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DEMAND AND SUPPLY ANALYSIS OF FOREST PRODUCTS IN INDIA

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Forestry has to fulfil three sets of needs in a developing economy: (*a*) ecological security, (*b*) fuel, fodder and other domestic needs of the population and (*c*) the needs of the wood based small and large scale industries. Proper planning of this sector is essential for the smooth performance of the three roles which the forestry has to play. For proper planning advance estimates of the demand and supply are the most important among the different sets of information required. As such, in the present study an attempt has been made (*a*) to estimate the growth rates of demand and supply, (*b*) to determine the demand and supply functions and to work out the income and investment elasticities of demand and supply and (*c*) to project the demand and supply of major forest products in the country.

METHODOLOGY

These objectives are quantitatively assessed with the time-series data of demand and supply of major forest products and net national income and forest investment. In the present study demand refers to the total production plus import minus export. Supply refers to the total production. The data for demand and supply from 1968 to 1979 were taken from F.A.O. Year Books of Forest Products and the data for net national income at current prices and forest investment for the years 1968 through 1979 were obtained from the Statistical Abstracts of India.

To estimate the growth rates, we propose to use the compound growth function. The functional form used is:

$$Dit = a\ b^{t} \quad \ldots\ (1)$$

$$Sit = a\ b^{t} \quad \ldots\ (2)$$

For the purpose of estimation, the equations are expressed in logarithmic form:

$$\text{Log } Dit = \text{Log } a + t \text{ log } b \quad \ldots\ (3)$$

$$\text{Log } Sit = \text{Log } a + t \text{ log } b \quad \ldots\ (4)$$

The variable t includes years 1........12.

Dit = demand of ith forest product (i=1-2....21) in the tth year,

Sit = supply of the ith forest product (i=1-2....24) in the tth year.

The compound growth rates are obtained by the expression (anti-log b—1).

Demand and supply of different forest products are measured in physical units.

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To estimate demand and supply functions, we have used transcendental production function. An important mathematical property of this form is that it can exhibit increasing, decreasing and negative elasticities either singularly or in pairs or all the three simultaneously. The form is as follows:

$$Dit = a\ Yt^{b}\ e^{cYt} \quad \ldots.(5)$$

$$Sit = a\ It^{b}\ e^{cIt} \quad \ldots.(6)$$

Dit and Sit carry the same meaning as explained in equations (3) and (4).

Yt = net national income in year t in crores of rupees at current prices.

It = investment on forestry in year t in thousand rupees.

For the purpose of estimation, functions (5) and (6) are expressed in logarithmic forms as:

$$\text{Log Dit} = \text{Log a} + \text{b log Yt} + \text{cYt} \quad \ldots.(7)$$

$$\text{Log Sit} = \text{Log a} + \text{b log It} + \text{cIt} \quad \ldots.(8)$$

In order to test the goodness of fit of the models, in addition to the usual criteria of R^2 values and the test of significance of the regression coefficients, Theil 'U' test is also used. Theil 'U' test is defined as:

$$\text{'U'} = \sqrt{\frac{\Sigma\ (Dit/Sit - \hat{Dit}/\hat{Sit})^2/n}{\Sigma\ (\hat{Dit}/\hat{Sit})^2/n}}$$

Dit/Sit = observed values of demand/supply,

$\hat{Dit}/\hat{Sit}$ = expected values of demand/supply,

n = number of observations.

The income and investment elasticities of demand and supply are derived from equations (7) and (8).

Ed/Es = b + c Yt/It

Ed/Es = income and investment elasticities of demand and supply respectively.

Here Ed/Es depends upon the income and investment in each year, therefore, Ed/Es is worked out at the geometric mean level of income and investment to present an average situation. The projections of demand and supply are made by two approaches: (*i*) by the compound growth functions of demand and supply and (*ii*) by the transcendental production function using the projected income and investment data derived through the estimated compound growth rate equations of income and investment. The results obtained with both the approaches are compared.

RESULTS AND DISCUSSION

The results obtained for the first objective are shown in Tables I and II. All the (log b) coefficients are found to be positive and significant at 5 per

TABLE I—ESTIMATED EXPONENTIAL TREND EQUATIONS (DEMAND)

Forest product	Log a	Log b	S.E. (b)	R^2	Theil 'U'	Compound growth rate (anti-log b—1)
Roundwood ('000 m^3)	5·1969	0·0115*	0·0001	0·9986	0·0010	0·027
Fuelwood + charcoal ('000 m^3)	5·1732	0·0109*	0·0002	0·9977	0·0012	0·025
Charcoal ('000 mt)	3·0661	0·0099*	0·0006	0·9996	0·0016	0·023
Industrial roundwood ('000 m^3)	3·9280	0·0198*	0·0008	0·9857	0·0179	0·047
Sawl logs and veneer logs ('000 m^3)	3·7234	0·0195*	0·0014	0·9459	0·0395	0·046
Pit-props ('000 m^3)	2·9964	0·0105*	0·0015	0·8180	0·0389	0·024
Pulpwood and particles ('000 m^3)	2·4263	0·0673*	0·0091	0·8582	0·2453	0·168
Wood pulp ('000 m^3)	2·0791	0·0564*	0·0062	0·9035	0·1364	0·139
Other industrial roundwood ('000 m^3)	3·3048	0·0106*	0·0001	0·9984	0·0040	0·024
Sawn wood + sleepers ('000 m^3)	3·3678	0·0220*	0·0015	0·9565	0·0592	0·052
Wood based panels ('000 m^3)	2·1352	0·0139*	0·0052	0·4207	0·1358	0·032
Veneer sheets ('000 m^3)	—0·0424	0·1384*	0·0165	0·8598	0·3505	0·376
Plywood ('000 m^3)	2·0172	0·0117*	0·0047	0·3759	0·1301	0·028
Chemical wood pulp ('000 mt)	1·9011	0·0484*	0·0067	0·8517	0·1628	0·118
Other fibre pulp ('000 mt)	2·7585	0·0089*	0·0018	0·7127	0·0448	0·021
Paper + paper board ('000 mt)	2·9411	0·0117*	0·0017	0·8183	0·0417	0·028
Newsprints ('000 mt)	1·8954	0·0921*	0·0262	0·4826	0·1073	0·236
Printing + writing paper ('000 mt)	2·5811	0·0147*	0·0013	0·9150	0·0329	0·035
Wrapping + packaging paper + boards ('000 mt)	2·0820	0·0236*	0·0067	0·4996	0·1396	0·055
Dissolving wood pulp ('000 mt)	1·3288	0·0899*	0·0134	0·8517	0·2224	0·230

*Significant at 5 per cent level.
All the R^2 are significant at 5 per cent level.
The compound growth rate of the particle board was not found satisfactory and thus was omitted.

TABLE II—ESTIMATED EXPONENTIAL TREND EQUATIONS (SUPPLY)

Forest product	Log a	Log b	S.E. (b)	R^2	Theil 'U'	Compound growth rate (anti-log b—1)
Roundwood ('000 m^3)	5·1969	0·0115*	0·0002	0·9958	0·0026	0·027
Fuelwood + charcoal ('000 m^3)	5·1941	0·0077*	0·0015	0·9959	0·0260	0·018
Charcoal ('000 mt)	3·0658	0·0100*	0·00004	0·9997	0·0004	0·023
Industrial roundwood ('000 m^3)	3·9307	0·0196*	0·0005	0·9913	0·0165	0·046
Sawl logs + veneer logs ('000 m^3)	3·7253	0·0194*	0·0015	0·9452	0·0390	0·046
Pit-props ('000 m^3)	2·9964	0·0105*	0·0015	0·8182	0·0391	0·024
Pulpwood + particles ('000 m^3)	2·4256	0·0674*	0·0086	0·8581	0·2455	0·168
Wood pulp ('000 m^3)	1·8034	0·0799*	0·0098	0·8670	0·2647	0·201
Other industrial roundwood ('000 m^3)	3·3045	0·0106*	0·0001	0·9985	0·0043	0·024
Sawn wood + sleepers ('000 m^3)	3·3577	0·0236*	0·00004	0·9095	0·0554	0·055
Wood based panels ('000 m^3)	2·1681	0·0163*	0·0031	0·7271	0·0845	0·039
Veneer sheets ('000 m^3)	—0·1020	0·1302*	0·0143	0·8916	0·1936	0·350
Plywood ('000 m^3)	2·0392	0·0153*	0·0029	0·7313	0·0756	0·036
Chemical wood pulp ('000 mt)	1·6125	0·0766*	0·0095	0·8645	0·1997	0·193
Other fibre pulp ('000 mt)	2·7574	0·0091*	0·0017	0·7127	0·0449	0·021
Paper + paper board ('000 mt)	2·8738	0·0110*	0·0010	0·9166	0·0263	0·026
Newsprints ('000 mt)	1·5168	0·0206*	0·0038	0·7359	0·1073	0·048
Printing + writing paper ('000 mt)	2·5951	0·0127*	0·0014	0·9107	0·0312	0·030
Other paper + paper board ('000 mt)	2·5067	0·0076*	0·0020	0·5637	0·0523	0·017
Wrapping + packaging paper+boards ('000 mt)	2·0585	0·0267*	0·0068	0·6018	0·1396	0·064
Dissolving wood pulp ('000 mt)	0·7268	0·2557*	0·0371	0·8261	0·6576	0·802

* Significant at 5 per cent level.

All the R^2 are significant at 5 per cent level.

The compound growth rates of particle board, fibre board + compressed wood pulp and mechanical wood were not found satisfactory and thus were omitted.

cent level. In addition to all the R^2 values being significant, Theil 'U' values also being less than one and closer to zero indicate that the compound growth model provides a good fit for all the forest products. In the case of demand, the highest compound growth rate (37.6 per cent) is for veneer sheets followed by newsprints (23.6 per cent). In the case of supply, the highest compound growth rate (80.2 per cent) is for dissolving wood pulp followed by veneery sheets (35 per cent).

The results for the second objective are given in Table III. For both demand and supply most of the R^2 and Theil 'U' being significant and less than one respectively support the validity of the model used. In the case of demand most of the 'c' coefficients are positive and significant but only two 'b' coefficients are positive and significant. Some of the 'b' coefficients are negative and non-significant. In the case of supply analysis 'b' coefficients for thirteen products are positive and significant whereas 'c' coefficients for two products are positive and significant and for nine products are negative and significant. When both 'b' and 'c' are significant being positive or negative, they support the basic property of varying elasticity of the model used. In computing the income and investment elasticities the values of both 'b' and 'c' are used.

TABLE III—INCOME AND INVESTMENT ELASTICITIES OF DEMAND AND SUPPLY FOR FOREST PRODUCTS IN INDIA

Forest product	Income elasticity of demand	Investment elasticity of supply
Roundwood ('000 m3)	0·1022	0·1806
Fuelwood + charcoal ('000 m3)	0·0972	0·1885
Charcoal ('000 mt)	0·0917	0·1084
Industrial roundwood ('000 m3)	0·0089	0·3124
Sawl logs + veneer logs ('000 m3)	0·1805	0·1724
Pit-props ('000 m3)	0·0903	0·3722
Pulpwood + particles ('000 m3)	0·5993	2·1174
Wood pulp ('000 m3)	0·5130	1·1827
Other industrial roundwood ('000 m3)	0·0953	0·1753
Sawn wood + sleepers ('000 m3)	0·1953	0·1020
Wood based panels ('000 m3)	0·7691	—
Veneer sheets ('000 m3)	1·2217	1·6869
Plywood ('000 m3)	0·1168	0·0536
Particle board ('000 m3)	0·0604	0·4028
Fibre board + compressed wood pulp ('000 mt)	—	0·4509
Mechanical wood ('000 mt)	—	—
Chemical wood pulp ('000 mt)	0·4397	2·3676
Dissolving wood pulp ('000 mt)	4·6647	11·1809
Other fibre pulp ('000 mt)	0·0784	0·0221
Paper + paper board ('000 mt)	0·1025	0·1958
Newsprints ('000 mt)	0·1119	0·8550
Printing + writing paper ('000 mt)	0·1270	0·2601
Other paper + paper board ('000 mt)	—	0·0325
Wrapping + packaging paper + boards ('000 mt)	0·2526	0·2605

The values of income elasticities (Table III) can provide the basis for assigning priority to the production of wood products and thereby for planning the appropriate investment pattern. The products having income elasticity

TABLE IV—DEMAND PROJECTIONS OF FOREST PRODUCTS

Forest product	Projections							
	I 1980	II 1980	I 1985	II 1985	I 1990	II 1990	I 1995	II 1995
Roundwood ('000 m^3)	217,000	233,000	253,400	325,500	289,400	576,600	330,300	1,453,000
Fuelwood + charcoal ('000 m^3)	206,500	230,500	234,100	316,900	265,500	546,200	300,900	1,316,000
Charcoal ('000 mt)	1,566	1,631	1,755	2,164	1,967	3,503	2,205	7,617
Industrial roundwood ('000 m^3)	15,320	7,178	19,210	7,384	24,170	7,749	30,370	8,375
Sawl logs + veneer logs ('000 m^3)	9,482	10,390	11,870	18,550	14,860	49,870	18,600	246,300
Pit-props ('000 m^3)	1,358	1,407	1,532	1,882	1,730	3,096	1,952	6,911
Pulpwood + particles ('000 m^3)	2,001	—	4,342	—	9,423	—	20,450	—
Other industrial roundwood ('000 m^3)	2,771	2,902	3,130	3,962	3,537	6,743	3,996	15,920
Sawn wood + sleepers ('000 m^3)	4,506	4,955	5,805	9,441	7,478	28,470	9,634	169,400
Wood pulp ('000 mt)	649	—	1,243	—	2,379	—	4,553	—
Chemical wood pulp ('000 mt)	339	—	592	—	1,034	—	1,804	—
Dissolving wood pulp ('000 mt)	315	—	885	—	2,492	—	7,015	—
Paper + paper board ('000 mt)	1,240	1,297	1,418	1,815	1,623	3,223	1,857	8,143
Printing + writing paper ('000 mt)	592	624	701	944	830	1,919	983	6,027
Wrapping paper + packaging paper + boards ('000 mt)	245	—	321	—	421	—	553	—
Other fibre pulp ('000 mt)	748	777	829	1,007	919	1,570	1,018	3,216
Plywood ('000 m^3)	—	158	—	231	—	438	—	1,230
Newsprints ('000 mt)	—	250	—	362	—	681	—	1,888
Particle board ('000 m^3)	—	15	—	18	—	28	—	50

Projection I is based on compound growth rate equation.

Projection II is based on transcendental production function.

In projection I, projection for wood based panels, veneer sheets, plywood, newsprints and particle board were not satisfactory and thus not reported.

In projection II, projections for wood based panels, veneer sheets, pulpwood + particles, wood pulp, chemical wood pulp, dissolving wood pulp and wrapping paper + packaging paper + board were not found satisfactory, thus not reported.

To derive income (Yt) projections for 1980, 1985, 1990, 1995, the estimated compound growth rate equation is log $Yt = 4\cdot4057 + 0\cdot0466t$ $(0\cdot0018)$ $R^2 = 0\cdot9846$.

TABLE V—SUPPLY PROJECTIONS OF FOREST PRODUCTS

Forest product	Projections I 1980	II 1980	I 1985	II 1985	I 1990	II 1990	I 1995	II 1995
Roundwood ('000 m^3)	221,800	219,500	253,400	238,200	289,400	239,100	330,300	201,900
Fuelwood + charcoal ('000 m^3)	196,900	202,300	215,100	206,800	235,100	179,100	256,800	107,800
Charcoal ('000 mt)	1,570	1,549	1,761	1,800	1,976	2,280	2,217	3,491
Industrial roundwood ('000 m^3)	15,330	15,050	19,210	17,220	24,070	17,020	30,160	11,410
Sawl logs + veneer logs ('000 m^3)	9,497	10,210	11,870	18,790	14,850	64,850	18,560	885,300
Pit-props ('000 m^3)	1,358	—	1,532	—	1,726	—	1,952	—
Pulpwood + particles ('000 m^3)	2,004	—	4,353	—	9,458	—	20,550	—
Sawn wood + sleepers ('000 m^3)	4,618	5,063	6,060	13,020	7,952	105,200	10,430	10,420,000
Other industrial roundwood ('000 m^3)	2,769	2,724	3,128	2,846	3,534	2,629	3,993	1,854
Wood based panels ('000 m^3)	240	286	289	890	349	13,050	426	5,680,000
Plywood ('000 m^3)	173	191	206	400	246	2,048	293	82,450
Chemical wood pulp ('000 mt)	406	—	980	—	2,368	—	5,715	—
Other fibre pulp ('000 mt)	751	803	834	2,291	926	3,806	1,028	42,290
Paper + paper board ('000 mt)	1,040	1,016	1,180	1,026	1,340	856	1,521	470
Newsprints ('000 mt)	61	—	77	—	98	—	124	—
Wrapping paper + packaging paper + boards ('000 mt)	254	289	346	686	471	3,913	640	151,600
Printing + writing paper ('000 mt)	576	553	666	509	771	319	893	87
Other papre + paper board ('000 mt)	403	422	440	598	480	1,297	524	7,153
Fibre board + compressed wood pulp ('000 mt)	—	9	—	11	—	13	—	12

Projection I is based on compound rate equation.
Projection II is based on transcendental production function.
In projection I, projection for wood pulp, veneer sheets, particle boards, mechanical wood, dissolving wood pulp and fibre board + compressed wood pulp were found unsatisfactory, therefore deleted.
In projection II, projections for wood pulp, veneer sheets, particle board, mechanical wood, dissolving wood pulp, pit-props, pulpwood + particles, chemical wood pulp and newsprints were found unsatisfactory, therefore deleted.
To derive investment (It) projections for 1980, 1985, 1990, 1995, the estimated compound growth rate equation is $\log It = 5\cdot6543 + 0\cdot0680t$ $(0\cdot0027)$ $R^2 = 0\cdot9840$.

more than one and low investment elasticity are the items of priority. The products having low income elasticity, *i.e.*, between zero and one with low or high investment elasticity are to be given less priority in planning for production.

The results obtained on the projections of demand and supply based upon compound growth rate and transcendental function are given in Tables IV and V. The greater accuracy in the prediction power of either function is measured on the basis of lower Theil 'U' values calculated for both the functions. In the case of charcoal the time based projections of demand are 1.755 million and 1.967 million mt in 1985 and 1990 and the corresponding supply projections are 1.761 million and 1.976 million mt whereas the demand and supply projections for the same product based upon transcendental function are 2.164 million, 3.503 million and 1.8 million, 2.28 million mt respectively. For charcoal Theil 'U' values in the case of compound growth rate equations in demand and supply analysis are 0.0016 and 0.0004, whereas these values in the case of transcendental function in demand and supply are 0.0108 and 0.0139 respectively. Theil 'U' values being lower in the compound growth rate equation reveals that the projections made with this form of function are better than the transcendental function. This finding is also supported by the past data of production, import and export. For other products also the comparison of the predicting power of the functions can be made on the basis of Theil 'U' values.

In all the cases the demand projections based on income are greater than those based on time. This may be due to the income taken on current prices and also on the form of the function used. In the case of supply also time based projections are always increasing, whereas the investment based projections reflect the mixed situation, *i.e.*, in some cases the projected values are increasing with increase in the time period (charcoal). On the other hand, in the case of fuelwood + charcoal the projected value decreased after 1985. This may be attributed to the over-exploitation, long gestation period and finally on the form of the function used. Looking at the difference in the projected value of demand and supply, we can plan the production process by allocating the resources accordingly, *i.e.*, to give high priority for the products where the demand is more and supply is less.

CONCLUSION

The results obtained in the study are summarised. Based on the results of demand and supply functions, we have derived income and investment elasticities of demand and supply of different forest products. These elasticities can be used for proper allocation of resources for the development of forestry. For veneer sheets and dissolving wood pulp, the income elasticity being greater than one, therefore, more attention needs to be paid on the supply of the raw materials required for these products as compared to the other ones. Compound growth rates of demand show that veneer sheets, paper + paper board and dissolving wood pulp have a high growth rate, *i.e.*, more than 20 per cent. Nine products have shown a growth rate ranging between 2 to 4 per cent. In the case of supply, dissolving wood pulp has shown a growth rate of as high as 80 per cent. The products like pulpwood + particles, chemical wood pulp, wood pulp and veneer sheets have shown a growth rate of 16.8, 19.3, 20.1 and 35 per cent respectively. The growth rate of the rest of the products lies between 1.7 to 6.4 per cent.

Demand and supply projections give an idea of the probable quantities that will be demanded and supplied in future. The difference in their projected values has clear implications on the policy matter in the production of different forest products in order of priority.

EX ANTE ASSESSMENT OF AFFORESTATION FOR FUELWOOD ON WASTE LANDS—A MULTI-OBJECTIVE PROGRAMMING APPROACH

P. K. Joshi and A. K. Agnihotri*

The rapid deterioration of the eco-system due to fast deforestation, over-grazing, denudation of productive land, etc., has resulted in the fuel energy crisis, particularly in rural India. It has been estimated that as against the calculated requirement of about 133 million tonnes of fuelwood per annum in India, all the present and projected plan will help to produce only about 39 million tonnes.[1] It has been realised that with the current pace of fuel energy crisis, the problem will be further aggravated in years to come. The scarcity of fuelwood in the rural areas has led to the use of valuable substitutes, like animal dung and agricultural wastes[2] as fuel, which have alternative productive uses in the agricultural sector and can enhance the food production manifold besides maintaining soil fertility. To overcome the problem of fuelwood crisis, there is an urgent need for long-term and micro level afforestation planning to meet the fuelwood demand by exploiting the tremendous potential of available uncultivated waste and salt affected lands.[3]

Since agricultural land is becoming scarce, the afforestation for fuelwood on these lands may seriously affect food production in the long run. Therefore, all possible waste lands, particularly village panchayat lands, need to be managed appropriately for growing fuelwood trees. The present study,

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1. Report of the Fuelwood Study Committee, Planning Commission, Government of India, New Delhi, March, 1982.
2. Out of the estimated production of 324 million tonnes of animal dung (air dry), about 73 million tonnes have been estimated to be burnt for energy purposes. The consumption of agricultural waste for fuel purposes is about 41 million tonnes of the total of 203·5 million tonnes.
3. Afforestation technology for salt affected lands has been developed by the Central Soil Salinity Research Institute, Karnal. The technology is popularly known as 'auger-hole technique'.