cause \( X_t \).

6.5. Unit Root and Cointegration Tests for the Variables

<table>
<thead>
<tr>
<th>Time-series data of variables (Intercept &amp; Trend)</th>
<th>ADF Test Statistic</th>
<th>MacKinnan’s Critical Values</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>1 %</td>
</tr>
<tr>
<td>Cashew exports – Q I(0)</td>
<td>3.2545</td>
<td>4.4691</td>
</tr>
<tr>
<td>--------do-------- I(1)</td>
<td>6.0807</td>
<td>4.5000</td>
</tr>
<tr>
<td>World Exports cashew I(1)</td>
<td>4.0907</td>
<td>4.5348</td>
</tr>
<tr>
<td>Unit value of cashew ex. I(1)</td>
<td>4.6732</td>
<td>4.5743</td>
</tr>
<tr>
<td>Cashew-New York prices I(1)</td>
<td>3.3196</td>
<td>4.5348</td>
</tr>
<tr>
<td>Quantity - marine exports I(0)</td>
<td>1.9388</td>
<td>4.5000</td>
</tr>
<tr>
<td>--------do-------- I(1)</td>
<td>3.2299</td>
<td>4.5348</td>
</tr>
<tr>
<td>--------do-------- I(2)</td>
<td>6.9456</td>
<td>4.5743</td>
</tr>
<tr>
<td>US per capita income I(0)</td>
<td>2.6936</td>
<td>4.5000</td>
</tr>
<tr>
<td>--------do-------- I(1)</td>
<td>4.5447</td>
<td>4.5348</td>
</tr>
<tr>
<td>Quantity – pepper exports I(0)</td>
<td>2.9605</td>
<td>3.8067</td>
</tr>
</tbody>
</table>
The hypothesis that the given time-series is stationary is not rejected if the computed absolute value of ADF-statistic exceeds the MacKinnan critical values (at 1%, 5% and 10% level). A time-series becomes non-stationary if the computed value is less than the critical value.

6.5.1. Johansen Cointegration Test -- Cashew exports

All the four variables - quantity of cashew exports from India (Q), world exports of cashew exports (WEX), unit value of cashew exports from India (UV) and New York prices of cashew (NWKP) - were found non-stationary at simple log levels, as the ADF statistics were found to be less than the MacKinnan's critical values. But all the data variables are found stationary at the first-differenced series – all variables are integrated of order one. The

<table>
<thead>
<tr>
<th>Variable</th>
<th>I(0)</th>
<th>I(1)</th>
<th>I(2)</th>
<th>I(3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Relative Price of pepper</td>
<td>3.5535</td>
<td>4.5743</td>
<td>3.6920</td>
<td>3.2856</td>
</tr>
<tr>
<td>World exports of pepper</td>
<td>3.4200</td>
<td>4.5743</td>
<td>3.6920</td>
<td>3.2856</td>
</tr>
<tr>
<td>Quantity – Coir exports</td>
<td>2.3069</td>
<td>4.5000</td>
<td>3.6591</td>
<td>3.2767</td>
</tr>
<tr>
<td>Relative Price of pepper</td>
<td></td>
<td>3.0197</td>
<td>4.6193</td>
<td>3.7119</td>
</tr>
<tr>
<td>World exports of pepper</td>
<td></td>
<td>5.9283</td>
<td>4.5743</td>
<td>3.6920</td>
</tr>
<tr>
<td>Quantity – Cardamom x</td>
<td>2.4796</td>
<td>4.6913</td>
<td>3.6454</td>
<td>3.2602</td>
</tr>
<tr>
<td>Quantity – Tea exports</td>
<td></td>
<td>4.5000</td>
<td>3.6591</td>
<td>3.2677</td>
</tr>
<tr>
<td>Quantity – Coir exports</td>
<td>2.3069</td>
<td>4.5000</td>
<td>3.6591</td>
<td>3.2767</td>
</tr>
<tr>
<td>Quantity – Cardamom x</td>
<td>2.4796</td>
<td>4.6913</td>
<td>3.6454</td>
<td>3.2602</td>
</tr>
<tr>
<td>Quantity – Tea exports</td>
<td>2.2795</td>
<td>4.4691</td>
<td>3.6454</td>
<td>3.2602</td>
</tr>
<tr>
<td>Quantity – Coir exports</td>
<td></td>
<td>3.9161</td>
<td>4.6193</td>
<td>3.7119</td>
</tr>
<tr>
<td>Quantity – Cardamom x</td>
<td></td>
<td>4.5090</td>
<td>4.6913</td>
<td>3.6454</td>
</tr>
<tr>
<td>Quantity – Tea exports</td>
<td></td>
<td>3.8440</td>
<td>4.5000</td>
<td>3.6591</td>
</tr>
<tr>
<td>Exports of goods &amp; services</td>
<td>3.0197</td>
<td>4.5348</td>
<td>3.6746</td>
<td>3.2762</td>
</tr>
<tr>
<td>Per capita income OECD</td>
<td>3.5269</td>
<td>4.5743</td>
<td>3.6920</td>
<td>3.2856</td>
</tr>
<tr>
<td>Real effective exch. rate</td>
<td>2.4094</td>
<td>4.5743</td>
<td>3.6920</td>
<td>3.2856</td>
</tr>
<tr>
<td>Unit value index-exports</td>
<td>2.5200</td>
<td>4.5743</td>
<td>3.6920</td>
<td>3.2856</td>
</tr>
</tbody>
</table>

Source: Computed from data on variables specified

The hypothesis that the given time-series is stationary is not rejected if the computed absolute value of ADF-statistic exceeds the MacKinnan critical values (at 1%, 5% and 10% level). A time-series becomes non-stationary if the computed value is less than the critical value.
quantity of cashew exports and unit value of cashew exports have ADF statistics higher than one percent critical value. The quantity of world cashew exports has ADF statistic higher than five percent critical value and New York prices of cashew has ADF statistic higher than 10 percent critical value.

Johansen Cointegration test was conducted in EViews for finding out any linear deterministic trend among the above four data variables and the results are given below:

Table – 6.21: Cointegration Test – Cashew Exports

Test assumption: Linear deterministic trend in the data
Series: log Q / log WEX / log UV / log NWKP / log PIUS
Lags interval: 1 to 1

<table>
<thead>
<tr>
<th>Eigenvalue</th>
<th>Likelihood ratio</th>
<th>5 Percent Critical value</th>
<th>1 percent Critical value</th>
<th>Hypothesized No. of CE(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.978611</td>
<td>174.37</td>
<td>68.52</td>
<td>76.07</td>
<td>None</td>
</tr>
<tr>
<td>0.897723</td>
<td>105.16</td>
<td>47.21</td>
<td>54.46</td>
<td>At most 1</td>
</tr>
<tr>
<td>0.830708</td>
<td>64.12</td>
<td>29.68</td>
<td>35.65</td>
<td>At most 2</td>
</tr>
<tr>
<td>0.663156</td>
<td>32.15</td>
<td>15.41</td>
<td>20.04</td>
<td>At most 3</td>
</tr>
<tr>
<td>0.502571</td>
<td>12.56</td>
<td>3.76</td>
<td>6.65</td>
<td>At most 4</td>
</tr>
</tbody>
</table>

*(**) Denotes rejection of hypothesis at 5% (1%) significance level

L.R. Test indicates 5 cointegrating equations at 5% significance level.

Normalized Cointegrating Coefficients: 1 cointegrating equation

<table>
<thead>
<tr>
<th>Log Q</th>
<th>Log WEX</th>
<th>Log UV</th>
<th>Log NWKP</th>
<th>Log PIUS</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.000</td>
<td>-1.1742</td>
<td>0.7325</td>
<td>1.0437</td>
<td>0.5893</td>
<td>0.0333</td>
</tr>
<tr>
<td></td>
<td>(0.0691)</td>
<td>(0.0891)</td>
<td>(0.0877)</td>
<td>(0.2872)</td>
<td></td>
</tr>
</tbody>
</table>

Source: Computed from variables specified

The above Cointegration relation can be written as:
\[ \text{Log } Q = 1.1742 \text{ log WEX} + 0.7325 \text{ log UV} + 1.0437 \text{ log NWKP} + 0.5893 \text{ log PIUS} + 0.0333 \]

### 6.5.2. Granger Causality Test – Cashew Exports

As explained earlier, the Granger approach to the causality test is to see how much of the current ‘Y’ can be explained by past values of ‘Y’ and then to see whether adding lagged values of ‘X’ can improve the explanation. ‘Y’ is said to be Granger-caused by ‘X’, if ‘X’ helps in the prediction of ‘Y’ or equivalently, if the coefficients on the lagged ‘X’ s are statistically significant. Granger causality measures precedence and information content but does not by itself indicate causality in the more common use of the term.

#### Table – 6.22: Pairwise Granger Causality Test – Cashew Exports

<table>
<thead>
<tr>
<th>Null Hypothesis</th>
<th>Observations</th>
<th>F-Statistic</th>
<th>Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Log WEX does not Granger cause log Q</td>
<td>18</td>
<td>0.0299</td>
<td>0.9706</td>
</tr>
<tr>
<td>Log UV does not Granger cause log Q</td>
<td>18</td>
<td>0.7184</td>
<td>0.5058</td>
</tr>
<tr>
<td>Log NWKP does not Granger cause log Q</td>
<td>18</td>
<td>0.8824</td>
<td>0.4372</td>
</tr>
<tr>
<td>Log PIUS does not Granger cause log Q</td>
<td>18</td>
<td>0.1285</td>
<td>0.8805</td>
</tr>
</tbody>
</table>

Source: Computed from data on variables specified

The above test results show that there is no granger causality running from the independent variables to the dependent variable.

### 6.5.3. Johansen Cointegration Test – Marine Exports

ADF unit root test on the quantity of marine products exports revealed that the data series became stationary after second differencing. Therefore, the series are said to be integrated of order 2. All the variables in the Cointegration relation – Quantity of marine exports (Q), US per capita income (PIUS), domestic production of marine products...
(INDPD), and Nominal exchange rate of the rupee (NER) are tested at the second differences of the series.

**Table – 6.23: Johansen Cointegration Test: Marine Products**

Test assumption: Linear deterministic trend in the data

Series: Log MQ / log PIUS / log INDPD / log NER

Lags interval: 1 to 1

<table>
<thead>
<tr>
<th>Eigenvalue</th>
<th>Likelihood Ratio</th>
<th>5 percent Critical value</th>
<th>1 percent Critical Value</th>
<th>Hypothesized No. of CE(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.9862</td>
<td>150.24</td>
<td>47.21</td>
<td>54.46</td>
<td>None **</td>
</tr>
<tr>
<td>0.9077</td>
<td>77.46</td>
<td>29.68</td>
<td>35.65</td>
<td>At most 1 **</td>
</tr>
<tr>
<td>0.8003</td>
<td>36.96</td>
<td>15.41</td>
<td>20.04</td>
<td>At most 2 **</td>
</tr>
<tr>
<td>0.4304</td>
<td>9.57</td>
<td>3.76</td>
<td>6.65</td>
<td>At most 3 **</td>
</tr>
</tbody>
</table>

*(***) Denotes rejection of the hypothesis at 5% (1%) significance level.

L.R. Test indicates 4 cointegrating equation(s) at 5% significance level.

Normalized Cointegrating Coefficients: 1 Cointegrating Equation

<table>
<thead>
<tr>
<th>Log Q</th>
<th>Log PIUS</th>
<th>Log INDPD</th>
<th>Log NER</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.000</td>
<td>5.4166</td>
<td>-5.5736</td>
<td>0.7603</td>
<td>0.0068</td>
</tr>
<tr>
<td>(0.5844)</td>
<td>(0.6443)</td>
<td>(0.1224)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Log likelihood 162.87

Source: Computed from data on variables specified.

The above cointegration relation can be written as:

Log Q + 5.4166 log PIUS - 5.5736 log INDPD + 0.7603 log NER + 0.0068

**6.5.4. Granger Causality Test – Marine Products**

**Table – 6.24: Pairwise Granger Causality Tests – Marine Products**

Sample: 1982 – 2000

Lags: 2

<table>
<thead>
<tr>
<th>Null Hypothesis</th>
<th>Observations</th>
<th>F-statistic</th>
<th>Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Log PIUS does not Granger cause log Q</td>
<td>17</td>
<td>0.8984</td>
<td>0.4329</td>
</tr>
<tr>
<td>Log INDPD does not Granger cause log Q</td>
<td>17</td>
<td>1.5488</td>
<td>0.2521</td>
</tr>
<tr>
<td>Log NER does not Granger cause Log Q</td>
<td>17</td>
<td>8.3833</td>
<td>0.0052</td>
</tr>
</tbody>
</table>

Source: Computed from data on variables specified.
The test results show that there is no granger causation of the variables PIUS and INDPD on the quantity of marine exports. The null hypothesis is rejected at percent level of significance in the case of NER, which shows that nominal exchange rate has influenced the quantity of marine exports from India.

6.5.5. Johansen Cointegration Test – Pepper exports

It is proposed to examine Cointegration relation among the four variables – the quantity of pepper exports (Q), per capita income of the US (PIUS), world exports of pepper (WEX) and the relative price of Malabar pepper to international price (RMIP). The ADF unit root test shows that the series of quantity of pepper exports do not conform to stationarity at simple log level. But the first-differences of the log series exhibited stationarity at 1 percent level of significance. The log series of relative price of pepper were found stationary at the level at 5 percent significance. Obviously, the first-differenced series were stationary at 1 percent level of significance. Also, the first differenced series of the world exports of pepper were found stationary at 10 percent level of significance. It is concluded that the first-difference log series of all the four variables are stationary, and cointegration relationship can be probed.

Table – 6.25: Johansen Cointegration Test – Pepper Exports

Test assumption: Linear deterministic trend in the data
Series: log Q / log PIUS / log WEX / log RMIP
Lags interval: 1 to 1

<table>
<thead>
<tr>
<th>Eigenvalue</th>
<th>Likelihood Ratio</th>
<th>5 percent Critical Value</th>
<th>1 percent Critical Value</th>
<th>Hypothesized No. of CE(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.8532</td>
<td>83.79</td>
<td>47.21</td>
<td>54.46</td>
<td>None **</td>
</tr>
<tr>
<td>0.7599</td>
<td>49.25</td>
<td>29.68</td>
<td>35.65</td>
<td>At most 1 **</td>
</tr>
<tr>
<td>0.5398</td>
<td>23.57</td>
<td>15.41</td>
<td>20.04</td>
<td>At most 2 **</td>
</tr>
<tr>
<td>0.4134</td>
<td>9.60</td>
<td>3.76</td>
<td>6.65</td>
<td>At most 3 **</td>
</tr>
</tbody>
</table>

*(**) Denotes rejection of the hypothesis at 5 % (1%) significance level
L.R. test indicates 4 cointegrating equations at 5% significance level

Normalized Cointegrating Coefficients: 1 Cointegrating equation

<table>
<thead>
<tr>
<th></th>
<th>Log PIUS</th>
<th>Log WEX</th>
<th>Log RMIP</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Log Q</td>
<td>1.000</td>
<td>3.1303</td>
<td>3.5545</td>
<td>-0.7364</td>
</tr>
<tr>
<td></td>
<td>(1.5665)</td>
<td>(0.5323)</td>
<td>(0.6567)</td>
<td></td>
</tr>
</tbody>
</table>

Log likelihood 149.96

Source: Computed from data on variables specified

The above cointegration relation can be expressed as:

\[ \log Q + 3.1303 \log \text{PIUS} + 3.5545 \log \text{WEX} - 0.7364 \log \text{RMIP} - 0.0815 \]

6.5.6. Granger Causality Test – Pepper Exports

Table – 6.26: Pairwise Granger causality test – Pepper Exports

Sample: 1981 – 2000; lags 2

<table>
<thead>
<tr>
<th>Null Hypothesis</th>
<th>Observations</th>
<th>F-Statistic</th>
<th>Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Log PIUS does not Granger cause log Q</td>
<td>18</td>
<td>0.6355</td>
<td>0.5453</td>
</tr>
<tr>
<td>Log WEX does not Granger cause log Q</td>
<td>18</td>
<td>0.6202</td>
<td>0.5530</td>
</tr>
<tr>
<td>Log RMIP does not Granger cause log Q</td>
<td>18</td>
<td>1.4192</td>
<td>0.6662</td>
</tr>
</tbody>
</table>

Source: Computed from data on variables specified

The test results support null hypothesis, as there is no indication of statistically significant causation of independent variables on the quantity of exports of pepper.

6.5.7. Johansen Cointegration Test – Aggregate exports

It was proposed to conduct cointegration relationship among the variables – aggregate exports of goods and services from India in constant USD values (1995) (AGX), per capita income of the OECD countries as a proxy for world income (PIOECD), real effective exchange rate (REEX) and unit value index of exports (UVIX). The ADF unit root test results show that none of these variables are stationary at simple log levels. The first-differenced series of AGX became stationary at 5 percent significance level, and the first differenced series of the PIOECD was found stationary at 10 percent significance level. But the first differenced series of REEX and UVIX still remained nonstationary. Therefore, cointegration relationship was tested between the variables AGX and PIOECD only.
Table – 6.27: Johansen Cointegration Test – Aggregate Exports

Test assumption: Linear deterministic trend in the data
Series: Log AGX / log PIOECD; lags interval: one to one
Sample: 1981 – 2001; included observations - 19

<table>
<thead>
<tr>
<th>Eigenvalue</th>
<th>Likelihood ratio</th>
<th>5 percent Critical Value</th>
<th>1 percent Critical Value</th>
<th>Hypothesized No. of CE(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.6366</td>
<td>21.9266</td>
<td>15.41</td>
<td>20.04</td>
<td>None **</td>
</tr>
<tr>
<td>0.1323</td>
<td>2.6962</td>
<td>3.76</td>
<td>6.65</td>
<td>At most 1</td>
</tr>
</tbody>
</table>

*(**) Denotes rejection of the hypothesis at 5% (1%) significance level

L.R. test indicates 1 cointegrating equation at 5% significance level

Normalized Cointegration Coefficients: 1 Cointegrating Equation

<table>
<thead>
<tr>
<th>Log AGX</th>
<th>Log PIOECD</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.000</td>
<td>5.0731</td>
<td>-0.0885</td>
</tr>
<tr>
<td></td>
<td>(1.8 81)</td>
<td></td>
</tr>
</tbody>
</table>

Log likelihood 120.56

Source: Computed from data on variables specified

The above cointegration relation can be expressed as:

\[ \text{Log AGX} = 5.0731 \text{ Log PIOECD} - 0.0885 \]

6.5.8. Granger Causality Test – Aggregate Exports

Pairwise Granger causality test resulted in the acceptance of the null hypothesis that log PIOECD does not Granger cause log AGX.

The unit root testing and cointegration analysis have shown that most of the variables under investigation are stationary at the first differenced or second differenced series. They were also found to be cointegrated, indicating that the variables are in the long run drifting together. Hence there is a long-term association among the variables.