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# Estimates of an Aggregate Cobb-Douglas Production Function for Nepales Industry

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## Introduction

Nepal has very few useful potential natural resources other than hydroelectricity, and thus has depended heavily on agriculture, which contributes more than 60 per cent of the gross domestic product and accounts for a substantial portion of overall export earnings. But the agricultural sector has begun to stagnate, primarily due to growing population pressures. Other agricultural problems include inadequate irrigation and soil erosion leading to smaller net yields.

As a result, Nepal has attempted to ease some of the heavy dependence on agriculture by virtue of planned industrial development, initiated in the first five-year plan in September, 1956. This effort to industrialize was given additional impetus by the complete dependence on imports for consumer goods.

As they have developed, Nepalese industries may be classified into two main categories--modern and cottage industries.[1] The cottage industrial sector includes capmaking, curios and jewelry, metallic vessels, carpetmaking, paper manufactures and the like. The modern industries are generally primary processing industries such as cereal processing, oil, bakery, jute, yarn and textiles, and sugar refining. Although the number of establishment increased from 1257 in 1965 to 3528 in 1976-77, with the addition of some new industries such as cement production and footwear, the basic structure has remained the same. Almost 80 per cent

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1. The analysis in this paper will not carry this distinction, however.

of the total increase in establishments over this decade was accounted for by increases in the cereal processing and extracting industries.

The contribution of industry to overall national income is still rather small, being about 4 per cent in 1979-80. Yet the growth in manufacturing output has been in excess of 50 per cent between 1974–75 and 1980-81.[2] Thus, the manufacturing sector is becoming increasingly significant as a source of employment and income in Nepal. Consequently, it is important to understand the characteristics of manufacturing production, in terms of output elasticities with respect to various productive inputs, returns to scale, and the like. It is also of interest to know whether these relatioships have change over time.[3]

This paper provides an initial analysis of these issues by estimating the production characteristics inherent in a simple specification of an aggregate techonology for Nepalese manufactusing for the years 1965, 1972-73 and 1976-77. In particular, we pose four questions. First, does a simple Cobb-Douglas specification provide an adequate representation of an aggregate production function across cross-section of industries in the years concerned ? Second, does estimating a four-input (capital, labor, raw materials, and fuel) as opposed to a two-input (capital and labour) function add significantly to our understanding of Nepalese prodution technology ? Third, are these Nepalese production functions characterized by constant or non-constant returns to scale ? Finally, do these characteristics change over time ? Notice that if the answer to the last question is no, so that the production function appears to be stable, we may improve the precision of our estimates by pooling across the years of analysis.

## Empirical Results

### A Basic Regressions

We begin with a two-factor Cobb-Douglas specification of the Nepalese production function

$$VA_i = AK_i^a L_i^b e^{u_i} \qquad (1)$$

2. On all of these figures, see *Central Bureau of Statistics of Nepal* (Various years)
3. Apparently the only previous study along these lines is Banskota (1979)

where, for industry i, $VA_i$ is real value added, defined as real output less real inputs of raw materials and fuel, $K_i$ is physical capital stock, and $L_i$ is total employment.[4] We attach a well-behaved disturbance term in exponential form so as to make double-log estimation of equation (1) feasible. The parameter A is generally considered, to be an indicator of the state of technological progress, which is appropriate in a time-series analysis, but in the current paper it is taken to reflect an average technological parameter across the set of industries in each year. The coefficients a and b represent the elasticities of value added production with respect to capital and labor, respectively. We impose no restrictions on a and b *a priori* so that we may examine the status of returns to scale. Finally, notice that the Cobb-Douglas function is somewhat inflexible, in that it imposes a unitary elasticity of subtitution between capital and labor.

In addition to examining the contributions to capital and labor to the production of value added, we consider the four-factor production function specification

$$Q_i = AK_i^a L_i^b R_i^c F_i^d e^{u_i} \qquad (2)$$

where $Q_i$ is real gross output, $R_i$ is raw materials, and $F_i$ is fuel inputs used by the i th industry Again, we impose no adding-up restrictions on the exponents so as to allow for nonconstant returns to scale. Of course, pairwise substitution elasticities are all constrained to unity by this specification.

The two-factor and four-factor Cobb-Douglas technologies were fitted to cross sections of manufacturing industries for each of the census year 1965, 1972-73, and 1976 77. Where appropriate, all variables were deflated into 1972-73 rupees by means of a price index discussed in the appendix so as to permit comparisons over time.

The results are presented in Table I. The equation numbers correspond to models (1) and (2) for each of the three years. Calculated t-values are reported in parentheses under each coefficient and are marked to indicate significance levels. We also report the number of industries included in each regression. In the first equation of each pair the dependent variable is real value added, while in the second equation the dependent variable is real gross output. Estimated coefficients are listed for the intercept (I), capital (K), labor (L), raw materials (RM), and fuel (FU).

4 For details on measurement and price deflation of the variables, see the appendix.

It is apparent from the first equation that the two-input model explained a significant proportion of the variation in value adedd in 1965. The coefficients are production elasticities so that, for example, a one-per cent increase in capital employment would have raised real value added by 0.35 per cent on average. The sum of the coefficients thus represents a total production elasticity. In this case a one per cent increase in both capital and labor employment would have raised value added by 0.88 per cent on average. In this regard, if the sum of the coefficients is significantly different from one, there is evidence of nonconstant returns to scale in generating value added. We test for this possibility later in the paper.

It appears from the first equation that both capital and labor inputs contributed significantly to value added in 1965. However, when the model is expanded to include raw materials and fuels in the explanation of variations in output in the second equation, the significance of the capital coefficient disappears and the labor coefficient is cut in half, although it retains its significance. It thus appears that in 1965 capital was an important input into residual output or value added, but was dominated by labor, raw materials, and to some extent fuel in the production of overall output Note the dominance of the raw materials input, which is consistent with the fact that most Nepalese industry is of the processed primary goods variety. It is also possible, of course, that the negative and insignificant coefficient on capital suggests that it has been estimated rather imprecisely, perhaps due to multicollinearity between capital and raw materials. Pooled estimates of the regression equations, to be presented later, will help correct this problem by virtue of increasing the sample size. In any event, it is evident that the explanatory power of equation (2) is significantly higher than that of equation (1), and that output reacted most strongly to changes in raw materials inputs.

A very similar picture is presented by the 1972-73 equations, although the intercept terms dropped somewhat, reflecting a reduction in the technological efficiency of Nepalese industry. Comparing the third equation with the first, it seems that the responsiveness of value added to labor rose considerably relative to 1965, while that to capital fell somewhat. This suggests that there may be some interesting shifts in the elasticity coefficients over time, an issue to which we

**Table 1**

**BASIC REGRESSION RESULTS**

| Year | Eq. No. | N | I | K | L | RM | FU | $\bar{R}^2$ | F |
|---|---|---|---|---|---|---|---|---|---|
| 1965 | 1 | 26 | 1.947 | .347 | .537 | | | .88 | 96.38$^{c}$ |
| | | | (5.05)$^{c}$ | (4.09)$^{c}$ | (4.55)$^{c}$ | | | | |
| 1965 | 2 | 26 | 1.878 | –.005 | .235 | .632 | .094 | .98 | 251.80$^{c}$ |
| | | | (7.69)$^{c}$ | (–.08) | (2.90)$^{c}$ | (10.87)$^{c}$ | (1.56)$^{a}$ | | |
| 1972-73 | 1 | 22 | –1.472 | .293 | .872 | | | .79 | 39.76$^{c}$ |
| | | | (–1.69)$^{a}$ | (1.66)$^{a}$ | (4.52)$^{c}$ | | | | |
| 1972-73 | 2 | 22 | 1.618 | –.014 | .252 | .612 | .159 | .96 | 143.38$^{c}$ |
| | | | (3.02)$^{c}$ | (–.13) | (2.47)$^{b}$ | (8.38)$^{c}$ | (1.98)$^{b}$ | | |
| 1976-77 | 1 | 29 | –.133 | .624 | .482 | | | .79 | 53.81$^{c}$ |
| | | | (–.16) | (4.09)$^{c}$ | (2.63)$^{c}$ | | | | |
| 1976-77 | 2 | 29 | 1.433 | .200 | .081 | .658 | .009 | .97 | 209.00$^{c}$ |
| | | | (3.40)$^{c}$ | (2.26)$^{b}$ | (.95) | (10.92)$^{c}$ | (.13) | | |

Note : a = different from zero at 10% significance level.

b = different from zero at 5% significance level.

c = different from zero at 1% significance level.

These are based on one-sided (positive) alternatives.

return later. Notice the increase in the fuel coefficient, which may be due to government subsidization of hydroelectricity use in Nepalese industry. The importance of the fuels inputs disappears in 1976-77, however.

With respect to the final two regressions, we point out that in the four-input equation capital retained its importance while the labor coefficient lost its significance. It would therfore be interesting to analyze the impacts of Nepalese import-substitution policies on the employment of capital and labor in the 1970.'s

## B. Returns to Scale

Strictly speaking, the coefficients we have estimated may be interpreted as input share parameters only if the production functions are homogeneous of degree one. If the functions display constant returns to scale, then by Euler's Theorem the estimated coefficients represent the shares of output going to each input in addition to being the respective output elasticities. As such, we may then equate the share coefficients with meaningful measures of overall factor intensities in production.

For this purpose in each year we test the hypotheses

$$H_0 : a + b = 1 \qquad \text{and} \qquad H_0 : a + b + c + d = 1 \tag{3}$$
$$H_1 : H_0 \text{ is false} \qquad\qquad H_1 : H_0 \text{ is false}$$

for the two models, respectively. The appropriate test statistics are

$$t_1 = \frac{\hat{a} + \hat{b} - 1}{\left[\hat{v}(\hat{a} + \hat{b})\right]^{1/2}} \qquad \text{and} \qquad t_2 = \frac{\hat{a} + \hat{b} + \hat{c} + \hat{d} - 1}{\left[\hat{v}(\hat{a} + \hat{b} + \hat{c} + \hat{d})\right]^{1/2}} \tag{4}$$

The tests are based on two-sided alternatives so as to allow for either increasing or decreasing returns to scale. The results are presented in Table 2.

It is clear that in each case we could not reject the hypothesis of constant returns to scale. Thus, we may now reasonably interpret the coefficients in Table 1 as input shares and therefore factor intensities. Comparing the four-input equations in that table, we see that Nepalese manufacturing has been consistently predominantly intensive in raw materials, as may be expected: We note, however, that the capital intensity rose from a minimal amount in 1965 to 20 per cent of real output in 1976-77, while at the same time the labor coefficient fell considerably.

This result may reflect the import-substitution policies which the Nepalese government pursued during this period.

### C. Pooled Analysis

Our last task is to provide the most precise estimate avaiable of the Cobb-Dougias production specification by means of pooling across the three years. This is possible so long as there is overall homogeneity in the regression coefficients in the three years. We tested for homogeneity by means of an F-test for a common relationship. This involved comparing the residual sums of squares which resulted from a pooled regression with coefficients constrained to be equal across years with the residual sums of squares available in the unconstrained annual regressions. Allowing for separate intercepts, in each model we could not reject the hypothesis of homogeneity. Hence, pooling was possible. The results are given in table 3.

The coefficients on D72 and D76 reflect the reductions in the intercept in 1972-73 and 1976-77, respectively, for the pooled analysis. Notice the significant declines in the technology parameters over the period, particularly between 1965 and 1972-73 This suggests that Nepalese industry had indeed become less efficient in its use of productive inputs. This trend clearly had not been reversed by 1976-77. This finding may indicate, for example, that Nepalese industrial incentives have led to widespread inefficiently, a finding which is consistent with the results of import substitution policies in other countries. Also of interest here are the various slope coefficients. In both pooled equations we find evidence of constant returns to scale, confirming our previous results. Thus, in the two-input model Nepalese manufacturing is seen to have been somewhat more intensive in labor than in capital In the four-input model, however, capital is seen to have had a fairly small claim (about 4 per cent) on industrial output. Thus, in spite of the recent increase in capital intensity, Nepalese industry has been characterized by the intensive use of raw materials and labor over the period. The four-factor equation provides the most comprehensive view available to date of the aggregate industrial production technology in Nepal.

### Conclusions

The Cobb-Dougals specifications we have estimated provided an adequate depiction of production technology in Nepalese manufacturing since 1965. Subject to the reliability of the data we have used, three significant conclusions may be drawn from the analysis.

First, raw materials have provided the basis for the types of industries in which Nepal has engaged, with an input share of 60—65 per cent. This is hardly surprising, but it does point to the need for the agricultural sector to provide necessary inputs for industrial expansion. In this regard, development plans aimed at industry to the neglect of agriculture may be counter—productive in the long run.

Second, although capital intensity was shown to be rather negligible in the pooled analysis, there was some evidence that capital intensity may be increasing, perhaps at the expense of the rate of increase of labor employment. Such a change in intensity would not be unusual in a developing country such as Nepal where there are continuous efforts at modern techonological adaptation. This would be the case if a capital-intensive industrial strategy were pursued rather than a labor-intensive one. There is evidence to believe that Nepal has followed such an approach in the development of the manufacturing sector, artificially lowering the costs of capital relative to labor. Thus, there may be reason to doubt the ability of the expanding industrial sector to absorb labor at a rate which will not cause additional unemployment.

Third, there is reason to believe that the average technological efficiency of the Nepalese manufacturing sector has declined over time, perhaps due to the policies pursued. This certainly provides an interesting avenue for futher research. These conclusions must be tempered by the observation that we have analyzed a a very small industrial sector. As industrialization increases, the various factor intensities may change in more appropriate directions. Public policy might well be redesigned to promote such adjustments, rather than hinder them.

## APPENDIX

### Data Source

The data used for this study were taken from the census reports published by the Central Bureau of Statitiscs, HMG/National Planning Gommission, Kathmandu Nepal.

**Table 2**

**TESTS FOR CONSTANT RETURNS TO SCALE (CRS)**

| Year | Eq. No. | Sum of Coefficients | $t_1$ or $t_2$ | Conclusion |
|---|---|---|---|---|
| 1965 | 1 | .884 | 1.66 | CRS |
| 1965 | 2 | .956 | .82 | CRS |
| 1972-73 | 1 | 1.165 | 1.26 | CRS |
| 1972-73 | 2 | 1 009 | .03 | CRS |
| 197677 | 1 | 1.106 | .94 | CRS |
| 197677 | 2 | .948 | 1.00 | CRS |

**Table 3**

**POOLED REGRESSION RESULTS**

| N | 165 | D72 | D77 | K | L | RM | FU | $\bar{R}^2$ | F |
|---|---|---|---|---|---|---|---|---|---|
| 77 | 1.149 | —1.580 | — 380 | .396 | .628 | | | .84 | 97.95[c] |
| | (3.12)[c] | (—5 02)[c] | (—1.63)[a] | (5.13)[c] | (6.45)[c] | | | | |
| 77 | 1.787 | —.530 | —.043 | .041 | .181 | .638 | .100 | .97 | 464.19[c] |
| | (9.96)[c] | (—3.63)[c] | (—.42) | (1.02) | (3.74)[c] | (18.38) | (2.85)[c] | | |

Note: The t-tests on the dummy coefficients are based on two-sided alternatives.

## Deflators

The data for 1965 and 1976-77 were deflated by the price index and GDP deflator of the respective years, assuming 1972-73 as the base years, Instead of using the same price index for all industries, different consumer price indices were used to deflate the inputs and output. These indices were taken from "*Quarterly Economics Bulletins*," published by Nepal Rastra Bank, Kathmandu, Nepal.

## Variables

Variables used for the study were capital (fixed assets values at the end of the year), number of laborers used, raw materials, fuels, gross output, all valued in Nepalese currency Rupees ($ 1.00 = Rs 14.30). To establish the values in terms of the 1972-73 price index and GDP deflators, values of the inputs and output for a particular industry were deflated by the national price index of its related commodity. For example, input and output of the cigarette industry were deflated by the national consumer price of cigarettes. Similarly, other industries' figures were deflated by their respective price indices.

**Industries**

The following Table A gives the yearwise composition of Nepalese industries.

**Table A**

| 1965 | 1972—73 | 1976—77 |
|---|---|---|
| 1. a. Rice Husking | Cereal Processing | Oil Extraction and Mill production |
| b. Flour Making | Oil Extracting | |
| c. Oil Extracting | | |
| 2. ——— | ——— | Fitting Canning and Bottling |
| 3. Bakery | Bakery | Bakery Products |
| 4. a. Sugar refineries | Sugar Refineries | Sugar Refineries |
| b. Crystal Sugar | | |
| 5. ——— | ——— | Animal Feeds |
| 6. ——— | ——— | Distilleries |
| 7. Tea Packing | Tea Packing | Tea Packing |
| 8. Biri Making | Biri Making | Biri Making |
| 9. Cigarette Factory | Cigarette Factory | Cigarette Factory |
| 10. Yarn and Textiles | Yarn and Textiles | Yarn and Textiles |
| 11. ——— | ——— | Knitting Mills |
| 12. ——— | Footwear | Footwear |
| 13. Wooden Furniture | Wooden Furniture | Wooden Furniture |
| 14. Metallic Furniture | Metallic Furniture | Metallic Furniture |
| 15. ——— | ——— | Paper Manufacture |
| 16. Printing Press | Printing Press | Printing Press |
| 17. | | Drugs and Medicine |

**Table A (Continued)**

| 1965 | 1972-73 | 1976-77 |
|---|---|---|
| 18. Soaps | Soaps | Soaps |
| 19. Matches | Matches | Matches |
| 21. Ice and Ice Cream | Ice and Ice Cream | Ice and Ice Cream |
| 22. Miscelleaneous | Miscellaneous | Activities N. E. S. |
| 23. ——— | ——— | Carpets and Rugs |
| 24. Cap Making | Cap Making | Cap Making |
| 25. Saw Mills | Saw Mills | Saw Mills |
| 26. Jute Processing | Jute Processing | Jute Processing |
| 27. Metallic Vessels | Metallic Vessels | Metallic Vessels |
| 28. Repairing Works | Repairing Works | Repairing Works |
| 29. Curios and Jewelry | Curios and Jewelry | Curios and Jewelry |
| 30. Cement Products | | |
| 31. Lime Kilns | | |

## References


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