Input Substitution in the Indian Paper Industry: a Variable Cost Function Approach

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Abstract

The trend towards trade liberalisation in developing countries is likely to increase the flow of recyclable waste paper from industrialised countries, raising concerns about the impact on local sources. Central to an analysis of the impact of international trade is the substitutability between imported and domestic waste paper by the paper industry as the main user of these inputs. It is particularly important in view of the uncertainty regarding future prices and availability of domestic forest raw materials and imported pulp. This paper presents the results of a survey which was undertaken among paper mills in Gujarat and Maharashtra, in India. The aim of the survey was to collect a cross section of data for firms in India which use waste paper as the primary material input to calculate not only an estimation of elasticities of substitution between imported and domestic waste paper but also the price and cross elasticities of raw materials, labour and energy. The results suggest that the substitution possibilities between the three specified inputs, are limited. The same conclusion is drawn for the substitution between imported and domestic waste paper, given the total material cost.

Resumen

La ruta hacia la liberalización del comercio en los países en desarrollo pareciera aumentar los flujos del papel de desecho reciclable desde los países industrializados, aumentando el interés sobre los impactos en las fuentes locales. Un aspecto central en el análisis del impacto del comercio internacional es la substituibilidad entre papel de desecho importado y doméstico, para la industria de papel como el principal utilizador de este recurso. Es de particular importancia en vista de la incertudimbre que se refiere a los precios futuros y la disponibilidad de materia prima forestal doméstica y la pulpa importada. Este documento presenta los resultados de una investigación llevada a cabo en aserraderos de papel en Gujarat y Maharashtra, en la India. El propósito de la investigación fue recolectar una sección cruzada de datos para empresas en la India que utilizan papel de desecho como el recurso material primario para calcular no sólamente una estimación de las elasticidades de substitución entre papel de desecho importado y doméstico, sino también el precio y las elasticidades cruzadas entre materia prima, trabajo y energía. Los resultados sugieren que las posibilidades de substitución entre los tres recursos especificados son limitadas. La misma conclusión se muestra para la subsitución entre el papel de desecho importado y local, dados los costos totales de los materiales.

Abrégé

La tendance à la libéralisation des échanges commerciaux dans les pays en développement risque de donner lieu à une augmentation du flux de déchets papetiers recyclables en provenance des pays industrialisés, phénomène dont l'impact sur les sources locales est cause d'inquiétude. Le potential de substitution entre les déchets de papier d'origine locale et ceux importés par l'industrie papetière - principal utilisateur de cette matière de base - constitue la pierre angulaire d'une analyse des effets du commerce international en la matière. Ce facteur prend toute son importance au vu de l'incertitude affectant les prix et la disponibilité futurs des matières premières forestières et de la pâte de cellulose importée. Ce document présente les résultats d'une enquête menée auprès des fabriques de papier du Gujarât et du Mahârâ_htra, en Inde, pour faire la collecte d'un échantillon représentatif de données relatives aux entreprises indiennes se servant des déchets de papier comme matière de base, afin d'établir non seulement une estimation des élasticités de substitution entre déchets papetiers d'origine importée ou domestique, mais aussi les prix et élasticités croisées des différents intrants: matière première, main d'œuvre et énergie. Les résultats de cette étude tendent à souligner l'aspect limité des possibilités de substitution entre ces trois facteurs de production. Étant donné le coût total de la matière, on est parvenu à une conclusion similaire quant à la substitution

entre déchets papetiers importés et locaux.

Contents

Introduction

The trend towards trade liberalisation in developing countries is likely to increase the flow of recyclable waste paper from industrialised countries, raising concerns about the impact on local sources. Central to an analysis of the impact of international trade is the substitutability between locally produced and imported waste paper by the paper industry as the main user of these inputs. It is particularly important in view of the uncertainty regarding future prices and availability of domestic forest raw materials and imported pulp: prices of both imported waste paper and pulp have risen sharply in recent years (Beukering *et al*. 1996).

To shed light on the issue of substitutability a survey was held in February-March 1995 amongst paper mills in Gujarat and Maharashtra, in India. The aim of the survey was to collect a cross section data for firms in India which use waste paper as the primary material input, to serve as a basis not only for the estimation of elasticities of substitution and but also of price elasticities of (derived) demand. In addition, the collected data provide the basis for the determination of the Material Flow Model in Beukering and Duraiappah, forthcoming.

This paper presents the results of this survey and the outcomes of the estimation of a variable cost production function. From these results the elasticities of substitution between imported and domestic waste paper are calculated, as well as the price and cross elasticities of raw materials, labour and energy.

The paper is structured as follows. The first section presents a short description of the survey results; in the following section the theoretical framework for the estimations is outlined, followed by their application. Empirical results are then presented after which conclusions are drawn in the final section.

The Survey

Sample selection

It was decided to select paper mills within the 700 km region around Bombay as Bombay is India's most important point of entry of imported waste paper. Within this area mills were selected randomly from an updated list of paper mills in the area constructed by the interview team. In total 70 paper mills were visited of which 68 interviews were sufficiently complete to be entered in a computerised data file

Selected mills had to fulfil four criteria:

1. the mill was running at the time of the appointment
2. the mill was using non-conventional (waste paper or agricultural residues) inputs
3. the owner of the mill had not been interviewed on a previous occasion
4. the interview could be fixed on short notice.

While the exclusion of wood based paper mills implies that the results are not representative for the whole paper sector, this does not seriously impact on the objectives of the project to evaluate the environmental impact of the international trade in waste paper. In addition, the results only hold for the Maharashtra/Gujarat region and not for the whole of India, although it may be argued that results are appropriate for most waste paper mills since they are generally located in or near large cities.

Sample description[9]

All but one of the 68 mills in the sample used waste paper in the production process. Eight mills used agricultural inputs, of which one used only agricultural inputs. Two thirds of all the mills (41) used imported waste paper. The main reason given (40 mills) was its quality (fibre strength), followed by the fact that the required type of waste paper was not available locally (21 mills), or that the local supply was not sufficient (17 mills). Although only eight mills used agricultural inputs, thirty indicated that they were technically capable of processing agricultural residues. In eight mills wood or bamboo could also be applied.

All the mills were established between 1932 and 1994, with an average age 15 years. The average age of the equipment was lower at 11.6 years since most mills had upgraded their machinery or expanded their capacity. Most of the equipment purchased at start-up, particularly for the more recently established mills, was produced in India (78%).

The selected mills were small in comparison to those in Europe or America. The average annual production of 6,700 tons per annum is much lower than quantities of 100,000 tons per annum which are realised in USA and EU (Ewing 1985). The average yearly turnover was 101 million rupees.

The majority of mills (43) produced one type of paper, usually kraft paper in different grades (burst factors). Fifteen mills produced two types of paper, and five mills produced three or more main products. Table 1 provides an overview of the principal types of paper produced.

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[9] For a more detailed description of the sample,see *The Indian Paper Industry, Facts and figures of the industry survey february, march 1995* by M.J. Bennis, P.J.H. van Beukering and J.G.M. Hoogeveen, background report, IVM De Boelelaan 1115, 1081 HV Amsterdam, 1995.

Table 1
Main types of paper produced

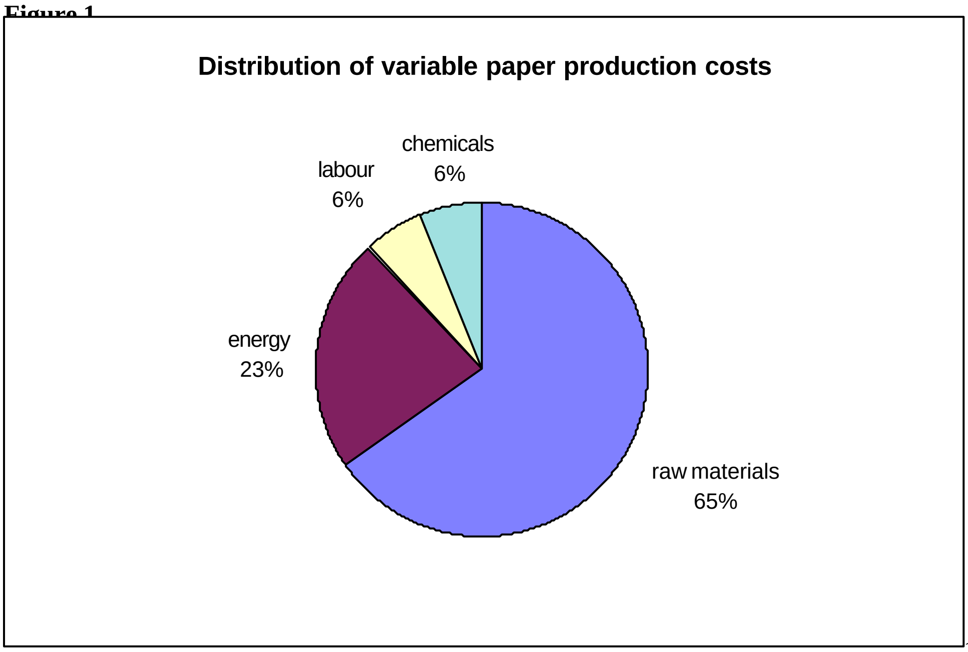
Type of paper	Observations
kraft	42
duplex board	5
(other) boards	8
newsprint	3
writing and printing	6
others	4
TOTAL	68

Modern equipment was not used, evidenced not only by the age of the equipment and the small size of the factories, but also by the types of paper most mills produced: the more popular kraft paper is easier to manufacture compared to writing and printing paper or duplex board.

The mills usually operated 24 hours a day, and employed a permanent workforce of between 20 and 750 people, usually men, with an average of 137 (excluding the owners). Women are rarely employed in this sector, usually taking on clerical or unskilled production work, or sorting waste paper as casual labourers. Casual labourers were employed in nearly half the mills (33), with an average of 38 persons per mill.

The variable production costs contain four main categories: raw materials (waste paper, agricultural inputs and wood pulp), chemicals (chlorine, rosin, soda, alum), labour and energy. The costs associated with these categories are variable at the level of production. Figure 1 presents the distribution of the variable production costs. On average, these costs accounted for 80 per cent of the sale price.

Figure 1



1

The aim of the analysis in this paper is the determination of cross elasticities between different inputs, particularly for the cross elasticity between imported and domestic waste paper. Therefore only those firms that used both imported and domestic waste paper are used in the calculations. Of the 41 mills that used imported waste paper, one used solely imported waste, hence 40 mills remain in the sample.

In the estimations capital has been measured as the replacement value of the current mill. In some cases this value is constructed using other relevant information provided by the firm, including:

1. cost of establishing/acquiring the mill
2. year of establishing the firm
3. age of the equipment at start up
4. total investments since start-up
5. age of the equipment at present
6. book value of land, buildings and equipment
7. market value of the firm.

Energy has been converted to joule equivalents, using the following conversion factors:

Table 2 Main types of energy sources

Energy source	Conversion factor (in millions KJ)
Coal (kg)	29
Electricity (kWh)	3.6
Natural Gas (m3)	30
Wood (kg)	16
Oil (l)	33

The price of materials is calculated as the weighted average of the price of domestic and imported waste paper whereby the weights are the shares of the values of domestic and imported waste in the total material value.

Table 3 Variables used in econometric analysis: mean, standard deviation and range

	Mean	Standard deviation	Maximum	Minimum
Capital (million rs)	125	220	1140	7.5
Wage (rs/employee/year)	26629	7690	44000	13817
Price of imported waste (rs/ton)	9182	2434	17000	5500
Quantity of imported waste (ton/year)	4311	3618	15188	151
Value of imported waste (million rs/year)	37.9	30.9	120.8	1.8
Price of domestic waste (rs/ton)	5415	1427	11000	2000
Quantity of domestic waste (ton/year)	5141	3056	14532	948
Value of domestic waste (million rs/year)	27.9	17.1	79.9	4.5
Value of materials (million rs/year)	65.9	41.1	146.9	13.2
Price of materials (rs/ton)	7393	1888	14029	4445
Price of energy (rs/million KJ)	0.15	0.05	0.34	0.08
Energy costs (million rs/year)	21.6	20.1	94.9	3.9
Total variable production costs (TVPC)	93.1	57.6	236	18.5
share of labour in TVPC	0.06	0.04	0.22	0.02
share of imported waste in TVPC	0.37	0.16	0.66	0.07
share of domestic waste in TVPC	0.34	0.14	0.67	0.03
share of energy in TVPC	0.23	0.09	0.56	0.13
share of materials in TVPC	0.71	0.13	0.88	0.29
share of imported waste in materials	0.51	0.19	0.96	0.11
share of domestic waste in materials	0.49	0.21	0.95	0.04

The Theoretical Framework

The estimation of elasticities of substitution and (derived) input demand is an exercise in applied production analysis. The conceptual framework is briefly explained below[10]:

Given the technology, producers make decisions regarding the use of inputs based on the technical possibilities embodied in the production function and on relative input prices. The concept of production function is used to represent the technical relationships between maximum output and a set of inputs given the state of technology. A specific functional form for the production function is assumed. The parameters of this function provide information on important characteristics of the technology, namely, elasticity of scale and elasticity of substitution. Elasticity of scale measures the proportional change in output due to a proportional change in all inputs. The concept of elasticity of substitution measures the ease of substitutability between two different inputs with constant output.

As an example, consider the well known Cobb Douglas production function:

$Q = AK^{á}L^{â}$, A > 0, á > 0, â < 1

where Q is output, K is capital and L is labour input and A is referred to as an efficiency parameter. It can be shown that á and â are parameters representing partial output elasticities of capital and labour and their sum (á + â) measures the elasticity of scale. The elasticity of substitution is unity for the above function. The implication is that all factors are "equally substitutable" with each other. Consequently the share of factors in total cost remains constant for all firms in the industry. This is a restrictive assumption.

In this paper the cost function is specified as the translog (or transcendental logarithmic) form. The translog cost function is a flexible functional form in the sense that it imposes few restrictions on the scale and substitution properties of the technology. In contrast to the Cobb-Douglas function, the estimated elasticities of substitution can now be different for each firm in an industry.

Direct estimation of a production function has several disadvantages. Note that the explanatory variables in the above function are factor quantities which are assumed to be exogenous to the firm. Entrepreneurs make decisions on factor usage by taking factor prices as given. In this case, factor quantities are endogenous decision variables. If cost minimisation is taking place then direct estimation of production function ignores such information. Therefore we model explicitly the cost minimising behaviour of firms by means of a cost function. It shows the minimum cost of producing a given output level expressed as a function of given input prices and this enables us to answer questions relevant to the present study. In other words what happens to input utilisation if the i th input price changes.

To do so we follow the modern duality theory which shows that under certain regular conditions, production and cost functions are two equivalent representations of the technology of production. Let us assume that there exists a production function

[10] For further details see Chambers, 1988.

relating output (Y) to the vector of inputs Install Equation Editor and double-click here to view equation. 1. The cost function is

Install Equation Editor and double-click here to view equation. 2

(1)

where C is the total cost and w = (w_i, i= 1..n) is a vector of factor prices. Given C we reconstruct f. Thus the cost and production functions are dual in the sense that each may be derived from the other. Given a valid functional form for C, we can derive in principal the production function which yields C as its cost function. Further following Shephards Lemma, if $C(w,y)$ is differentiable in w then the factor demand function coincides with the partial derivatives of C with respect to the factor prices. Consequently, the conditional factor demands (conditional on output) for the i th factor are:

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(2)

If we define

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(3)

as the share of factor i in the costs of production then the cost share equations can be obtained as

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(4)

It is clear that (2) and (1) are equivalent representations of the technology since (2) is obviously derived from (1). We can add disturbances u_i to the demand equation to represent errors in cost minimisation and estimate the parameters as a multivariate regression.

The Model

The model for the paper industry is based on the following assumptions:
i) input prices are predetermined for the firms in the paper industry;
ii) paper industry exhibits constant returns to scale.

The focus of the present study is on substitution and derived demand and not on scale properties.[11]
iii) Firms minimise variable cost subject to a given level of output and fixed capital.

Hence we estimate a short run variable cost function with capital stock as quasi fixed input (ie, fixed in the short run). This is justified on two grounds: first, if all the inputs in the cost function are variable, instantaneous adjustment is implied whereby all inputs are in full static equilibrium (Brown and Christensen, 1981). It is considered more realistic to assume that the firm is in equilibrium only with respect to its set of variable inputs but not necessarily with respect to its capital input; second, prices of capital services are not available.

Thus a constant returns to scale variable cost function is defined:

$$C = Yg(P_L, P_M, P_E, K)$$

where C is total variable cost, Y is output and P_L, P_M, and P_E, represent prices of labour materials and energy respectively. K is the quantity of capital.

The translog variable cost function for the paper industry then takes the following form:

$$\ln c = \ln \alpha_0 + \Sigma \alpha_i \ln P_i + 1/2\, \Sigma\, \Sigma\, \beta_{i,j} \ln \underline{P_i} \ln P_j + \gamma_k \ln K + 1/2\, \gamma_{kk} (\ln K)2 + \Sigma\, \gamma_{i,k} \ln P_i \ln K \qquad (5)$$

where $\beta_{i,j} = \beta_{j,i}$, i,j = L (labour), M (material), E (energy) and $c = C/Y$.

For a cost function to be well behaved, it must be homogenous of degree one in prices, given Y: ie, if all input prices double, costs double too. To this end the following restrictions apply:

$$\Sigma\, \alpha_i = 1 \text{ and} \qquad (6a)$$

$$\Sigma\, \beta_{i,j} = \Sigma\, \beta_{j,i} = \Sigma\, \gamma_{i,k} = 0 \qquad (6b)$$

Logarithmic differentiation of the variable cost function (5) with respect to P_L, P_M, and P_E yields three cost share equations:

[11] One of the referees pointed out that we should relax the assumption of constant returns to scale. We attempted this without success. Estimation of scale parameters requires the addition of the cost function to the system of share equations to be estimated. Severe multicollinearity led to meaningless results.

$$S_L = á_{L} + â_{LL} \ln P_{L} + â_{LM} \ln P_{M} + â_{LE} \ln P_E + ã_{LK} \ln K \qquad (7)$$

$$S_M = á_{M} + â_{LM} \ln P_L + â_{MM} \ln P_M + â_{ME} \ln P_E + ã_{MK} \ln K \qquad (8)$$

$$S_E = á_{E} + â_{LE} \ln P_L + â_{ME} \ln P_M + â_{EE} \ln P_E + ã_{EK} \ln K \qquad (9)$$

where S_L , S_M and S_E are cost shares of labour, materials and energy, that have to sum to unity (restriction 6a).

We impose the linear homogeneity restrictions (6b) by dropping the energy share equation (homogeneity implies that the three equations are no longer independent) and estimating the labour and material share equations with the price of energy (P_E) as the numeraire. The coefficients of the third share equation can be easily retrieved from the coefficients of the two estimated equations by substitution.

Using the estimated parameters of the above translog cost function the following elasticities of substitution and price elasticities can be calculated[12].

1) Allen Partial Elasticities of substitution:

$$ó_{i,j}^{A} = (â_{i,j} + S_i S_j) / \; Si \, S_j \quad i = j$$

$$ó_{i,i}^{A} = (â_{i,i} + S_i^{2} - S_i) / \; S_i^{2}$$

and the factor price elasticities by

$$ç_{i,j} = ó_{i,j} S_j.$$

2) Morishima elasticities of substitution[13] :

$$ó_{i,j}^{M} = ç_{i,j} - ç_{j,j} .$$

The Morishima elasticity measures the percentage change in the ratio of input j to input i, when the price of input i changes.

Elasticities of substitution and cross elasticities of demand are positive for substitutes and negative for complements. Note that Allen partial elasticities of substitution measured by $ó_{i,j}^{A}$ are one price-one factor elasticities of substitution. They are symmetric. It is a derived demand elasticity divided by a cost share. The price elasticities of factor demand given by $ç_{i,j}$ are not symmetric.

The Morishima elasticity measures relative input adjustment (or response of input ratios) to single

[12] For a formal proof of these formulas see Binswanger , 1974.

[13] See Kang and Brown, 1981, Thomson and Taylor,1995, for a discussion of the properties of the Morishima elasticities of substitution.

factor price changes. This is in contrast to $\sigma_{i,j}^{A}$ which measures how a single input adjusts to changes in a single input price. Morishima elasticities are not symmetric and they measure the ease of substitution between two inputs. When two inputs are Allen substitutes they are also Morishima substitutes.

Results

Estimation procedure

Our modeling strategy was to estimate first a full model, including three factors labour, energy and materials (materials being a sum of imported and domestic waste paper). A distinction between domestic and imported waste paper is not made and the concept of *materials* is thus used to calculate the elasticities between waste paper, energy and labour.

The share equations to be estimated are given in the earlier section (7, 8, 9). There are three share equations pertaining to three factors of production, viz. labour, materials and energy in the case of the first model. For the estimations we chose to drop the share equation corresponding to energy.

As the sum of three factor shares sum to unity a non zero contemporaneous covariance between the disturbances of the two share equations can be expected. Due to the presence of contemporaneous correlation Ordinary Least Squares (OLS) estimators are not efficient. This is solved by estimating the two equations as a system of Seemingly Unrelated Regression Equations (SURE). Efficiency then is assured by using the iterative SURE method to estimate the two equations.[14]

In brief the iterative SURE method involves the following steps. Initially each of the equations is estimated using OLS. From these estimates the residuals are calculated and the covariance matrix of the residuals is estimated. The coefficients arrived at the initial stage are then revised to take into account the covariance between the residuals. The residuals are recalculated and the same procedure is repeated till convergence is achieved.

This iterative SURE method yields estimates which converge to maximum likelihood parameter estimates. An important property of these estimates is that the parameters are unique and independent of the share equation that is dropped. In other words the estimation method yields the same estimates of parameters irrespective of the equation dropped.

Materials sub-model

Since the firms in our sample predominantly use two types of raw materials (and not one material M) namely imported waste paper (M_I) and local waste paper (M_D) and as the question of substitutability between imported and domestic waste paper is of intrinsic interest to the present study we also estimate a material sub model. Such a model can be estimated, assuming that material inputs adjust to their optimal cost minimising level, keeping the total material output and non material inputs constant. This allows the cross elasticities between imported and domestic waste paper to be calculated. A weakly separable variable cost function corresponding to this can then be written as:

$$C = Yg\,[P_L, P_M\,(P_{MI}, P_{MD}, K), P_E, K] \qquad (10)$$

where P_{MI} and P_{MD} are prices of imported and domestic waste paper respectively and where it is

[14] For a detailed discussion of this procedure see Johnston , 1984, pp 330-342.

assumed that (quasi) fixed capital influences the substitution between imported and domestic waste. Since P_M is the price per unit of material input, it is also the cost per unit to the cost minimizing firm. We can estimate a translog material price function which results in the following two material share equations.

$$S_I = á_{I} + á_{II} \ln P_{MI} + á_{ID} \ln P_{MD} + â_{IK} \ln K \qquad (11)$$

$$S_D = á_{D} + á_{DI} \ln P_{MI} + á_{DD} \ln P_{MD} + â_{DK} \ln K, \qquad (12)$$

if the following restrictions are imposed:

$$á_{I} + á_{D} = 1,\ á_{II} + á_{ID} = 0\ ,\ á_{ID} + á_{DI} = 0,\ â_{IK} + â_{DK} = 0.$$

The elasticities of substitution and factor price elasticities can be calculated from the parameters as described for the earlier model.

In the materials sub model we have two share equations pertaining to share of imported waste paper and domestic waste paper. The restrictions imposed imply that we need to drop one equation and the parameters of the other share equation can easily be retrieved from the parameters of the estimated equation. We choose to drop the share equation pertaining to share of domestic waste paper. As only one equation needs to be estimated we use OLS method to estimate the materials sub model. The Allen partial substitution elasticities and own demand and cross price elasticities are then calculated using the formulas given in the previous section.

Results

The results of the regression pertaining to the model with three inputs are reported in table 4 below. Note that the estimated share equations satisfy the regularity condition, ie, the predicted values of the factor shares are in all cases positive. The R^2s are not very high. The coefficients of the price variables are all significant at the 5 per cent level except the coefficient of price of labour in the labour share equation. For brevity we have not reported the coefficient of capital. It is significant in both equations. The model was also estimated using 67 observations (i.e. including those firms who only use domestic waste paper and the one that uses only imported waste paper). The results of this exercise are similar to those obtained when only 40 observations are used but are not reported here.

Table 4 Estimates of the Coefficients of the Restricted Translog Cost Function and T Ratios

Dependent Variable	Constant	Price of Labour	Price of Materials	Price of Energy[1]	R^2
Share of labour	-0.047 (-0.467)	0.022 (1.487)	-0.032 (1.846)	-0.01	0.17
Share of materials	1.891 (7.435)	-0.032 (-2.077)	0.061 (2.561)	-0.029	0.44
Share of energy[1]	-0.844	-0.01	0.029	0.019	

1. Implied estimates computed using homogeneity constraint.

Tables 5, 6 and 7 present the Allen Partial and Morishima elasticities of substitution and own factor demand and cross demand elasticities. They are calculated at the means of the actual factor shares.

It should be noted that the estimated elasticities are valid only for the levels of the fixed factor (capital in our case) at which they are evaluated. From the tables below it is clear that all factors are substitutes with respect to each other. The elasticities of substitution are rather small. All own elasticities of factor demand have the correct sign and none of them are close to one. The own elasticity of materials is the lowest. The responsiveness of all the three inputs to their own prices is surprisingly low. Demand for all the three inputs are price-inelastic.

We have not reported the standard errors of the computed elasticities. The primary reason for this is that the conventional method of calculating the standard errors has been severely criticized in the literature. The conventional method of estimating the standard errors is basically an approximation and little is known about the properties of this approximation in small samples. Thus, in studies which use small samples, like our own, it is advisable not to use the standard errors calculated on the basis of an approximation, to test for the statistical significance of the various elasticities computed.

Table 5 Estimates of Allen Partial Elasticities of Substitution[1]

	Labour	Materials	Energy
Labour	-9.271	0.291	0.277
Materials		-0.293	0.823
Energy			-2.616

1: The elasticities of substitution are symmetric. The own elasticity of substitution has little economic meaning.

Table 6 Estimates of Morishima Elasticities of Substitution[1]

	Labour	Materials	Energy
Labour	-	0.412	0.617
Materials	0.618	-	0.787
Energy	0.662	0.788	-

1: The Morishima elasticities of substitution are not symmetric.

Table 7 Factor Demand and Cross Elasticities implied in the Estimated Translog Cost Function[1]

	Labour	Materials	Energy
Labour	-0.599	0.205	0.063
Materials	0.018	-0.207	0.188
Energy	0.017	0.581	-0.599

: Each element in the table is the elasticity of demand for the input in the row with respect to a price change of the input in the column.

Let us now turn to the materials sub-model. The regression results are presented in table 8. As before we do not report the coefficient of capital. In this case it is not significant, and our results are much weaker than previously, while the coefficient of the price of imported waste paper is significant only at the 10 per cent level. Again the regularity conditions are satisfied and none of the predicted shares are negative. The implied cross elasticity of substitution is 0.157 suggesting that the two inputs are (weak) substitutes[15]. The implied own elasticities of demand of imported and domestic waste paper are negative but at -0.075 and -0.082 respectively have extremely low values.

Table 8 Estimates of the Coefficients of the Translog Cost Function in the Materials Sub-model and T Ratios

Dependent Variable	Constant	Price of Imported Waste Paper	Price of Domestic Waste Paper	R^2
Share of Imported Waste Paper	-0.250 (-0.523)	0.208 (1.802)	-0.208	0.12
Share of Domestic Waste Paper[1]	1.250	-0.208	0.208	

1. Implied estimates computed using homogeneity constraint

[15] These are called gross elasticities in the literature. We also estimated the net price elasticities, which allows all inputs to adjust to new cost minimizing levels. They are found to be higher than the gross price elasticities but still low at -0.33.

Conclusions

Industries differ with respect to technological changes, resource constraints and input substitution possibilities. We have, in this paper attempted to shed some light on the input substitution possibilities in a segment of the Indian paper industry. We have focused on firms which use waste paper as the primary material input. We have used the cost function approach to arrive at estimates of the elasticities of substitution and price elasticities of demand.

The signs of the estimates of the substitution and cross price elasticities suggest that there exists a substitution relationship between the three inputs namely, labour, materials and energy. The numerical values of these estimates are found to be rather low. This suggests that substitution possibilities between the three specified inputs, are limited. The same conclusion holds for the substitution between imported and domestic waste paper, given the total material cost. In addition, the derived demand elasticities indicate that input usages are relatively unresponsive to changes in the relative prices of inputs.

The low values of the elasticities signify that, given the level of capital stock, the flexibility of the production structure to respond to relative price changes is very restricted. We have already documented that the Indian paper industry is saddled with obsolete capital equipment. Consequently, the limited ability of the firms in the paper industry to adjust in the short run to unpredictable changes in the relative prices of inputs through substitution is likely to result in high adjustment costs. The implications of our findings related to the waste paper recycling industry and the environmental impacts are dealt with in a separate paper.

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