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Analysing and forecasting trade behaviour of major pesticide trading countries in the world

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ABSTRACT

To supply two meals per day to the ever increasing population of the world with limited resources, protection of crops against pests is an essential components in augmenting food production. Use of pesticides in this direction play is well established. Though hundreds of countries in the world use pesticides for the purpose, production and contribution of only a few countries play vital role in supply of pesticides through out the world. The present study is an attempt to visualize the nature of changes that have taken place in the major countries w.r.t the trade of pesticide i.e. import and export. It is revealed from the study that on an average 10-12 countries contribute more than 75% of the total world pesticide market. If supply of pesticides from these countries to the food growing zones get hampered by any means, the hole world will under food crisis. The study also revealed that there have been a quantum jump in the trade surplus of pesticides of these countries during last two decades and forecasting of export-import behaviour of these countries suggest that this trend will continue. On the basis of best fitted model forecasting values of the major pesticides countries w.r.t their import and export potentials have been suggested.

Key words : Export, forecasting, import, pesticides.

In a country like India, the second most populous in the world with a population of more than 11 billion, the planners are facing twin problems of ever increasing populations and limited resources. It has become a stupendous task to provide two square meals per day to its huge population. The possible avenues in mitigating the supply of balanced food are through a higher growth rate in production of food grains in conjunction with minimizing the loss of crops or food grains due to various factors. Pest and diseases of crops and stored food products contributes to the worsening of food supply. Near about 900 billion of rupees of crop yield is being lost due to attack of pests each year in India.

In nature nothing is to be treated as pests; all living and nonliving components have their own utilities in preserving our earth. It is indeed true that human beings are the most successful living creatures in this universe. And we the human being group some animals and plants and other things as 'pests' which endanger our food supply, health and comfort. In the process, to manage or to control these pests we have developed pesticides. Growth of pesticides industry and its use began after the World War II with the introduction of DDT, BHC, 2, 4-D etc. the miraculous effect of these pesticides was well accepted by the farming community towards the improvement in crop production. Indiscriminate use of pesticides in crop protection, household protection etc. was in vogue till the publications of the 'Silent Spring' by Rachel Carson in 1962. In her book the effect of indiscriminate and careless use of pesticide on environment was first pointed out. As a result of which situation specific and judicious use of pesticide was thought of and in this directions integrated pest management (IPM) came into effect as one of the tools in crop protection.

In a study by Knutson et al.(1990) opined that the ban of pesticides in US would lead to a drop in export of corn, wheat and soybean by 27% with a loss of 132000 jobs coupled with a 73% reduced crop yield in the above mentioned three crops. Another study by Hodgson (1991) reported that 95% of the productions of crops in developed countries were meant for export; in absence of pesticides these would not be possible. In India, the ministry of fertilizer is spending over Rs 100000 crores in the form of subsidy on fertilizer in every year and this amount would be of no use if adequate crop protection measures are not being taken simultaneously. An estimate shows that the crop loss due to pests etc. in absence of any use or inadequate use of pesticides may result in a loss of food stuff which is sufficient to feed $1/5^{th}$ of our population.

Today, pesticide (may be bio pesticides or some other eco-friendly pesticides) are regarded as one of the major components in crop productions throughout the world. Indian pesticide industry with a production of 85000 mt (2007) second in Asia and 12^{th} in World occupies a significant place in world pesticide industry. It is not only helping to protect our crops but also helps in earning a huge amount of foreign money. But the most striking features of consumption of pesticide in India is that it is very low , 381 gms/hectare compared to 500gms/hectare world

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wide. More over more than 64% of the total pesticides use in India during the year 2007 is accounted for insecticides, there by making a highly skewed consumption pattern of pesticides. So far as crop wise consumption of pesticides in India is concerned a report by Singhal, the Managing Director PI Industries (2000) indicate that 50%-55% consumption of pesticides is accounted for cotton crop only. Thus the average use of pesticides in India, leaving cotton, is very poor. On the other hand the export performance of Indian pesticides industries is recorded a bright performance over the years. An annual compound growth rate of 18% during the year 2003-2007 is recorded (Anonymous, 2009). In fact out of total estimated size of Rs 74 billion (2007) pesticides industries in India includes exports of Rs 29 billions, thereby forming export to the tune of more than 39% of the total turn over of the pesticides industries. With this importance of pesticides industries, both in and outside of the country, it is imperative and time worthy to study the growth and behaviour of Indian pesticides industries to the global contexts. The growth and behaviour of other major players in the world pesticide market needs to be critically examined to have policy formulations, future directives of the Indian pesticide industries under changing global scenario. With this pretext the present study is aimed at analyzing the behaviour, growth and trend of major importers and exporters of pesticides in global pesticide markets.

MATERIALS AND METHOD

Data used for the present study are collated from the website of Food and Agriculture Organisation, United Nations. For the present study country wise data of import and export in US$ terms for the period 1961-2006 have been used.

Country wise data for the year 2006 reveals that though the 10 most importer country of pesticides in the world imports only 44.61% of the total import, the first 10 exporter countries export more than 75% of the total export. It is also found that the most of the exporter countries though import a good amount of pesticides but their export is far beyond the import, thereby making a trade surplus countries with respect to pesticides trades in world. The countries like France, Germany Canada, USA, UK, Italy, Belgium, Brazil, Netherland, Poland, Spain,China are found to contribute near about 50% shares of import of pesticides with a contribution of more than 81% to export market. Another interesting feature is that there are certain countries like Israel which has surplus trade with respect to pesticides to be counted among the best ten performers with respect to surplus trade in pesticides in the world, but does not figure either in the list of ten best importers or exporters. As such the present study focuses on the import export of the following countries like India, China, France, Switzerland, UK, USA, Germany, Israel and Belgium-Luxemburg having trade surplus more than 1%.

Table 1: Import – Export performances of the major pesticide trading countries in the world

A: Import

Sl No	Country	Import Performance Value		Cumulative Import%
		('000US$)	%	
1	France	1462328	8.99	8.99
2	Germany	975375	5.99	14.98
3	Canada	859833	5.28	20.27
4	USA	655367	4.03	24.30
5	UK	646404	3.97	28.27
6	Italy	603081	3.71	31.98
7	Belgium	547171	3.36	35.34
8	Brazil	516941	3.18	38.52
9	Netherland	496295	3.05	41.57
10	Poland	494610	3.04	44.61

B : Export

Country	Export Performance Value		Cumulative Export %
	('000US$)	%	
France	2477606	14.79	14.79
Germany	2355308	14.06	28.85
USA	1906288	11.38	40.23
Belgium	1304887	7.79	48.02
China	1136184	6.78	54.80
UK	1020423	6.09	60.90
Switzerland	644567	3.85	64.74
India	635131	3.79	68.53
Netherlands	623290	3.72	72.26
Italy	512257	3.06	75.31

C: Surplus/Deficit in trade

Country	Import%	Export%	Imp-Exp.%
Germany	5.99	14.06	-8.07
USA	4.03	11.38	-7.35
France	8.99	14.79	-5.80
Belgium	3.36	7.79	-4.43
China	2.46	6.78	-4.32
India	1.09	3.79	-2.70
Switzerland	1.18	3.85	-2.66
Israel	0.36	2.95	-2.59
UK	3.97	6.09	-2.12
Netherlands	3.05	3.72	-0.67
Total	34.50	75.20	

Each and every series is subjected to test of randomness to examine whether the realized values have changed in a random fashion or have changed with a definite pattern. For the purpose test of randomness as given by Kendall and Stuart (1966) is used. Test for randomness is non-parametric test based on the number of turning points. The process is to count peaks and troughs in the series. A "peak" is a value greater than the two neighbouring values and a "trough" is a value, which is lower than of its two neighbours. Both the peaks and trough are treated as turning points of the series.

Hence the number of turning points "p" is then $p = \sum_{i=1}^{n-2} X_i$

then we have $E(p) = \sum_{i=1}^{n-2} E(X_i) = 2/3(n-2)$ and

$E(p^2) = E(\sum_{i=1}^{n-2} X_i)^2$ which ultimately comes out to be (40n2-144n+131)/90, resulting in

$Var(p) = E(p^2)-(E(p))^2 = (16n-29)/90$

It can easily be verified that as 'n', the number of observation increases the distribution of 'p' tends to normality. Thus for testing the null hypothesis: H_0: series is random

We have the test statistic, $\tau = \{p-E(p)\}/s_p \sim N(0,1)$

where, s_p is the standard deviation of 'p'.

Time series data are often criticized for having outliers in the set. Grubb's test for outlier is applied to find out the existence of outlier in the series.

The first step is to quantify how far the outlier is from the others. Calculate the ratio Z as the difference between the outlier and the mean divided by the SD. If Z is large, the value is far from the others. Note that we are to calculate the mean and SD from all values, including the outlier.

$$Z = \frac{|\text{mean} - \text{value}|}{SD}$$

Since the presence of an outlier increases both the numerator and denominator. Z does not get very large. In fact, no matter how the data are distributed, Z cannot get larger than $(N-1)/\sqrt{N}$, where N is the number of values. For example, if N=3, Z cannot be larger than 1.555 for any set of values and so on. Critical values for Z are provided by Grubbs and others. Once we identify an outlier, we may choose to exclude that value from our analyses / may retain or replace it.

Each and every series is then critically examined for its average performance, simple growth rate [{(last years observation – 1st years observation)/(1st years observation x No. of years)}x100] and compound growth rate [(b-1)*100] where b= the coefficient of the trend equation [$y_t=ab^t$].

The next objective of the present study is to forecast the trade behaviour of the pesticides trade surplus countries under consideration. For the purpose we have considered two parts: the whole period of investigation - the model building and validation period (1961-2006) and the forecasting period (2007-2012). For the purpose different linear and non-linear models have been used. Best fit models are selected based on the criteria of maximum value of coefficient of determination R^2 and the significance of the individual parameters of the models through t test. The best fit models have been used to predict the future behaviour of the series.

RESULTS AND DISCUSSION

The test of randomness (table 2) rejects the null hypothesis of randomness nature of all the series. Thereby, indicating that the export-import of the major pesticide trading countries have changed with a definite pattern. Critical examination of the nature of export and import performance of the countries under considerations reveals that both the import and the export values have increased many fold but the striking feature is that in most of the cases export performance has increased many times compared to the growth in import. On an average 8%-12% compound growth rates in export values are recorded among the countries with the exception of India, which has recorded a compound growth rate of 23.7%, highest among the countries (table 3). It can be seen from the table 1 that though India do not figures among the 10 major pesticide importers, it ranks 7 among the major exporters in year 2006. Among the countries France is found to be the maximum importer of pesticides amounting to 664 million US$ against an export of 774 million US$. Thereby, having a trade surplus of 110 million US$. The import of India is only 32 million US$ against an average export of around 97 million US$. Thus, the export is almost 3 times compared to that of import. Among the countries Germany is found to be the highest exporter of pesticides in world trade with 936 million US$ followed by USA 769 million US$, France 774 million US$ and UK 599 million US$. Positive skewness in all the series emphatically depicts that all these countries have steady progress in both export and import during the recent years (figure 1). These may be due to the augmented use of pesticides across the world coupled with the increasing number of importer countries.

With this pretext our next objective is to find out the suitable model which can picturise the changing behaviour of import and export of the major traders of pesticides in global market. As has already been pointed out , for the purpose we have used different linear and nonlinear models like linear, compound. growth, logistic, gompertz, exponential etc.. On the basis of the best models forecasting values have been generated up to the period 2012. Among the competitive models for each and every series, the best model has been selected on the basis of the criteria as mentioned in the materials and method section. The best fitted models are presented in table 4. It is clear from the table that, quadratic, cubic or compound growth models along with linear in one or two cases are suitable for capturing the behaviour of the series. These models, when used for forecasting purposes one can frame three groups of countries with these nine countries under onsideration (table 5). The first group of countries are characterized by continuing their existing trend in both the import and export of pesticides during the years to come; this group is comprised of the countries like India, France and Switzerland. The 2nd group of countries are those countries which have tendency of declining or static export but increasing import during the years to come; USA, UK and Germany are included in this group. The last group is consists of those countries which have declining import forecasts but increasing export forecasts for years to come; China, Israel and Belarus-Luxemburg figure among these countries. Thus from this finding it can be inferred that there is a likely possibility of changing scenario of export-import of pesticides in the world market. From this table it is also clear that the countries under third group are likely to change their Import : Export ratios to 1:17.25, 1:17.13 and 1:8 for China, Israel and Belarus-Luxemburg respectively against the figures 1:2.8, 1:8 and 1:2.35 during the year 2006. On the other hand India will continue to have its ratio around 1:3.5.

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Table 2 : Test of randomness

Country	Parameter	n	p	E(p)	Sp	τ	Sig
India	Import	46	18	29.33	2.80	-4.04	*
	Export	46	10	29.33	2.80	-6.90	*
	Import-Export	46	18	29.33	2.80	-4.04	*
China	Import	46	8	29.33	2.80	-7.61	*
	Export	46	9	29.33	2.80	-7.25	*
	Import-Export	46	8	29.33	2.80	-7.61	*
France	Import	46	14	29.33	2.80	-5.47	*
	Export	46	8	29.33	2.80	-7.61	*
	Import-Export	46	16	29.33	2.80	-4.76	*
Swiss	Import	46	12	29.33	2.80	-6.18	*
	Export	46	19	29.33	2.80	-3.69	*
	Import-Export	46	17	29.33	2.80	-4.40	*
UK	Import	46	12	29.33	2.80	-6.18	*
	Export	46	15	29.33	2.80	-5.11	*
	Import-Export	46	20	29.33	2.80	-3.33	*
USA	Import	46	17	29.33	2.80	-4.40	*
	Export	46	16	29.33	2.80	-4.76	*
	Import-Export	46	23	29.33	2.80	-2.26	*
Germany	Import	46	10	29.33	2.80	-6.90	*
	Export	46	13	29.33	2.80	-5.83	*
	Import-Export	46	17	29.33	2.80	-4.40	*
Isriel	Import	46	17	29.33	2.80	-4.40	*
	Export	46	11	29.33	2.80	-6.54	*
	Import-Export	46	13	29.33	2.80	-5.83	*
Bel_Lux	Import	46	16	29.33	2.80	-4.76	*
	Export	46	10	29.33	2.80	-6.90	*
	Import-Export	46	16	29.33	2.80	-4.76	*

n: no. of years, p: number of turning points, E(p) : Expectation of 'p', Sp: Standard deviation of 'p', τ : test statistic, * : significant at p= 0.05

Table 3: *Per se* performance of major pesticide trading countries during 1961-2006

Parameters	Import	Export	Import-Export	Import	Export	Import-Export	Import	Export	Import-Export
	India			**China**			**France**		
Minimum	1253	60	-461885	28335	19450	-1128708	3805	13640	-1015278
Maximum	178006	635131	32337	505030	1491443	280333	1774133	2633837	243444
Mean	32744	97310	-64566	229881	259237	-29356	664270	774270	-110000
SE	6034	23550	17933	23815	51567	41891	87731	116453	40680
Kurtosis	6	4	3	-2	4	7	-2	0	4
Skewness	3	2	-2	0	2	-3	0	1	-2
SG%	307	19722	-842	29	125	-182	833	393	222
CG%	7	24	-100	7	10	-100	13	13	-100
	Switzerland			**United Kingdom**			**Unites States of America**		
Minimum	1732	12930	-637737	2450	22410	-748963	140	53073	-1253034
Maximum	244035	755214	-11198	741150	1416538	-19870	748955	1906288	-50044
Mean	68378	362662	-294284	243445	599337	-355891	271367	769848	-510280
SE	9874	37620	29250	31713	68949	39322	33317	87223	59002
Kurtosis	0	-1	-1	-1	-2	-2	-1	-1	-1
Skewness	1	0	0	1	0	0	0	0	0
SG%	240	106	86	551	97	39	720	37	24
CG%	11	9	-100	13	10	-100	14	8	-100
	Germany			**Israel**			**Belgium-Luxemburg**		
Minimum	2578	49230	-1379933	777	150	-435215	2321	2390	-757716
Maximum	1000303	2355308	-46652	58784	493999	2308	547171	1304887	151156
Mean	314680	936358	-621678	24069	73991	-49922	176856	275356	-98500
SE	43588	100644	59861	2662	17249	15284	23193	45973	30539
Kurtosis	-1	-1	-1	-1	7	9	-1	3	4
Skewness	1	0	0	0	3	-3	1	2	-2
SG%	820	102	62	47	3462	-412	510	1185	23870
CG%	13	8	-100	9	13	-100	12	12	-100

SG% = Simple Growth Rate, CG% = Compound Growth Rate

Table 4: Forecasting Models

Country	Parameter	Model	R^2	Significance
India	Import	Cubic : $Yt = -24.648+8.679t-0.510t^2+0.009t^3$ (9.511) (1.733) (0.085) (0.001)	0.877	*
	Export	Cubic : $Yt = -36.857 + 12.705t -0.976t^2 + 0.0215t^3$ (19.626) (3.577) (0.176) (0.002)	0.965	*
China	Import	Cubic : $Yt = 85.686 -20.100 t+1.769t^2 -0.026t^3$ (32.475) (5.919) (0.291) (0.004)	0.908	*
	Export	Compound = 12.401×1.10^t (0.699) (0.002)	0.979	*
France	Import	Cubic : $Yt = 145.583 -52.379 t+ 4.288t^2 -0.054t^3$ (80.563) (14.686) (0.722) (0.01)	0.958	*
	Export	Quadratic: $Yt = 47.08 - 15.454t + 1.497t^2$ (73.468) (7.210) (0.149)	0.961	*
Switzerland	Import	Quadratic: $Yt = 6.853 - 1.313t + 0.127t^2$ (6.458) (0.634) (0.013)	0.958	*
	Export	Quadratic: $Yt = -109.743 +23.764t -0.118t^2$ (33.405) (3.279) (0.068)	0.923	*
UK	Import	Quadratic: $Yt = -30.101+ 4.296t + 0.237t^2$ (20.845) (2.046) (0.042)	0.958	*
	Export	Cubic : $Yt = 101.300 -34.895t+ 3.529t^2 -0.049t^3$ (53.487) (9.749) (0.479) (0.007)	0.97	*
USA	Import	Quadratic: $Yt = -31.322+ 6.319t + 0.195t^2$ (35.128) (3.448) (0.071)	0.889	*
	Export	Cubic : $Yt = 159.829 -30.593t+ 3.115t^2 -0.037t^3$ (64.944) (11.838) (0.582) (0.008)	0.973	*
Germany	Import	Linear : $Yt = -172.169 + 20.717t$ (30.421) (1.127)	0.885	*
	Export	Linear : $Yt = -229.922 + 49.629t$ (45.152) (1.672)	0.952	*
Israel	Import	Linear : $Yt = -6.826 + 1.314t$ (1.158) (0.043)	0.955	*
	Export	Compound = $0.94 \times 1.144t$ (0.218) (0.009)	0.848	*
Bl-LX	Import	Linear : $Yt = -84.152 + 11.107t$ (15.213) (0.564)	0.898	*
	Export	Compound =$6.088 \times 1.128t$ (1.41) (0.009)	0.818	*

Figures in parentheses are the standard errors.

Table 5: Forecasted values (million US$) for the period 2007-2012

	India		China		France		Switzerland		UK	
Year	Import	Export	Import	Export	Import	Export	Import	Export	Import	Export
2007	176	639	301	1094	1539	2627	225	746	695	1137
2008	197	704	270	1204	1528	2754	236	759	722	1103
2009	218	774	234	1324	1510	2883	247	771	749	1063
2010	242	849	195	1456	1484	3016	258	783	777	1015
2011	267	927	151	1602	1451	3152	270	795	805	959
2012	293	1011	102	1762	1410	3291	281	807	834	895

Table 5. conted.

Year	USA		Germany		Israel		Bl-Lux	
	Import	**Export**	**Import**	**Export**	**Import**	**Export**	**Import**	**Export**
2007	697	1760	802	2103	55	537	438	1787
2008	722	1774	822	2152	56	614	449	2016
2009	748	1785	843	2202	58	703	460	2276
2010	773	1790	864	2252	59	805	471	2568
2011	799	1791	884	2301	60	921	482	2898
2012	826	1787	905	2351	62	1055	493	3270