

**PROCESS ANALYSIS OF STEEL FORGINGS INDUSTRY
IN INDIA WITH SPECIAL REFERENCE TO THE PROBLEMS
OF CONTINUITY AND MULTIDIMENSIONALITY FOR SECTOR
SPECIFICATION IN THE INTER INDUSTRY FRAME - WORK**

April, 1970

**By
V. V. N. SOMAYAJULU**

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THE UNIVERSITY OF POONA
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CHAPTER I

INTRODUCTION

1.1 Theme of the Study

The technological forging process,¹ by its definition and nature of the products and technological operations, is a continuous phenomenon, whereas an economic process with unique input-output combination or an activity or a combination of such activities, needs to be a discrete concept to serve as a sector in the inter-industry analysis. The technological forging process is faced with problems of product-multidimensionality² and of continuous change in product dimensions, as it is a jobbing type industry. This study of process analysis of steel forgings industry is an attempt to bring out the discrete economic processes or activities³ or product groups with unique input-output combination. The intermediate stages of production, as intermediate technological processes in a firm or a production unit, do not specify the final products, so as to meet the

¹ Definition is given in Chapter II, nature of the operations is given in Chapter III and nature of the products is described in Chapters III and VI.

² The problems of multidimensionality and of continuity are described in Chapter III, VI and VII. See Leontief, W.W. and others (ed.), Studies in Structure of American Economy - Theoretical and Empirical explorations in input output analysis, Chapter 9, pp. 343-344, New York, Oxford University Press, 1953.

³ The terms, economic processes, activities and product groups with unique input output combination, are synonymously used in this study, though distinctions of them are also found in the literature. See Koopmans, T.C. (ed.), Activity analysis of Production and Allocation. Cowles Foundation for research in Economics, Monograph 13, Chapter I, p. 15. John Wiley and Sons, Inc., New York, 1954. See also Tibor Barna, "The interdependence of British economy", in the Journal of the Royal Statistical Society, Series A (General), Vol. LXV, Part I, 1952, pp. 32-33.

customers' specifications. Besides, not all production units do have similar intermediate technological processes. As such, the derivation of economic processes is not directly linked with the technological intermediate processes of the industry. In this direction, attempts are made to specify the product groups with respect to the homogeneity of product dimensions and to derive the distinct average prices and autonomous input structures of a set of aggregated product groups. The distinct economic processes of the product groups, disintegrated from a continuous forgings sector, may serve as discrete sectors in the disaggregative commoditywise input output tables or as activities in the linear programming models. In economic theory, these structural relationships are often referred to as the 'production functions'⁴ of the respective sectors.

The sectors, so formed, are the most disaggregative sectors, which cannot be incorporated in the available aggregative input output tables in India. For the purpose of incorporating steel forgings industry as a separate sector in the available Input Output Table of Indian Economy for 1963, it is necessary to assume that this jobbing type industry may serve as a discrete sector with its instantaneous production function. The direct and indirect repercussions of incorporating this steel forgings industry as a separate sector in the Input Output Table of Indian Economy at

⁴ Leontief, W.W., op.cit., Chapter I, Introduction, p.10.

purchasers prices of 1963 are examined in this study. Thus, this study is framed as a process analysis of steel forgings industry with special reference to the problems of continuity and of product multidimensionality for sector specification in the inter-industry framework.

1.2 Need for this study of product specification and Discrete product groups' input structures for sector specification

The inter industry tables are generally prepared with industries as sectors for which the unit of analysis is a process or a combination of processes producing multiple products. Similarly the commodity wise input output tables are also based on the various principles of aggregation like horizontal integration, vertical integration and the like for the purposes intended.⁵ If each process is identified with a single product, then both the industrywise and commodity-wise input output tables remain the same. But in practice, there are multiple products produced by a process or a number of processes.

If, in the sectors, productmix is more likely to be variable than techniques of production, then the sectors classification should identify separate products.⁶ If the sectors are experiencing rapid technological change and product mix is not highly variable, then the classification

⁵ Barna, Tibor, (ed.), Structural interdependence of the economy, Chapter 7, pp. 175-185. John Wiley and Sons, Inc., New York.

⁶ Mathilda Holzman, "Problems of classification and aggregation", in Studies in the Structure of American Economy (ed.), Leontief and others, op.cit., pp. 343-344.

should identify separate processes.⁷ In the theoretical input output models,⁸ these problems can be overcome by the ideal sectors with unique processes or products of unique input output combination. But, such disaggregative sectors are not amenable for identification in the empirical studies.

Even these disaggregative sectors may not be free from problems of product multidimensionality⁹ and continuity of product dimensions. This problem can be stated like this : There may be very many dimensions to identify a wide range of products of a non-discrete process and the variations in the physical values of the continuous product dimensions are likely to influence the input structures of the firms or plants in the industry. In such cases, these problems are to be taken into account within each such process or product for the purpose of establishing discrete processes or products having independent input structures, which may serve as activities of linear programming models and as the most disaggregative sectors of commodity-wise input output tables.

Here, the distinction of the input output and linear programming models is of relevance. The input output analysis and linear programming are two analytical approaches to production theories of sectors. Both have the common

⁷ Ibid.

⁸ Malin Vaud Edmond, "Aggregation problems in input output models, in Structural interdependence of the economy, ed. Tibor Barna, op.cit., pp. 189-191.

⁹ Mathilda Holzman, op.cit., pp. 343-344.

basic assumptions of linearity and additivity,¹⁰ but they differ in respect of sector specification. Leontief input output analysis assumes that each commodity (or group of commodities) is supplied by a single industry (or sector of production). It implies (a) that only one method is used for producing each group of commodities and (b) that each sector has only a single output. But the linear programming analysis assumes that there may be more than one way of producing a given commodity because of inputs substitution.

Each of these assumptions depends both on the nature of production in single plants and on the way in which these units are aggregated into sectors.¹¹ In this context, Leontief¹² observes, "As soon as the economist abandons grossly aggregative formulations, he will find in engineering data a promising and accessible source of direct empirical information on the input output structure of the individual industries." This has provided an inspiration to investigate the problems of a continuous multidimensional product in respect of sector specification.

1.3 Use of engineering data in the industry studies for sector specification and their production functions : A brief review

Production is assumed to involve a change in the form

¹⁰ Chenery H.B. and Clark P.G., Inter industry economics, pp. 33-42, New York, John Wiley and Sons, Inc., London, 1959.

¹¹ Ibid.

¹² Leontief, W.W., op.cit., p. 14.

of materials under the applications of energy. Chenery¹³ derived the engineering production functions expressing production as a function of engineering variables, from the material transformation functions and the energy supply functions. He, then, related them with a set of input functions to arrive at the economic production functions¹⁴ and/or cost functions of the industrial processes. In each instance, the type and quantity of the economic input is supposed to be determined by the types and magnitudes of the engineering variables specified¹⁵ once the dimensions of inputs and outputs are specified. Thus, the total cost is shown as a function of engineering variables. Minimising the total cost under the constraint equation of engineering production function will provide simultaneously the equilibrium values for the engineering variables. When equilibrium output and the engineering variables are inserted in the input function, the ideal mix of economic inputs will be derived.

For a given rate of output and fixed product dimensions,

¹³ Chenery, H.B., "Process and production functions from engineering data", in Studies in Structure of American Economy, op.cit., pp. 297-311.

¹⁴ See also Chenery, "Engineering Production functions" in Quarterly Journal of Economics, Vol. LXIII, No. 4, Nov.1949, pp. 507-31. See also Samuelson, P.A., Foundations of Economic Analysis, Harvard University Press, Cambridge, 1947, pp.57-61 for the least cost solutions.

¹⁵ Furbton, E.G., "Some questions on the theory of engineering production functions", Artha Vijnana, Vol. 9, 1967, No. 2, pp. 252-277.

the optimum design of each individual process can be determined separately.¹⁶ Then the production function for the plant will consist merely of all process functions. If two or more processes are inter-dependent, especially when the output of one becomes the input of the other, they can be combined together into a single function by suitable aggregation. The extent to which the existence of such processes complicates the analysis can only be determined from actual trials.¹⁷ The problem therefore, is to decide, on the basis of technical and economic considerations, which products or processes are likely to have linearly dependent or independent production functions.¹⁸

The theory of process and production functions from engineering data has not been left undisputed as Furubton¹⁹ points out that it is not always possible to construct technological production functions and that the transformation of a set of design laws describing a process into an economic production function is also not always possible. There is no way to insure that each function will be both

¹⁶ Chenery H.B., "Processes and Production functions from engineering data", in Studies in the Structure of American Economy, op.cit., p. 311.

¹⁷ Ibid., p. 311.

¹⁸ Mathilda Holzman, "Problems of classification and Aggregation in input output analysis", in Studies in the Structure of American Economy, op.cit., pp. 326-329.

¹⁹ Furubton, E.G., "Some questions on the theory of Engineering production functions", Artha Vijnana, Vol. 9, No. 2, pp. 252-277.

single valued and analytically meaningful.²⁰ If the physical properties specified in the engineering design laws happen to be rather general, so that the individual input functions are unable to pinpoint a unique economic input, the cost function has no clear meaning and the whole system disintegrates.²¹ The real question, then, is whether the input functions can unfailingly link given values for the engineering variables with one definite set of commodities and one definite cost.

The economic input represents a class of producers' goods rather than an individual producer good, in Chenery's sense, which would be satisfactory²² only if a direct linear relationship exists between quantities and prices. The assumption that a single price parameter can always be substituted for an input price structure, must lead to an error in the statement of cost and to the effective collapse²³ of a model based on cost minimization. Chenery²⁴ suggested input price functions to account for price variations, broadly analogous to the factor supply functions, confronting a monopolistic firm.

In going from one form of economic input to another or from one combination of input units into another, the

20 Ibid.

21 Ibid.

22 Ibid.

23 Ibid.

24 Chenery, H.B., "Engineering Production functions", Quarterly Journal of Economics, November 1949, Vol. LXIII No. 4, pp. 507-31.

values of several significant physical dimensions are likely to change simultaneously.²⁵ To establish a complete array of efficient alternatives, it is first necessary to recognise that each form of a general economic input constitutes a distinct factor of production. Furubton²⁶ considers in such situations that a multi-equation production function will emerge, where economic inputs exist in more than one physical form. The number of equations in such a production function can vary with the scale of operations conducted. To determine the optimal input mix for producing a specified output, the possibilities offered in each sub-function of the extended system,²⁷ must be examined carefully. An acceptable subsystem would be one where each axis of the relevant isoquant map was identified with one economic input rigidly defined as to type and form.²⁸

Various uses of engineering analysis and process results are suggested for input output analysis :²⁹

(i) as a basis for classification and aggregation, (ii) as a supplement to other methods of calculating input coeffi-

²⁵Furubton, E.G., "Some questions on the theory of Engineering production functions", Artha Vijnana, Vol. 9, No. 2, 1967, pp. 252-277.

²⁶ Ibid.

²⁷ Ibid.

²⁸ Ibid.

²⁹ Chenery, H.B., "Process and Production functions from engineering data", in Studies in Structure of American Economy, op.cit., p. 361.

cients, (iii) in testing and modifying the underlying assumptions of fixed proportions among inputs and outputs. Carter,³⁰ in this connection, distinguished three fundamental problems: (1) the problem of dividing the economy into technologically homogeneous industries (classification problem), (2) the problem of selecting technically significant attributes or input and output dimensions in each industry, and (3) the choice of appropriate types of functions in which these input and output variables are to be related in each industry.

1.4 Use of Engineering Data in the 'Process analysis of the Steel forgings industry study'

Mathilda Holzman³¹ observed that the input structures for multidimensional products must be obtained from engineering production functions of the products. It is in the context of these basic ideas, enlisted above, about the uses and problems of the process and production functions from engineering data, an attempt has been made in this study for product specification³² of continuous multidimensional products of steel forgings industry. However, the engineering variables could not be related directly to the economic variables, viz. prices, to arrive at the economic production

³⁰ Carter, Anne P. (previously Grosse Anne, P.), "The technological structure of cotton textile industry" in Studies in Structure of American Economy.., op.cit., p. 361.

³¹ Mathilda Holzman, "Problems of classification and aggregation in input output analysis" in Studies in the Structure of American economy.., op.cit., p. 359.

³² See Chapter VI of this study.

functions in this study, as the number of forgings available does not cover all product groups. Making use of the data on the distribution of tonnage and value of production of the product groups and firms, an attempt has been made to derive the distinct average prices and dissimilar input structures of the aggregated product groups,³³ which may serve as the ideal sectors in the disaggregative commoditywise input output tables and as activities in the linear programming models. However, it should be stated explicitly that utilization of technically derived input structures for a multi dimensional product requires that the final bill of goods demand be also specified in terms of the same ranges of output dimensions,³⁴ for any applications of input output technique.

1.5 Brief review of the earlier attempts of industry studies with similar problems

(1) Chenery's studies³⁵ on gas compression and pipe line flow technological production functions, their cost curves and economic production functions, similarly, for the processes of evaporation, electrolysis and electrical transmission, have demonstrated the analysis of multidimensional products and use of engineering data.

³³ See Chapter VII of this study.

³⁴ Mathilda Holzman, "Problems of classification and aggregation in input output analysis", in Studies in the Structure of American economy..., op.cit., p. 359.

³⁵ Chenery, H.B., "Process and Production functions from engineering data" in Studies in the Structure of American economy..., op.cit., pp. 311-325.

The output of the compressor is identical with the input of pipe line and the two processes are linked by the common variable R (the compression ratio), so that any value of R implies a given amount of horse power per unit of output for a given technology. To make current and durable inputs comparable in a cost function, the proper charge to be associated with the capital goods must be determined. One method would be to define the unit of time as the expected life of the most durable factor in the production function. It may not be feasible for every durable equipment. A more practical alternative is to take the average annual depreciation, obsolescence and maintenance charges associated with each type of equipment in the production function.

The costs in the process are assumed to fall into three categories only :

- (a) Proportionate to particular dimensions of capital goods,
- (b) proportionate to total investment,
- (c) proportionate to output.

These types of cost elements in the final cost equation are divided into two groups -- those which vary with the design variables, and those which are fixed by the quantity of output and the length of the line. From these equations four graphical solutions are presented : (i) engineering production function of gas transmission, (ii) a production function in terms of quantities of the principal inputs -

horse power and tons of pipe, (iii) the various types of cost curve which can be derived by successive least cost solution to the production function. The curves are :

- (a) L A C : Long run average cost curve (all factors variable),
- (b) L M C : Long run marginal cost curve,
- (c) I A C : Intermediate average cost (fixed pipe line, variable amounts of horse power),
- (d) I M C : Intermediate marginal cost,
- (e) S A C : Short run average cost (fixed plant).

(2) Mathilda Holzman's³⁶ two processes studies, viz.

(i) for a production function of a two dimensional product or service of rail road transportation and (ii) for a multi-dimensional product or service of a machining process, bring out a few important results.

(1) If one wishes to find out the quantities of inputs necessary for the same amount of service, rail road transportation, the number of tons to be carried and the distance to be traversed must both be specified. The economic fact with respect to the multidimensionality of rail road transportation is that one and the same rail road does produce transportation in a widely variable array of both the dimensions. The process is such that the production

³⁶ Mathilda Holzman, "Problems of classification and aggregation in input output analysis", in Studies in the Structure of American Economy..., op.cit., pp. 345-359.

function generally can be written : $p(t, d, i_1, i_2 \dots i_n) = 0$ where t = tons, d = distance and $i_1, i_2, \dots i_n$ = inputs. It is a possible exception to the warning that the input structure for a multidimensional product must be obtained from an engineering production function. The product multidimensionality of rail road transportation is assumed not to give rise to instability of technical coefficients because the relationship of tons to miles of rail road transportation used by each separate industry has not changed radically over the last twenty years. As such, the input functions of this service were not calculated by Holzman.

(ii) The production function for the machining process consists of two sets of relationships. The first set contains variables relevant to machining itself and the second set relevant to the preparatory operations. If costs are split into these two components, then for each of the machines technically suited to the job, a cost function can be written and if these functions are plotted on a graph, then the range of values of the output dimensions (therefore of different lot sizes) can be seen. Here, Holzman explains the missing link between technical data (the engineering production function for machining with seven output dimensions) and economic data (output of a metal fabricating industry). The production function contains 15 variables in a non-linear and non-homogeneous relationship. Since the metal fabricating industries are vertically integrated processes,

statistical data for census industries on man-hours, installed horse-power, electric energy, etc., relate to total processing and not to machining alone. Because it has proved possible in her study to obtain the engineering production functions and yet be unable to utilize it, she is forced to conclude that the elimination of technical coefficients instability due to product multidimensionality is not always practical.

(3) Similarly, Anne P. Carter's two studies, viz., (i) cotton textiles³⁷ and (ii) tin can industry³⁸ studies are of special mention here.

(1) She described the technical relationships to determine the required inputs of direct processing machinery, power, labor and fibre for the production of a specified type of cotton cloth with the equipment of recent vintage. This study has tested the feasibility of deriving economically meaningful technical coefficients, particularly the best practice coefficients, from technical source materials. Comparisons of the best practice and average coefficients have demonstrated that this type of procedure can produce economically significant results. And the increase in the stability of the production function cannot be realized unless the output statistics describe each year's product

³⁷ Carter, Anne, P., "The technological structure of cotton textile industry", in Studies in the Structure of American Economy..., op.cit., pp. 360-420.

³⁸ Carter, Anne, P., "Investment, Capacity utilization and changes in the input structure in the tin can industry", The Review of Economics and Statistics, Vol. XLII, August 1960, pp. 283-291.

in terms of the appropriate quality dimensions.

(ii) In the earlier works, the technical parameters are derived from engineering data while in the study of tin can industry, the parameters of new technology are inferred from observed changes in individual plants' average coefficients at two different points of time and their given investment patterns. While the new plants' average coefficients are the same as incremental coefficients, the old plants' average coefficients represent a capacity weighted average of older and newer techniques simultaneously in use in the plant. In this cross sectional study, predicted changes in a given plant's input coefficients depend on its own equipment expenditures and the common incremental or best practice production function for the industry as a whole.

For this purpose, tin cans and other tin ware was the industry chosen in which there seemed to be a close complementarity between equipment and other inputs and in which the product variation covered a relatively narrow range during 1951-54 period of the study. The author proposed that technological change be taken into account in a dynamic input output model by making the input coefficients themselves vary with capital expenditures for growth and change over. Direct verification of a dynamic input output system with changing coefficients was plagued with three major difficulties : (1) comparable coefficient matrices at two points of time are not available; (2) available estimates of plant and equipment expenditures for individual industries

have been crude at best; (3) the available input information was restricted to labor and electricity and hence the analysis is restricted to interpretation of changes in these two kinds of input coefficients.

(4) Allen R. Ferguson³⁹ has ascertained the amounts of current and capital inputs in the production of air transportation in United States in the years 1939 and 1947, making use of technological data. The marginal costs of quantitative and qualitative changes and of technological change of the air lines transportation product are explained in detail.

(5) P.G.Clark's study⁴⁰ of the "Telephone industry — A study in private investment" indicates that the capital requirements theory can justifiably be used in integrating investment and disinvestment in capital equipment into the inter-industry framework.

(6) Mathur, P.N., Valavade, S.P. and Kirloskar, M.V.'s study⁴¹ of "optimum capacity and imbalance of capital structure -

³⁹ Ferguson, Allen R., "Commercial Air Transportation in the United States", in Studies in the Structure of American Economy..., op.cit., pp. 421-447.

⁴⁰ Clark, P.G., "The Telephone industry - A study in private investment", in Studies in the Structure of American Economy..., op.cit., pp. 243-294.

⁴¹ Mathur, P.N., Valavade, S.P. and Kirloskar, M.V., "optimum capacity and imbalance of capital structure - the case of machine manufacturing industries" in Economic Analysis in Input output Framework, ed. by P.N.Mathur and R.Bharadwaj, 1967, pp. 428-436.

See also the unpublished theses of Valavade, S.P., "Economic Structure of the organised sector of Machine Tool Industry" and of Kirloskar, M.V., "Electrical Machinery Industry in India - A Techno-economic Study", both under manuscript, 1969.

the case of machine manufacturing industries' brings out the concept of optimum production pattern and optimum capacity of multiproduct firms, a measure of imbalance in capital structure and of unutilized capacity with a lower bound to the imbalance coefficient, empirically verified in the cases of machine tools and electrical motor industries.

Here, a distinction of the earlier five authors' studies and Mathur and others' study is necessary as they deal with different problems with different types of data and techniques. Chenery and Holzman have mainly dealt with multidimensional products' economic production functions and cost curves through engineering production functions. Carter's studies are to bring out the use of processes-wise input structures in the static input output analysis and relating the input coefficients with the capital expenditures in the context of dynamic input output system. While Fergusson's study follows the same lines of Carter's study, Clark's study makes use of requirements analysis being integrated into the input output scheme. Mathur and others' studies are to establish optimum capacity of multiple products' firms with the help of linear programming technique and standard machine time requirements and market constraints data with different objective criteria of the firm. The following "Studies in process analysis, economy-wide production capabilities" of a number of industries,⁴² edited

⁴² Manne, A.S., and Markowitz, H.M. (ed.), Studies in Process analysis, economywide production capabilities, Cowles foundation for research in Economics at Yale University, Monograph 18, 1961, John Wiley and Sons, Inc., New York, London.

by Alan S. Manne and H.M.Markowitz, are also similar to Mathur and Others' industry studies, making use of the techniques of linear programming, requirements analysis and the requisite technical data.

(7) Alan S. Manne's study⁴³ of 'A linear programming model of the U.S.Petroleum refining industry' answers the following question : using the refining equipment and the raw materials available in the U.S.A. on January 1, 1953, what product mix alternatives were possibleas between the output of JP-4 Jet fuel and the output of other refinery products, and how would these alternatives be affected by a reduction in the available capacity of refining equipment.

(8) Thomas, A. Marschak's study⁴⁴ of a 'Spatial model of U.S. Petroleum refining' adds a spatial dimension to A.S. Manne's model to describe petroleum production and refining in each of several regions and then adds the third major sector of the petroleum industry - petroleum transportation.

(9) Tibor Fabian's⁴⁵ study of 'Process analysis of the U.S. Iron and Steel industry' is for prediction of the industry's responses to variations of a range of exogenous factors such as the availability of certain input materials and the desired productmix.

⁴³ Manne, Alan, S., "A linear programming model of the U.S.Petroleum refining industry", in Studies in Process Analysis..., op.cit., pp. 33-74.

⁴⁴ Marschak, Thomas, A., "A Spatial model of U.S. Petroleum refining", in Studies in Process analysis..., op.cit., pp. 75-135.

⁴⁵ Fabian, Tibor, "Process analysis of the U.S. Iron and Steel industry", in Studies in Process analysis..., opcit. pp. 264-263.

(10) Harry, M. Markowitz and Alan J. Rowe's study⁴⁶ of 'The Metal Working Industries' is concerned with the flexibility or bottlenecks involved when the metal working industries attempt to alter the composition of their output. In other words, this study suggests the industries or combinations of industries whose expansion might cause particular resources to become bottlenecks. The same authors point out the possible trouble areas where the demand for particular resources will exceed their supply, in their study⁴⁷ on 'Metal working requirements analysis', which assumes fixed requirements of men, machines and materials. As the inputs per unit output are not fixed, their next study⁴⁸ on 'A machine tool substitution analysis' presents the disaggregative analysis of 'one for one' substitution possibilities. The loss of efficiency due to such substitution depends on the availability of tasks which the machines can do equally well. So, they consider the classification of machines and tasks, the estimation of rates at which the various machines can perform different tasks, problems and potentials for obtaining task requirements by product and

⁴⁶ Markowitz, H.M., and Alan J. Rowe, "The Metal working industries", in Studies in Process analysis, op.cit., pp. 264-284.

⁴⁷ Markowitz, H.M., and Alan J. Rowe, "Metal working requirements analysis", op.cit., pp. 285-312.

⁴⁸ Markowitz, H.M. and Alan J. Rowe, "A Machine tool substitution analysis", op.cit., pp. 313-351.

class with respect to applications. In the latter study⁴⁹ of "Future metal working analysis", they point out some potential applications of simulation techniques to the analysis of economy-wide capabilities.

(11) Thomas Vietorisz⁵⁰ compares the Markowitz-Rowe's study with the study of the University of North Carolina,⁵¹ 1959, on 'Production coefficients and technological trends in Soviet industry - An input output analysis of machinery construction' and suggests ways of integrating their two alternative approaches. In another study⁵² on 'Sector Studies in Economic development planning by means of process analysis model', the same author suggests the necessity of the two preliminary phases of diagnosis and trend projection for the applications of more sophisticated techniques, such as process analysis, to the preparation of sectoral development plans, especially in underdeveloped countries.

(12) Further, we may note the study⁵³ of Harry Markowitz

⁴⁹ Markowitz, H.M., and Alan J. Rowe, 'Future of Metal working analysis', op.cit., pp. 352-356.

⁵⁰ Vietorisz, Thomas, 'Alternative approaches to Metal Working Process analysis', op.cit., pp. 364-376.

⁵¹ University of North Carolina, Institute for research in social science, 1959, Production coefficients and Technological trends in Soviet industry - An input output analysis of Machinery construction, Soviet Planning Study No. 7, Chapel Hill, North Carolina.

⁵² Vietorisz, Thomas, 'Sector studies in economic development planning by means of Process analysis models' in Studies in Process analysis, op.cit., pp. 401-415.

⁵³ Markowitz, Harry, "Industry wide, multi industry and economy wide process analysis", in the Structural interdependence of the economy, ed. by Tibor Barna, John Wiley and Sons, Inc., New York, pp. 119-150.

on 'Industry wide, multi industry and economy wide process analysis' of petroleum refining industry as a series of sub analyses. Each sub-analysis having value in itself forms a part of the larger whole. An economy wide process analysis model is not intended to or capable of replacing the operating decisions of the industrial engineer or the allocation decisions of the market mechanism. Its purpose is to estimate over all capabilities of an economy in terms of equipment and commodity classes that are much more detailed than those usually found in economic models.

1.6 Importance of this industry study in relation to previous attempts

Most of the earlier attempts can be broadly classified as (i) Production requirements studies and (ii) Production capabilities studies, based on the process analysis of the sectors with the help of cost curves, input output analysis, requirements analysis and linear programming techniques. Each of those studies deals with different problems of the sectors in the economy. They bring out methodological issues as well as illustrative principles that are to be kept in mind of the researchers on Techno-Economic studies of the sectors in the economy. However, only a few of those earlier attempts,⁵⁴ especially from the Harvard Economic Research Project School, have contributed to the studies of the problems of product multidimensionality with specific emphasis

⁵⁴ See the studies under review listing 1 to 5 in the Section 1.5 of this chapter.

on the engineering production functions and input functions. A mixture of engineering and statistical methods of analysis, whose proportions depending upon the individual technologies and industrial practices of the individual industries and their relevance to the economic variables of the study are often emphasized by the above authors in the process analysis studies of individual sectors and their production functions.

In the light of the earlier attempts, this study tries to bring out an approximate identification⁵⁵ of the product groups from the continuous multidimensional products of the technological forging process. For each of such discrete product groups, distinct average prices and dissimilar input structures have been brought out.⁵⁶ These discrete processes or product groups may serve as activities or sectors in the linear programming and commodity wise input output tables for both the types of studies, viz., production capabilities studies and production requirements studies.

For each sector specified in an input output coefficients matrix, the structural role of the sector is represented by its column elements as technological parameters of the instantaneous production function of the sector and by its row elements as the distribution of the output of the sector for

⁵⁵ See Chapter VI of this study.

⁵⁶ See Chapter VII of this study.

the unit outputs of all its using sectors. When these sectors are specified, it requires that the column and row vectors' input coefficients exhibit reasonable stability and that there be substantial independence among the individual columns in the matrix (i.e. stability of individual production functions with respect to changes in other production functions).⁵⁷ These conditions on sector specification may not be ensured if the sectors are producing a number of commodities and if their product mix, process mix and continuous product multidimensionality are very much fluctuating from firm to firm of the given sector. Those problems arise because of the aggregations of the commodities that are produced by different processes and/or by the same process in the classification schemes and in the nature of the available statistical data on inputs and outputs for the purpose of preparation of input output tables. The instability of technical coefficients may be reduced by defining the sectors commodity wise rather than industry groups wise.

In the disaggregative input-output table of 65 x 65 sectors of India for 1963, "all Iron and steel industries other than basic Iron and Steel" is shown as a single sector which is inclusive of steel forgings industry. But the steel forgings industry has its specific role, as the supplier of intermediate products to many using industries and its dependence on the particular variety of forging quality steels

⁵⁷ Carter, Anne, P., "The technological structure of cotton textile industries", in Studies in the Structure of American Economy.., op.cit., p. 361.

in the inter-industrial complex of the economy.⁵⁸ In a developing economy with its five year plans for industrial development and economic growth, the structure of this industry becomes a key to many of its using industries. Its technology is completely different from other Iron and Steel industries. For these reasons, this steel forgings industry is incorporated as 66th Sector in the above table, for studying the direct and indirect repercussions on the economy.⁵⁹

In addition, this study provides a methodology for product specification of similar jobbing type industries. The product groups so specified, are likely to serve as sectors in the commoditywise input-output tables. While deriving the distinct aggregated product groups' input structures, it brings out the limitations of United Nations general methods⁶⁰ of linear transformations under the two technologies assumptions to derive the commodity x commodity and industry x industry input-output tables. Thus, this industry study is intended to serve the production units in respect of the project cost estimates of specified product dimensions' ranges as well as to bring out an approximate sector specification in the input-output tables of the economy.⁶¹

⁵⁸ See Chapters II and V of this study.

⁵⁹ See Chapters IV and V of this study.

⁶⁰ A System of National Accounts, Series F, No. 2, Rev. 3, Studies in Methods, United Nations, Department of Economic and Social Affairs, Statistical Office of United Nations, Chapter III, "The system as a basis for input output analysis", pp. 35-51.

⁶¹ See Chapter VII of this study.

1.7 Brief Summary of the following chapters

Chapter II brings out the structure, supply, demand pattern and development problems of this industry during the five year plans in India.

Chapter III brings out the technical processes, materials and products as would be applicable to the existing steel forgings industry in India and the innovations in them that are developed in the advanced countries. The case studies of each firm under investigation are enlisted as a proper background to the following analytical chapters.

Chapter IV discusses (i) the analytical approaches to the study of production functions of the firms or of an industry and the relative merits of input-output analysis as an empirical tool and a theoretical approximation to the general equilibrium analysis, (ii) the nature, uses and limitations of the input-output analysis, (iii) conceptual and empirical problems in the evaluation of input and capital structures as instantaneous production functions of the firms, processes and of the industry. Refinements on the input structures, especially in respect of subcontracting jobs, are carried out with the primary information of the individual firms.

Chapter V illustrates the use of a disaggregative input output table incorporating the steel forgings as a separate sector. An estimate of the indigenous production of captive and/or small scale units of steel forgings industry is attempted.

Chapter VI provides a methodology of the use of principal components and scatter diagram methods for product specification of a multidimensional product of steel forgings industry.

Chapter VII derives the distinct average prices of the aggregated product groups and the independent input structures of those aggregated product groups within specified ranges of product dimensions. It brings out the limitations of the United Nations' general methods of linear transformations to derive the commodity \times commodity and industry \times industry tables. These independent input structures are likely to serve as project cost estimates of the specified ranges of product dimensions in the production units and as sector specification in the commoditywise input-output tables and as activities in the linear programming models.

Chapter VIII provides summary and findings of this study.

CHAPTER II

**STRUCTURE, SUPPLY, DEMAND PATTERN AND
DEVELOPMENT PROBLEMS OF STEEL FORGINGS
INDUSTRY IN INDIA**



2.0 Introduction

Industrial planning in India aims at two main inter-related objectives : (a) maximising the total output (especially in the priority areas) in relation to the given volume of investment and materials, (b) minimising the total cost including the foreign exchange component of the industrial programme. In the context of these objectives, industry studies are often suggested to bring out the importance and the structural role of the industry with its specific development problems in the general industrial complex of the economy. For this purpose, this chapter deals with mainly (1) historical development of the levels of operation of the forging process in general, (2) structure of the industry in private sector during 1963-66 and state-wise structure during 1963-65, (3) development of the industry since the inception of five year plans, (4) imports and exports during 1957-1969, (5) demand pattern of forgings by using industries in India during 1960-1964, (6) market imperfections, growth of unutilized licensed capacities and other development problems (see also Appendix to this Chapter II) and nature of official statistics of the industry. Thus, this chapter is intended to bring out the general background of this industry study, emphasizing the significance of a jobbing type industry in the Indian economy and the need for detailed data on product multi-dimensions for planning purposes.

2.1 Historical development¹ of forging process

Forging hammers have undergone a constant development with the introduction of forged parts of larger size and more intricate complex shapes. After the development of gravity hammers with guided ram, mechanical power and closed die impression forging processes are introduced during 18th century. During the 19th century, progress in power hammers has been accelerated. A number of technical innovations in processes and materials² for hot forging and cold forging methods have been developed and improved upon, as the efficient use of materials and quality forgings are needed during 20th century. Steel age of 20th century brings forth the foremost importance of steel among all metals for forging process purposes. Thus, the art of forging has taken many transformations through its historical development. In general, the art of forging process may be defined³ as the plastic deformation of metals or alloys into some pre-determined size or shape generally at elevated temperatures, by a compressive force exerted by a hammer, press or upsetting

¹ See Jenson, Jon, E., Forging Industry Handbook (ed.) Director of Marketing and Technical Services, Forging Industry Association, Cleveland, Ohio, 1966. The Ann Arbor Press, Inc., Ann. Arbor, Michigan.

The art of forging dates back to rock ages when man needed crude weapons hammered between stones. The old primitive forge, wherein metals are heated by means of a blast of air, is employed during the second lineage of stamping jewelry and coins, around 1600 B.C. Hand Sledge is the principal tool of hand hammering, supplying energy for many centuries.

² Some of these have been discussed in the Appendix to the III Chapter.

³ W. Steeds, Engineering Materials, Machine tools and Processes, Longmans, Third ed. 1957, Ch. 5 Forging, p.120.

machine. Parts or members produced in such a manner are called forgings.

2.2 Levels of operation and their nature

Depending on the requirements of size, shape, mechanical properties and many other dimensional specifications, different forging methods with different time requirements of activities in die shop, heat treatment, machining, finishing, shot-blasting and inspection, are made available. All these facilities form part of and are ancillary to the forging process. These ancillary shops are the features of a fullfledged commercial independent forge unit whose main activity is to produce forgings on customers' orders. These are generally large scale units providing employment to hundreds of persons and producing illimitable forgings of varied dimensions. However, the age old procedures of hand forging on an anvil are still followed by small units, especially for repairs and maintenance works of large units to upkeep latter's equipment. Some other forge shops are captive units of the large units, whose main products consume the forgings of their captive forge shops. Next, there are many an unaccountable list of small household black smithy type forge units as ancillary shops to the local large establishments. Thus the levels of operation range from a single blacksmith's shop to the large scale units. However, there are no reliable estimates of production statistics of all these levels of operation to analyse the economies of different levels of operation with respect to

any optimum size.⁴

2.2 Modal type size as an approximation to optimum size and the structure of the industry in private sector during 1963-1966 and over states in India

While it is not often possible to discover the optimum size by factual investigation, the existence of a modal type size associated with a large proportion of the total number of firms, may be taken as a first approximation and as empirical evidence to identify the optimum size of a firm.⁵ In what follows, the modal type sizes are computed from the structure of firms distributed over plant capacity ranges. For this purpose, licensed capacities of the firms in private sector during the years⁶ 1963 to 1966 are taken and the structure with respect to modal type size is examined.

Actual installed capacities of the firms are required to be taken for this purpose of analysis. Such data are not available from any source. Similar data for public sector units and for any other years are not available. It is assumed that the structure of the firms based on tonnage

⁴ See Chamberlein, E.H., Theory of Monopolitic Competition, 1933, Harvard, pp. 104 for the definition of optimum size as the output corresponding to minimum of average cost curve of a firm.

⁵ See Robinson, E.A.G., Structure of competitive industry, pp. 15-17.

⁶ The period 1963-66 is the latter half of the Third Five Year Plan period in India. During this period, it is observed that this industry attained peak levels of growth of production (see the Section 13 of this Chapter II).

licensed capacities in private sector, as depicted in Tables 1, 2 and 3 may provide an approximation to the structure of firms based on installed capacities. Similarly, the percentage of utilized to licensed capacities may serve as an approximation to the percentage of utilized to installed capacities. They are underestimates to the extent of divergence of installed to licensed capacities. These production/licensed capacities include those of some captive units. However, there is no specific knowledge of the contribution of the captive units to the total production/licensed or installed capacity.

2.2.1 Structure Over Years

While there is not much change in the structure from 1963-64 to 1964-65, there is quite a drastic change in the structure of firms and of tonnage licensed during the period ending December 1966. These are observed from the percentages in Table I and from the modal sizes in Table 2. The negative quantities in Table I refers to (i) either revoking of the licenses or (ii) actual reductions in the number of firms or (iii) due to increases in the plant capacities so that a shift of those firms' capacities fall in the succeeding capacity ranges over the years 1963-1966. While there is no evidence to justify the cases (i) and (ii), the case (iii) can be deduced from Table I (especially columns (6) to (9)). A summarized picture of the distribution of the firms and tonnage licensed capacities is presented in Table 2.

Table I. Structure of the firms licensed upto 1963-64, during 1964-65 (average of two years) and 1966 (calendar year) in private sector, according to their licensed capacity ranges

Plant capacity ranges in tons per year	Upto 1963-64 (financial year)				During 1964-1965		During 1966		Upto 1964-65		Upto 1966 Dec.	
	No. of units	Percentage of (2) to total number of units	Total tonnage capacity licensed	Percentage of (4) to total tonnage	No. of units licensed	Tonnage capacity licensed	No. of units	Tonnage capacity licensed	Percentage of No. of units under (2)+(6)	Percentage of tonnage capacity under (4)+(7)	Percentage of No. of units under (2)+(6)+(8)	Percentage of tonnage capacity under (4)+(7)+(9)
1	2	3	4	5	6	7	8	9	10	11	12	13
0-1000	21	55	9638	17.03	5	2920	15	6263	57	17.01	23	4.83
1000-2000	13	35	20312	35.90	2	2500	2	4000	25	24.14	27	16.79
2000-5000	2	5	8400	14.84	3	10800	13	41672	11	26.01	38	46.61
5000-12000	2	5	18240	32.23	1	6000	3	17185	7	32.84	12	31.77
Total	38	100	56590	100.00	7	17220	3	56614	100	100.00	100	100.00

**Table 2. Modal sizes and Mean sizes of plant capacity
(licensed) in private sector upto 1963-64,
1964-1965 and upto 1966**

(all in tons per year)

	Upto 1963-64	Upto 1964-65	Upto 1966
(a) Modal size	334	396	1551
(b) Mean size	1489	1640	2717
(c) Mean-Mode	1135	1244	1166

Table 3. Statewise structure of licensed and utilised licensed capacities of firms in private sector

Year		1963-64 (March ending)			1964-1965 (Average of two years)						
State	No. of units	Percent- age of (2)	Licensed tonnage capacity (4)	Percent- age of (4)	No. of units	Percent- age of (6)	Licensed tonnage capacity	Percent- age of (8)	Actual tonnage produc- tion	Percent- age of (10)	Percentage of utilised to licensed capacity (10)/(8) 12
1	2	3	4	5	6	7	8	9	10	11	12
West Bengal	16	42	37260	65.84	19	42	41920	56.79	26304	58.06	62.75
Maharashtra	5	13	2618	4.64	7	16	9078	12.30	6393	14.11	70.42
Madras	4	11	3500	6.18	5	11	7600	10.30	4732	10.44	62.26
Uttar Pradesh	5	13	5880	10.39	5	11	5880	7.97	3828	8.45	65.10
Delhi	2	5	1500	2.65	2	4	1500	2.03	984	2.17	65.60
E. Punjab	3	8	2040	3.60	3	7	2040	2.76	333	0.74	16.32
Andhra Pradesh	1	2.67	1092	1.93	1	2.25	1092	1.48	851	1.88	77.93
Kerala	1	2.67	900	1.59	1	2.25	900	1.22	787	1.74	87.44
Rajasthan	1	2.66	1800	3.18	1	2.25	1800	2.44	371	0.81	20.61
Gujarat.	-	-	-	-	1	2.25	2000	2.71	723	1.60	36.15
All India Total	38	100.00	56590	100.00	45	100.00	73810	100.00	45306	100.00	61.38

Sources to prepare Tables 1, 2 and 3 are both official and non-official data collected from (1) the annual reports of (a) Directorate General of Technical Development (DGTD), New Delhi and of (b) the Association of Indian Drop Forging and Stamping Industries, Bombay.

Identification of the figures with the sources is not possible as the tables are processed for uniformity and presentation purposes from the original more detailed data. The modal sizes presented in Table 2 are based on a more detailed distribution. (-) values refer to reduction while the +ve values refer to additions.

2.2.2 Structure over states

For statewise analysis of the structure of licensed and utilized capacities, only for an average of the calendar years 1964-1965, licensed tonnage and actual production statistics are available. For 1963-64, licensed tonnage capacity statistics only are available. While there is an increase in the actual number of units and licensed tonnage in West Bengal, Maharashtra and Madras, there is no change in the number of units and in the licensed tonnage capacities of the rest of States, as observed from Table 3. Historically, the concentration of forging units in West Bengal is to meet the railways requirements. Maharashtra and Madras have developed very recently quality forgings' units to meet the requirements of automobiles, diesel engines, tractors, earth-moving machinery and other heavy engineering equipments.⁷ Maharashtra and Madras are thus leading the industry in private sector.

The actual production structure is closely similar to that of licensed tonnage capacities. There are 7 States utilizing their licensed capacities at a higher percentage compared to all India private sector firms' average percentage utilization (61.38%). The other three states, E. Punjab, Rajasthan and Gujerat are far below this level in their percentage utilization of licensed capacities in private sector.

⁷ Because of recent growth of forging units especially in Maharashtra, some firms which have been licensed very recently and covered under the field investigation of this study in III Chapter are not included in the above table.

2.3 Development of the industry since the inception of Five Year Plans

Prior to the First Five Year Plan (1950-51 to 1955-56) the forging industry is completely under the shadow of their using industries as captive small scale or even as household units. Such small ancillary shops are continued to be unaccounted for, due to the difficulties of estimation. Industrial programmes, in general and of steel plants in particular, are launched during the Second Five Year Plan (1955-56 to 1960-61). But the steel forgings industry has not grown along with the steel plants.⁸ Tata Iron and Steel Plants' (TISCO) yearly production of wheels, axles and tyres for railways from 1948 to 1962 has remained stagnant around 21,000 tons. The Durgapur steel plant started producing wheels, axles and tyres from 1962-63 onwards. Coupled with the Durgapur Steel Plant's (DSP) production of the wheels, axles and tyres, the total production rose to 32,000 tons in 1962-63; 52,000 tons in 1963-64, 60,000 tons in 1964-65, with a small fall to 58,000 tons in 1965-66. Similarly, the railway sleepers production remained stagnant around 7,000 tons per annum during 1957-1960-61, rose to 16,000 tons in 1961-62, 32,000 tons in 1962-63, 41,000 tons

⁸ The steel plants launched during the Second Plan have started their production only after the end of the Second Plan because of the gestation period for erection and installation.

in 1963-64, 68,000 tons in 1964-65 and to 69,000 tons in 1965-66.⁹

By the end of the Third Plan, the Indian Railways' demand for sleepers is as much as 75,000 tons per year. The original capacity of 60,000 tons per year, of sleepers plant is expanded over years by 1967, to 75,000 tons per year. Similarly, the wheel sets plant capacity of 57,000 tons per year at DSP is likely to expand to 93,000 tons per year. Thus, it is only after the development of Iron and steel plants and of railways that forge shops came into existence since the Third Plan.

2.3.1 Recent Public Sector Projects and their features

Though plans are there (since the inception of Third Five Year Plan (1960-61 to 1965-66) to develop forging capacity in public sector, especially the Foundry Forge project (FFP) at Ranchi, Mining and Allied Machinery Corporation (MAMC) at Durgapur and a forge shop at Alloy Steel Project (ASP), much of their construction, erection and installation work is still in progress. FFP may take upto 1975-76 to reach its full capacity of 50,000 tons per year according to their estimates. MAMC forgeshop could not reach its 8,000 tons per year capacity. ASP forge shop

⁹ Source to all these production statistics :

Hindustan Steel Ltd. (H.S.L.), Statistics for Iron and Steel Industry in India, Ranchi, 1966, p. 9. Though the wheel sets and sleepers are manufactured by the basic process of forging these have not been included in the official statistics of demand, production, etc. of steel forgings, but they have been included in those of Iron and Steel industry as perhaps their mills are part and parcel of steel plants.

started production from 1966-67 onwards attaining its yearly capacity of 4,000 tons of finished forgings in a few years.¹⁰ Thus, these three plants together may provide a maximum production of 6,000 tons by 1966-67, whereas their potential capacity likely to be available by 1975-76 is 62,000 tons per year to meet the demand of steel plants, heavy machine building plant (HMBP) and Heavy Machine Tools Plant (HMTP).

Two more projects, one at Hardwar and another at Wardha, are proposed to be set up, during Fourth Five Year Plan ending by 1973-74, with capacities of 15,000 tons per year and 8,300 tons per year respectively, to meet the demand of heavy electricals and engineering industries.¹¹ If these two projects are also realized, there will be a potential capacity of 85,300 tons per year by 1975-76 in public sector. The nature of the equipment like heavy presses, upsetters and hammers with high capacities in the public sector projects is such that they can produce heavy forgings of above 3 ton piece weight, while the private sector has invested in such equipment which can turn out a maximum piece weight of 3 tons only.¹²

¹⁰ These observations are drawn from the booklets and annual reports of the companies and are similarly felt on field investigation of the plants. Source to these general production statistics or targets of the plants is the small booklets published by the concerned companies, firms and industry.

¹¹ Report of the Planning Commission for machinery group industries for IV five year plan.

¹² This is observed by the members of the Association.

2.3.2 Growth of Private Sector

In private sector, there are 28 firms licensed to produce 35,000 tons per year by 1960-61, 30 firms to produce 47,752 tons by 1961-62, 38 firms to produce 56,590 tons by 1963-64, 45 firms to produce a maximum capacity of 1,30,424 tons per year, by the end of December 1966. However, the actual percentage utilization of the licensed capacity in 1965 is observed as 61.38% (See Table 3). Due to general recession in demand,¹³ followed by labour unrest etc. during 1967, almost all firms have been affected, with the result that the licensed capacity and output figures have gone down to 83,740 tons per year and 40,500 tons per year¹⁴ respectively. During 1968, licensed capacity reached to 1,00,800 tons per year and the actual production 44,000 tons per year of 44 licensed firms in the private sector. Utilization of licensed capacity is 48.36% in 1967, 43.65% in 1968, whereas it is 61.38% in 1965.¹⁵ Thus, the private sector has faced a growth in production and licensed capacity from 1960-61

of drop forgings and stamping industries and also being accepted by the public sector projects like FFP, ASP and MAMC officials. As on field investigation of both private and public sector projects, this distinction is visible.

¹³ See "Economic Survey for 1968-69" Govt. of India Budget Papers. See Mathur P.N. and Venkatramaiah P., "Utilisation of Business survey data in the analysis of business troughs in India and recovery (1965-66 to 1968-69)" submitted to a Business Conference in Madrid, Spain in 1969.

¹⁴ The main sources for all these production/capacity statistics are (i) Planning Commission's Fourth Five Year Plan Report of the planning group for machinery industries, (ii) Annual reports of Directorate General of Technical Development (DGTD), (iii) Annual report of Association of Steel Forgings and stamping industries. All these have to be conglomerated as all these are partial in reporting their statistics.

¹⁵ See footnote 14.

to 1965-66 reaching peak levels, followed by a sudden trough during 1966-1967 and a slight recovery in 1968 in steel forging industry. Taking both public and private sectors together, there may be a maximum of 50,000 tons per year achieved production available by 1968, while the demand estimate by 1973-74 is 2.75 lakh tons.¹⁶

2.4 Imports and Exports of Iron and Steel Forgings

Imports form as a part of supply and exports as a part of demand. The statistics of imports and exports of iron and steel forgings and castings are published in "Monthly Statistics of Foreign Trade of India" from 1957 onwards. Those of iron and steel forgings are distinguished in the same reports from 1966 onwards. The imports and exports statistics of iron and steel forgings for the period 1957 to 1965 are estimated on the basis of the composition of the forgings and castings in the year 1965 as ratio estimates. As the re-exports are negligible (4 or 5 tons during 1959 and 1960), these have not been shown separately and deducted from the imports. All these statistics are in current prices.

An analysis of 5 to 6 months imports of iron and steel forgings during 1967, collected unofficially from the Bureau of Commercial Intelligence, Bombay, shows the demand for imports using industry-wise on an average as follows :
Railways consume 75%, motor vehicles 12%, tractors 3% and all others like metals and machinery industries require 10% of the total imports.

¹⁶ Same as 15.

Table 4. Estimates of imports and exports of iron and steel forgings

Year ending	Imports		Exports	
	Tonnage	Value in Rs.	Tonnage	Value in Rs.
1957 December	6340	1,64,14,766	99	53,898
1958 December	3080	95,00,400	49	36,051
1959-60 March	7566	2,27,41,442	18	18,496
1960-61 March	9852	2,82,14,792	326	1,22,502
1961-62 March	12759	3,71,21,851	988	3,65,983
1962-63 March	7985	2,57,48,749	698	2,76,144
1963-64 March	9016	2,93,73,964	1169	4,51,068
1964-65 March	22657	4,07,81,095	1346	4,58,490
1965-66 March	12332	3,74,29,905	334	1,98,309
1966-67 March	11238	5,24,21,876	4	7,792
1967-68 March	13000	6,10,00,000	6	4,590
1968-69 March	N.A.	N.A.	158	3,52,393

Source. Monthly Statistics of Foreign Trade of India, Department of Commercial Intelligence and Statistics, Calcutta, Government of India.

N.A. - Not available.

2.4.1 Trends in imports and exports

Imports are increasing from 1957 upto 1961-62 March (except in 1958), with a sudden fall in 1962-63 and galloping increase upto 1964-65 March, with a sudden fall in the immediate year 1965-66. Exports are decreasing upto 1959-60 March, with a sudden increase during 1960-62, a slight fall in 1962-63, a sudden increase during 1963-65, and a sudden fall in 1965-66. The imports and exports are steady during 1966-68. Imports and exports are following similar trend from 1960-61 onwards.

2.4.2 Imports and exports as external supply and external demand to the economy

Exports are relatively negligible compared to imports or to total supply. Indigenous production or gross domestic output + imports = total supply, while the total intermediate demand + exports = total demand. As total demand = total supply, the total intermediate demand = indigenous production + imports - exports. Thus, intermediate demand is the same as supply for internal demand. Changes in stock are assumed to be zero. The statistics of indigenous production of large scale units are available from the Annual Survey of Industries reports. They are shown under the 'Products and byproducts (Table 6 of ASI reports) of '341-3 Iron and Steel castings and forgings' industry group. These total intermediate demands for different years 1960-1964 are calculated for studying the demand pattern of using industries in the next section. Each using industry's con-

sumption of steel forgings as material inputs are also given in the ASI reports (Table 5 of the ASI reports). Thus, the ratios of the using industry's demand to the total intermediate demand of steel forgings provide the demand pattern of using industries.

2.5 Demand pattern of steel forgings according to using industries

To know the demand pattern using industrywise, percentage share of each industry's consumption demand out of the total supply for internal demand over 1960 to 1964 and their averages are computed. While the detailed tables¹⁷ distinguishing the tonnage and rupee values using industrywise are prepared, a more aggregated table is presented below. (Table 5 on page 45).

From the above table, it is clear that the major consumers are (1) Motor vehicles, (2) Earth-moving equipment

¹⁷ In which some ratio or proportional method adjustments are required to be made for the non-availability of the details for steel forgings and castings separately in the reports, to distinguish the consumption of steel forgings by (1) Motor vehicles, (2) Diesel engines, (3) Earth moving machinery (4) Others of non-electrical machinery.

The source for Table 5 is the original rupee values given in Table 5 of Annual Survey of Industries (ASI) Reports and Monthly Statistics of Foreign Trade of India for the respective years.

(a) The indigenous production of steel forgings reported in ASI reports is that of large scale units only which employ 50 or more workers with the aid of power and/or 100 or more workers without the aid of power. So, to the extent that the intermediate demand does not cover the small scale and captive units, the estimate of intermediate demand is an underestimate and the percentages are overestimates. No statistics of production corresponding to small scale and captive units are available from any source.

(b) The above table 5 does not include railways consumption demand as railways' major requirements of wheel sets and sleepers have not been classified under forgings but classified under Iron and Steel by ASIC and ASI reports.

Table 5. Using industrywise demand pattern of steel forgings over 1960-1964
(All in percentages of rupee values consumed)

S.No.	Using Industry	1960	1961	1962	1963	1964	Average	Range of (3) to (7)
1	2	3	4	5	6	7	8	9
1	Motor vehicles	43.23	49.85	40.85	50.16	47.19	46.26	40.85 to 50.16
2	Diesel engines	17.48	14.43	18.36	13.82	10.59	14.94	10.59 to 18.36
3	Earthmoving equipment	14.87	14.10	12.91	15.33	24.48	16.34	12.91 to 24.48
4	Power driven pumps, air and gas compressors, vacuum pumps, refrigeration plants, speed reduction units	0.98	0.52	3.10	2.17	2.52	1.86	0.52 to 3.10
5	Others of non-electrical machinery	10.00	11.27	8.28	8.35	9.93	9.54	8.28 to 11.27
6	Shipbuilding and repairs	9.75	5.72	7.61	1.90	1.40	5.28	1.40 to 9.75
7	Machine tools	-	0.96	3.38	5.14	0.05	1.91	0.00 to 5.14
8	Sugar and tea machinery	-	2.20	2.40	2.00	1.74	1.67	0.00 to 2.40
9	Textile and jute "	3.69	0.29	1.21	0.01	0.16	1.07	0.01 to 3.69
10	Conveying equipment like buckets, elevators, strip hoists, cranes etc.	-	-	0.90	0.47	0.76	0.43	0.00 to 0.90
11	Agricultural implements	-	0.66	0.99	0.39	0.34	0.48	0.00 to 0.99
12	Tractors, harvestors etc.-	-	-	0.01	0.07	0.74	0.16	0.00 to 0.74
13	Paper M/c construction M/c and oil mill machinery	-	-	-	0.19	0.10	0.06	0.00 to 0.19
	Total	100.00	100.00	100.00	100.00	100.00	100.00	

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(3) Diesel engines, (4) Shipbuilding and repairs and (5) All non-electrical machinery goods like tractors, machine tools, pumps, compressors, etc. These percentages are approximately true with those of tonnage consumption of steel forgings (not presented here for this reason only) using industrieswise. The percentages of the indigenous production to the total intermediate demand are 4.78% in 1960, 4.38% in 1961, 13.24% in 1962, 37.27% in 1963 and 36.84% in 1964. However, these percentages are higher estimates to the extent they do not include captive and small scale units production of the steel forgings industry. It is to be noted that these percentages are exclusive of railways demand for wheel sets and sleepers, whose proportion is likely to be more than even that of motor vehicles.

2.6 Development problems of steel forgings industry in India

(1) Nature of market imperfections

When project cost estimates have been prepared, the usual practice is to make financial projections for a particular tonnage capacity of the project by the prospective entrepreneurs. No attempts have been made so far by any of the entrepreneurs to know the demand potentialities, existing capacities, actual production with respect to product dimensions of the variety of forgings and the possible range of prices for the discrete ranges of the product dimensions. The nature of the market for numerous types of forgings is that it is purely jobbing type customers oriented. Price

discriminations¹⁸ of all kinds, viz. charging different prices for a homogeneous commodity for different customers at the same time and place or for the same customer at different times and places, prevail much in this industry. The prices for homogeneous goods are not uniform between the firms in the industry as every thing is to be decided at each stage by negotiations and relations between the producer and the consumer.¹⁹ As the very nature of the industry demands the complete specifications of various product dimensions by every customer on each and every order, it is all the more necessary for the producers to have a view of the range of prices for different ranges of the product dimensions, so that their project cost estimates will be reliable.

(2) Growth of unutilized licensed capacities

The growth of licensed capacity in steel forging industry has been so fast that the main problem facing the industry today is unutilization of the licensed capacities. The captive capacities in production are estimated to the tune of 32,000 tonnes and capacities for which letters of

¹⁸ Robinson Joan, The Economics of Imperfect Competition, Macmillan, 1933.

¹⁹ Especially during the recent recession period, many orders have been cancelled without notice of any kind with the result that even weekly forecasts of the orders of the customers are just uncertain. This has resulted in the stock piling of certain materials, increase in unutilized capacities of certain machinery, bottlenecks on other equipment and inefficiency as well as unrest of labour. These observations are based on the survey of firms in this industry.

intent of licences have been issued to the order of 2,58,000 tonnes. It has therefore become all the more imperative to take cognizance of this situation, while reviewing the present status and future programmes of the industry,²⁰ especially with reference to product dimensions and to users of steel forgings.

(3) Nature of the broad nomenclature²¹ of the steel forgings and their users

All these nomenclatures are just indicative, as they are neither exhaustive nor truly representative of the actual requirements of the different quantitative and qualitative features of product dimensions with specifications of numerous forgings, used by the different using industries.

(1) Many models of the autos and trucks contain over 250 separate forgings. Steering spindle, steering cross link rod, differential spides, anchor, crankshafts, torsion

²⁰ Source: Annual report, 1966-67 of the Association of Indian Drop Forging and Stamping Industry.

Towards this end, the Association of Indian Drop Forging and Stamping Industries (hereinafter termed as Association) urged the Government - (a) to review the targets for the Fourth Plan for the steel forging industry in consultation with the producers and consumers, (b) to defer capital goods clearance in the case of licenses who had not implemented their projects by an immediate review of all licences/letters of intent, and (c) to set up a panel to guide the development of the steel forging industry. In response, (a) Government have not reviewed the target of the steel forgings for Fourth Plan, (b) the Steel forging industry has been completely delicensed without any review of the earlier licenses/letters of intent, (c) it is decided to set up a panel for steel forgings industry in 1968.

²¹ Source: Forging industry handbook (ed) Director of Marketing and Technical Services, Forging Industry Association, Cleveland, Ohio, 1966. The Ann Arbor Press, Inc., Michigan.

bars, ball studs, spring seats, hubs, idler arms, pitman arms, driving axles and steering arms for passenger cars, buses, and trucks are used as forgings in automotive industry for heavy duty service. Similarly, the tractors and agricultural machinery and implements parts.

(2) High strength to weight ratios and reliability are essential in structural components for air crafts which contain over 450 structural forgings (exclusive of the hundreds of the forged parts comprising the engine). Forged bulkheads, wing roots, hinges, engine mounts, brackets, beams, shafts, ball cranks, landing gear cylinders wheels, brake carriers, discs, arresting hooks, many other fittings and structural members illustrate the important forgings for aircraft production.

(3) In jet turbine engines, iron base, nickelbase and cobalt base alloys are forged into components such as buckets, blades, couplings, discs, manifolds, rings, chambers, wheels and shafts requiring uniformly high yield and tensile strength, along with good ductibility. Super alloy spacer rings, injectors and titanium reactor cases are typical of engine forgings.

(4) Heavy tanks in defence contain over 550 separate forgings. Each 250 lb and 500 lb Bomb contain 7 forgings and each of shells and mortar projectiles contain at least two forged components.

(5) Internal combustion engines and ship building repair forged crankshafts, connecting rods, rod caps, camshafts, rocker arms, valves, gears, shafts, levers and flywheels.

(6) Railways locomotives and rolling stock demand wheels, axles, tyres, wheel sets, sleepers and couplings.

(7) Earth moving equipment include rollers, pumps, bucks shoes, sidetinks. Similarly hardware items.

(8) Petroleum industry requires flanges and parts of low pressure valves, parts for high pressure pumps, such as valves, piston rods, pump liners.

(9) Air compressors include air driven tools. Similarly, the materials handling equipment and sugarcane crushers.

4. Nature of published statistics of demand estimates and supply of steel forgings in India

The published demand estimates of different organisations are very aggregative. No extensive market survey is conducted on scientific lines to specify the demand pattern, taking into account the various product dimensions required by using industries. After the estimates or the targets are published for a plan, many a time castings and forgings being clubbed together, there is hardly any publication bringing out the progress that this industry makes during the tenor^{year} of the plan, which can be readily available for entrepreneurs. The combined demand estimate for castings and forgings together, does not serve purpose to either of the entrepreneurs in making their financial projections as it involves problems of both productmix and process mix.²²

The more the disaggregation of the demand pattern each using

²² Problems of productmix, processmix, product multi-dimensionality are explained in Chapters IV and VI of this industry study.

industrywise, the more fruitful it will be for the producers in fixing up their production pattern. Indigenous production, imports and exports statistics are also very aggregative. Steel forgings industry is not shown as a separate industry group in the ASI reports. As such the inputs and outputs of this sector cannot be traced from those reports, which are the main source of information for the construction of input output tables. If the inputs corresponding to the outputs of each commodity are made available, the problem of constructing commodity-wise input output tables becomes easier.

2.7 Summary

The forging process is as old as antiquity and as new as tomorrow, developing the levels of operation from the household black smithy to the large scale manufacturing. The modal type optimum size of the industry is around 1551 tons per year by the end of December 1966. There is a drastic change in the structure of firms and tonnage licensed from 1963 to the end of 1966 in private sector. West Bengal, Maharashtra and Madras are the leading States in the industry. Development of the industry has started after the steel mills and railways have been established. The public sector projects are still in infant stage even during third five year plan period, while the private sector has grown fast especially after 1964. Imports are phenomenally high while the exports are negligible during 1957-69. Unutilized licensed capacity is growing in the industry. If it is due

to general recession, it may be a short run phenomenon. Railways, automobiles, diesel engines, earth moving equipment and ship building dominate the demand pattern. Market imperfections, growth of unutilized capacities, nature of the broad nomenclature of the steel forgings users' wise, nature of published statistics of demand estimates and supply of steel forgings in India are the main problems for the development of the industry. All other development problems of the industry are appended to this chapter. All these development problems emphasize the need for detailed data on capacities, production, demand, prices, imports, exports and other economic variables with respect to product dimensions and to users, so that the construction of commoditywise input output tables becomes easier. The results based on the use of such a disaggregative commodity wise input output table are likely to be stable for planning purposes either for the firm, industry or for the economy.

Appendix to Chapter IIDevelopment problems of protection and of production cost reduction in steel forgings industry

Main development problems of steel forgings industry stressing the need for detailed data on product dimensions are presented in the text of this chapter II. A few more problems in respect of (i) differential imports duties of steel forgings, (ii) imports of steel forgings that can be substituted, (iii) export promotion measures and policies of steel imports, (iv) lead time for indigenous production of forging quality steels, (v) reduction in excise duty of liquid petroleum gas, (vi) impediments due to foreign collaborations, (vii) need for developing ancillary shops of forge units, (viii) productivity calculations, (ix) provision for many break downs in this industry, and (x) skills, efficiency, incentives and other labour problems, are presented in this appendix. All these problems can be broadly classified as problems of (a) protection and (b) cost reduction of the industry. All these are generally felt by the industry officials and the members of the Association of Drop forging and Stamping industries. The Association brought out all these problems in their Annual Report for 1967-68. The other sources of information presented here are also referred to, at the appropriate places. No attempt is made here to analyse the problems in detail and to suggest alternatives, as it is a stupendous task in the absence of reliable and detailed data on all economic variables, especially with respect to product dimensions and to users of steel forgings.

(1) Differential rates of import duties of steel forgings

The problem of growth of unutilized licensed capacities due to present delicensing policy, still persists when the import of steel forgings continues to be licensed. The differential rates of import duties also may aggravate the problem.¹ Inasmuch as tractor parts are imported duty free, forgings are imported by the tractor manufacturers without payment of duty.²

(2) Imports of forgings that can be substituted

The import and export statistics from the Monthly Statistics of Foreign Trade, do not show distinctly the forg-

¹ Forgings are being imported into the country in various forms, both as machined parts and in semi-finished or unfinished form. The manufacturers of assembled products like automobiles, tractors, etc. import forgings in substantial quantities in their completely knock down (c.k.d.) packs.

² Some of the anomalies of differential rates of import duty of steel forgings are presented below from the source Indian Customs Tariff (Fifty-sixth issue)

- | | | |
|---|----------|---|
| (1) Steel forgings - item 63 (28) | page 154 | Duty - 50% advalorem |
| (2) Steel forgings for sugar mill machinery components | page 155 | Duty - 10% ad valorem |
| (3) Steel forgings for machine tools components | page 155 | Duty - 15% ad valorem |
| (4) Unmachined forgings of crawler tractors semi-finished components | page 156 | Duty - 27 $\frac{1}{2}$ % ad valorem |
| (5) Semifinished forgings of railway rolling stock components | page 156 | Duty - 40% ad valorem |
| (6) Unfinished forgings for textile machinery components | page 156 | Duty - 27 $\frac{1}{2}$ % ad valorem |
| (7) Tractors' parts (forgings) Item 72(9)b finished form or c.k.d. form | page 174 | No import duty |
| (8) Motor vehicles parts (forgings) Item 73(9) | page 216 | Duty 50% ad valorem
42% ad valorem
(British origin) |

ings from casting upto the end of March 1965 and do not show distinctly the types of forgings with respect to either their nomenclature, or their dimensions or their users for the later periods. While not much can be told in the absence of such detailed statistics especially with respect to their product dimensions, it is felt that most of these imports are in a range of below 3 ton piece weight. The same range of forgings are also being produced by indigenous industry.³ The steel forgings industry is introducing new products of quality steel forgings which were formerly imported and an illustrative list of those components are given below:

- (a) An illustrative list of some of the components forged at a leading unit, many of which were formerly imported

I. Automotive Parts

(A) For various truck manufacturers

Crankshaft Finished
 Connecting Rod
 Stub Axle
 Front Hub
 Bevel Wheel
 Bevel Pinion
 Front Axle Beam
 Axle Shaft

(B) Automotive Gears

Crown Wheel
 Pinion

(C) Scooters

Crankshaft Half Clutch
 Front Axle (4" upsetting job)
 Kick Starters

³ This is observed by the Association.

(D) Three-wheelers

Bearing Shafts
 Swing Arm (LH and RH)
 Steering Knuckle

(E) Jeeps

Crankshafts
 King Pin Ball Yoke
 Shift Fork
 Connecting Rod

(F) Fuel Injection Parts

Pivoting Part
 Nozzle Holder
 Guide Lever

II. Tractors

Gear Reverse Idler
 2nd Speed Main Shaft
 Counter Shaft
 Gear Main Drive

III. Diesel Locomotives

Saddle
 Yoke
 Main connecting rod and cap.
 Driver Gear
 Water Pump Gear
 Extension Shaft Gear

IV. Diesel and Oil Engines

Rock Lever
 Crankshaft
 Connecting Rod
 Gear Camshaft Drive
 Camshaft
 Gear Wheel

(b) Illustrative List of Components which a Leading Unit can forge**Components**

- | | |
|-----------------------------------|---|
| 1. Diesel and Petrol Engine Parts | Crankshafts, levers, flywheels, couplings |
| 2. All automotive and Truck Parts | Driving axles, front axles, steering components, levers, spring seats, hubs, in addition to engine parts mentioned. |

- | | |
|--|---|
| 3. Tractor Parts | Including components for track laying vehicles. |
| 4. Earth moving equipment | Rollers, Track Shoes, side links. |
| 5. All Hardware Items | Such as hooks, turn-buckles, special studs, wing nuts, eye-bolts. |
| 6. All Ordnance and Defence items | Shell forgings, artillery material parts, mortar shell bodies, motor vehicle components, pintles, hooks, breach rings, depth charge components, aerial bomb fittings. |
| 7. All air frame forgings | In aluminium alloy steels, stainless steels, titanium and titanium alloys. |
| 8. All Railway Forgings | Requirements from carbon and alloy steels - hooks, clamps, screw couplings, diesel locomotive parts. |
| 9. Non-ferrous alloy forgings | In brass, bronze and aluminium bronze forging grades. |
| 10. Petroleum industry requirements | Flanges, couplings, parts for high and low pressure valves, parts for high pressure pumps such as valves, valve seats, piston rods, pump liners, drill bit parts, components for well control equipment, etc. |
| 11. Forgings for air compressors | Shafts |
| 12. Forgings for Hydraulic Equipment Manufacturers | Cylinders, pistons, valve parts, etc. |
| 13. Parts for the material handling equipment industry | Such as motive power parts, hooks, fittings, steering components, hydraulic valves and similar items. |

(3) Export promotion and Steel imports duties -
Policies and problems⁴

Japan is the major competitor in the international market for forgings. Japan has the three tier pricing system for reducing the steel cost as follows :

- (a) Export price of steel controlled through consortium in the international market,
- (b) domestic price of steel for internal use only and
- (c) concessional price of steel for export of end products in which the export of forgings plays a dominant role.

The Indian steel forging industry has to face a tough competition in the international market, particularly from Japan. Thus, the exports of forgings are linked to quality steel imports.

In this connection, the Association in their Annual

⁴ During the past decade, due to rapid development of and diversification in industrial technology, considerable difficulty was experienced by manufacturers both for procuring and producing forgings in the advanced countries, mainly because of the drift away of skilled labour from the forge shops to those industries offering better incentives, healthier surroundings. The American forge companies have therefore systematically diverted their interest to the development of forgings for the Aero space industries, which demand forged components of fancy alloys and refractory metals like molybdenum, tungsten, tantalum, zirconium etc. to avoid unhealthy working environment of steel forging manufacturing to Automobiles. This is a more lucrative business than the traditional forging of steel for the automobiles, tractors and other conventional industries in America. This situation has been rapidly taken advantage of, by the Japanese forge companies in exporting their traditional steel forgings.

report for 1967-68, submitted a number of proposals for the consideration of Government of India. A summary of them is presented below.⁵

⁵ A few proposals on which Government have no immediate reaction are given below: As the steel mills are of Govt. undertaking, this problem of communication between the Association and the Government arises. The source for these is the same Annual report of the Association.

(1) The Government may issue the necessary import licences for importing the required forging quality steels from the cheapest source against export orders.

(2) The industry may get the benefit of 100% drawback of duty against exported forgings on a specially expeditious basis.

(3) Some proposals for steel prices:- The steel from the Durgapur Alloy steel plant be supplied to the forging industry to match the quality and price at which our major competitor in the world market, viz., Japan, gets it. In the case of forging quality carbon steels (say EN-8 or EN-9), the price can be between Rs. 500 and Rs. 600 per tonne and in the case of alloy steels of forging quality, it can be between Rs. 1000 and Rs. 1100 per tonne to enable the Indian forging industry to export forgings in the teeth competition from the Japanese forge companies, in view of high import duties on steels.

(4) Differences in forging cost and export price:- The forging industry in India would not miss any possibility of export, where it possible to meet variable costs as some illustrative export inquiries given below are received by three leading units of Indian forging industry.

Schedule of the computation of forging cost

Item	Forging cost (variable) Rs.	Export price (F.O.B.) Rs.
Steering Arm Spindle	9.04	6.70
Frong axle	24.50	16.00
Camshaft	99.10	51.00
Crankshaft	797.00	400.00

Note (i) Raw material has been computed after knocking out the element of customs duty and excise charges. (ii) The prices of raw material is based on the cheapest source of supply from global tenders. (iii) The cost computation does not include administrative and selling overheads or profit margins.

(1) Cash assistances for exports promotion

The cash assistance on the export orders of a value less than Rs. 45 lakhs shall be only 15% of the F.O.B. value, and if the export orders contracted for, lie between Rs.45 lakhs and Rs. 2 crores, the cash assistance on the total of value of export orders shall be 25% for the period upto 31st March 1969 from 1st September 1967. If the target of Rs. 2 crores is contracted for before 31st March 1969, the cash assistance payable on the whole 'export effort' for the period upto 31st March 1969 will be 30%. The outcome of this is that the Government of India agreed to give cash incentive to the steel forging industry to stimulate export of steel forgings. The incentive is put at 15% if the total exports of steel forgings from 1st September 1967 to 31st March 1969 reached an F.O.B. value of Rs. 1 crore or if contracts for exports of steel forgings are entered into, by 31st March 1969 from 1st September 1967 for a total value of Rs.1 crore. If this target is exceeded, an additional 5% would be given, bringing the total incentive to 20% of F.O.B. value of exports.

(2) A scheme for re-imbusement in the import policy⁶
of mild steels

A scheme for reimbursing the difference between domestic and international prices of especially mild steels of blooms, billets, slabs, bars, rods and rounds (meant for steel forgings)

⁶ Source: Annual report for 1967-68 of the Association. The opinion given under this para 2 is that of the Association.

in addition to some other steels produced in India, to the fabricators/exporters of engineering goods (steel forgings) was introduced by the Government. But the problem faced by the leading forge shops in the country in case of export of forgings is that the overseas buyers require a high standard of quality in the forgings consequently they are to rely on EN-8 and other high carbon steels to meet the standards expected. By using this type of high grade steel, the manufacturers are deprived of the price subsidy which would otherwise have been available if the products were of mild steel.

(3) Envisaged import policy for spring/alloy steels

The current import licensing policy on iron and steel items envisages that the imports of following categories of alloy steels are to be restricted :

- (a) Spring steel flats/sections
- (b) Alloy constructional steel
- (c) Case hardening steel
- (d) Alloy case hardening steel
- (e) Plain carbon steel
- (f) High speed steel.

Since the above categories of spring steel/alloy steel are being produced in the country they may also be covered by the reimbursement scheme.⁷

⁷ Opinion of the Association given in the Annual report for 1967-68.

(4) Recent amendments in steel import policy

The recent amendment in the steel imports policy has attempted to ban the imports of following categories of steel:

(a) carbon steels totally, (b) die blocks upto 400 mm totally, (c) 50% of the requirements of alloy steels. This policy has been further sought to be compulsorily implemented by ensuring that no licences for imports of steel will be allowed till letters of credit are established by the users for 50% of the requirements.⁸

(5) Forging quality steels and lead time for indigenous production

Very often the rejections on poor quality steels, once made are not accepted for months resulting in a tremendous loss of production to the forging industry.⁹ While the

⁸ op.cit.

^{9,10} All the supporting points on this issue are given below as the Annual report of the Association provides.

(1) Steel manufacturing industry today does not have the scarfing equipment necessary to produce good surface condition free from seams. It is also necessary that the steel should satisfy the fine grain structure alumina killed to ensure that there is no adverse grain growth at the time of heating the forging billets.

(2) Steel sizes upto 25 mm are required : Steel in sizes upto 25 mm of any category of carbon and alloy steels may be freely allowed to be imported for a minimum period of two years. This is necessary particularly in view of the problems of reduction, heating and nonavailability of rolls to meet the small sizes.

(3) Requisite quality steels for forgings : Certain categories of high and low carbon steels where carbon composition is very critical are difficult to maintain. They may also be allowed to be imported as variations in carbon percentage can create tremendous problems in metallurgical controls.

Continued/..

development of indigenous steel is encouraged over a period of time for the entire range of forging quality steels, imports of such nonavailable forging quality steels at least for that much period may be allowed to prevent any loss of production in steel forging industry.¹⁰

(4) No annealing facilities in steel mills : Whatever indigenously available alloy steels, particularly Mn cr steels, are purchased by the industry. The problem in case of Ni Mo V based steels is not only one of production but also of the availability of alloying elements, which creates further delay. Almost all steel mills in India do not have annealing facilities and unless and until the alloy steels are received in annealed condition, the processing of these steel billets or bars becomes extremely difficult.

(5) Time lag to get the requisite quality steels : The forging industry has placed orders on Durgapur Alloy Steel plant for die blocks, but they are not able to get the requisite quality in time. Any breakage in die-block will result in complete dislocation of the forging production as the die sinking operation requires hours of skilled work and involves considerable expenses in operation. Therefore, to ban imports before actual trial productions have been tried out is to invite troubles in production and emergency licensing at a later date of not only the die blocks but also of forgings and quality steels, completely nullifying the actual gains in import substitution.

(6) Terms of business relations between steel mills and forging firms : The terms of business specified and insisted by steel mills like opening letters of credit, prices and settlement of claims are not in consonance with normally accepted principles of commercial business practices. Forging quality specifications are not allowed to be in the letters of credit opened by the buyer on the steel mills and is to be described as 'Iron and steel materials' and no responsibility is accepted either for the quality or the quantity of the materials shipped. Deliveries are totally uncertain and make it impossible to do any production planning and inventory control based on anticipated supplies. Not even a guarantee that defective steel will be replaced within a reasonable time limit of 45 days is forthcoming. Which commercial banks would be prepared to open such letters of credit under impossible terms of business with no guarantee for claim settlements. In the U.S.A., U.K. and Germany, which are the main importers of our steel forgings, it is an accepted practice that if the defective steel is the cause of a defective forging, not only do the steel mills replace the steel but also bear the total cost of forgings produced. The steel mills in India also must fall in line with accepted international practices both as to quality and deliveries as well as settlement of claims.

(4) Reduction in excise duty of liquid petroleum gas¹¹

The input cost of fuel before the excise duty on liquid petroleum gas (LPG) was Rs. 531 per M.T. and after the inclusion of duty on LPG it increased to Rs. 639 per M.T. - an increase of nearly 20% in most of the forge companies. A comparative incidence of duty on furnace oil ISI 593-1959 Grade LV and Liquid petroleum gas (LPG) is shown below:

Description	Fuel categories	
	Furnace Oil	L.P.gas
Caloric value BTU's per lb.	18.600	21.000
Excise duty/ton (Rs.)	49.55	196.00
Heat content/ton (Million)	4.09	4.62
Excise duty expressed in Rs. per million BTU's available	1.21	4.24

It is apparent from above that the excise duty incidence on LPG in terms of million BTU is 350% higher than on furnace oil.

(5) Imports of plant and equipment as a result of foreign collaborations

Rs. 240 million out of Rs. 750 million worth of fixed investment has been financed by foreign exchange resources as indicated in the Fourth Five Year Plan report of Planning Group for Machinery Industries. It is felt that most of the civil construction, erection and installation of the plants and machinery can be done by proper location of Indian personnel, land and the indigenous supply of the steel

structures etc.¹²

(6) Need for developing ancillary shops of forge units

Occasionally, finished forging components such as finished crankshafts, finished dies and others are yet being imported and one of the reasons for this seems to be that the licensed forge-shops, both commercial as well as captive, are not adequately equipped with the finishing, machining, heat treatment and die shop facilities as their ancillary shops. Absence and/or shortage of these ancillary facilities often become main bottlenecks. For a new entrepreneur, it is necessary to install these ancillary shops alone or go for an integrated project with well balanced capacities for all these shops including the crankshaft machining facility.¹³

(7) Productivity calculations

Conventional procedure of estimating available hours on three shifts basis aggregating 20 hours a day and 300 days a year may be misleading for financial and productivity calculations in this industry. Based on the experience over a century, even an advanced country like the U.S.A. does not consider more than 1300 hours per year as productive hours in this industry.¹⁴ Productivity per worker seems to be

¹² These observations are collected from (i) "A Study on project evaluation" by S.D.Joshi, Sr.Dy.General Manager, Foundry Forge Project, Ranchi and (ii) "Export policy, foreign exchange saving and import substitution", by T.R.Gupta, Chairman, Heavy Engineering Corporation, Ranchi.

¹³ Opinion of the Association.

¹⁴ Jensen, Jon E., Forging industry handbook (ed.), Director of Marketing and Technical Services, Forging industry Association, Cleveland, Ohio, 1966. The Ann. Arbor Press, Inc., Ann Arbor, Michigan.

more only during winter season, night shifts of summer and only if wages are tied to quantity and quality specifications of the jobs compared to regular scales.¹⁵

(8) Too many break-downs and provision for them

While equipment in this industry by its very nature is self-destructive due to frequent breakdowns¹⁶ of hammers, presses, dies, furnaces, etc., provision to be made for repairs and maintenance in the calculations of production hours, replacements and additions to stocks in financial projections is often lost sight of.

¹⁵ This is observed on the field investigation. See Chapter III also to confirm the results.

¹⁶ To analyse the reasons concretely for under-utilization of the capacities installed, percentages of the loss of production hours or of the loss of tonnage have been found as below, in a die forging firm in Maharashtra and in an open forging firm in West Bengal on field investigation - Table 5. Reasonwise unutilized capacities in two firms (all in percentages).

Reason	A firm in Maharashtra		A firm in West Bengal
	On hours lost basis	On tonnage lost basis	On hours lost basis
1. Breakdown and repairs of hammers, presses, furnaces, dies and trimmers	62.36	25.69	38.79
2. Power shortage	2.32	26.56	31.05
3. Material shortage	4.59	25.70	2.38
4. Lack of demand and planning	26.63	20.03	11.05
5. Operator shortage	3.37	-	12.68
6. All other reasons	0.73	2.02	4.15
Total	100.00	100.00	100.00

The foremost of all the reasons implies the maximum dependence and uncertainty of this industry's equipment on their repairs and maintenance, a regular feature all through the year and as important as production itself.

(9) Skills, efficiency, incentives and other labour problems

Skills acquired in this industry are meagre in India as the organized sector is of recent origin and the learning period, especially for die sinkers is around 6 to 8 years.¹⁷ Substandard skills are not to be given as much weightage as the standard skills in determining the rated capacity, which mislead the financial projections. As the skills are improved, the capacity of the unit increases even with the same capital equipment. This may be one of the main bottlenecks in achieving the rated production capacities during the early years of production. The efficiency in the acquisition of skills can not be quantified especially in Die-shop, as the die sinking is an activity which can not be rated only on the basis of number of hours taken on the jobs.¹⁸ All the jobs are dissimilar in their working process because of draft angles, tolerances, specification of depth, smoothness, differences in the internal curvatures and the angles of the vertexes, for all of which actual skill, carefulness, constant attention of the die sinker is required rather than just time considerations. As this activity takes days and months together to prepare a die, a number of die sinkers are required to be placed on the continuing job in different shifts. This suggests group incentive scheme rather than individual incentive scheme, though there are still problems

¹⁷ Opinion of the Industry officials.

¹⁸ Ibid. See also Chapter III of this study.

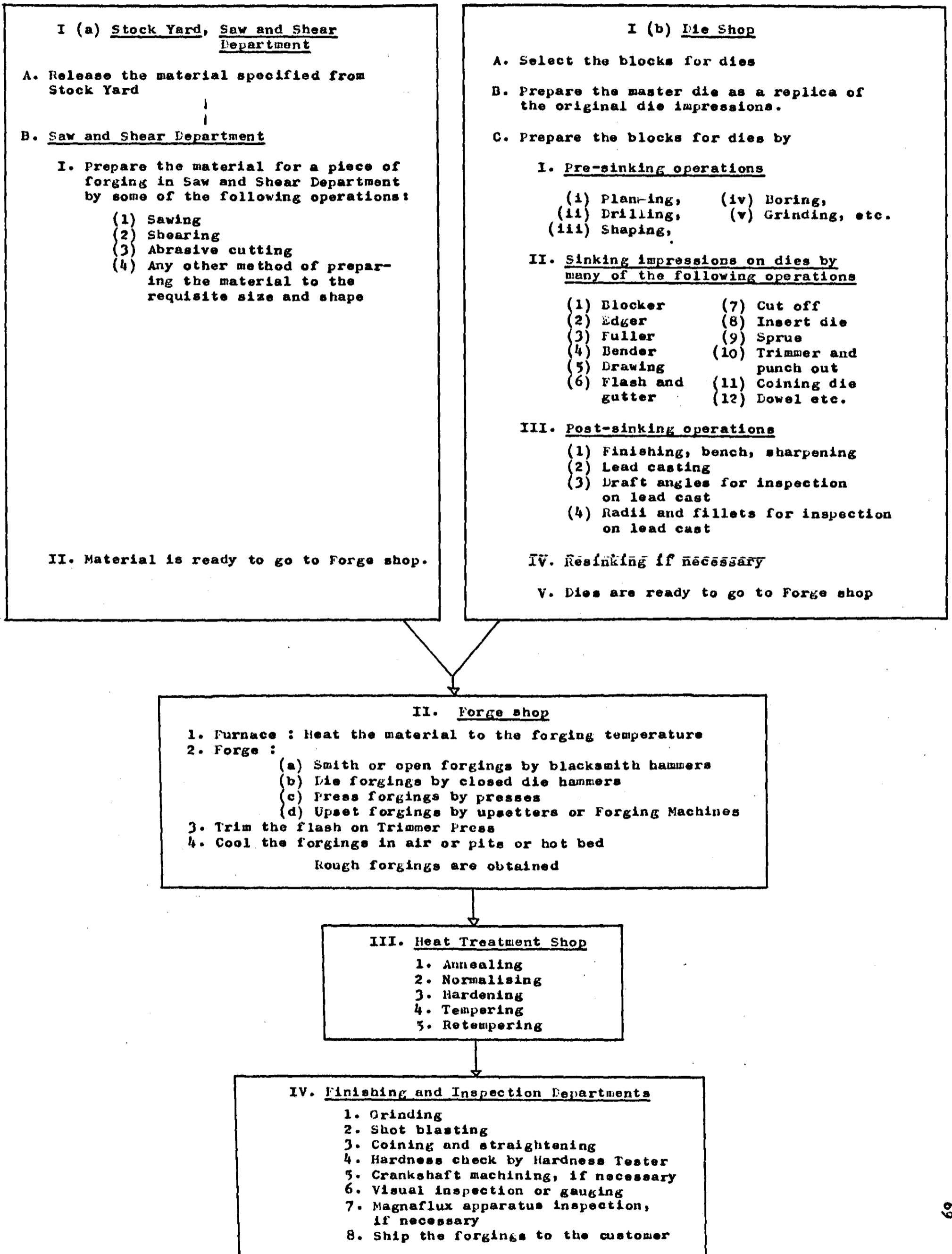
of judging the intricacies and difficult parts of the jobs done by the different operators over-time. There is an argument that time standards could not be arrived at, even with many years experience in America in the die sinking activities because of the dissimilarities in the nature of the jobs. So, instead of introducing incentive schemes, some suggest that higher remuneration be paid to die sinkers compared to other labour. The working environment is so bad that the labour is too anxious to escape the heat, grim and dirt of the forge shops. Unless some better incentives compared to other engineering industries are given, it may be really difficult to attract the skilled labour.

CHAPTER III

**TECHNICAL PROCESSES, MATERIALS AND PRODUCTS
IN STEEL FORGINGS INDUSTRY**



FLOW CHART OF OPERATIONS IN A FULLFLEGGED FORGINGS PRODUCTION UNIT



3.0 Introduction

A probe into the details of technical processes, materials, products and of their technological relationships is imperative for a process analysis of the economic structure of steel forgings industry in the context of input output frame work. The general definition of a forging process, as described in Chapter II, has undergone many transformations through its historical development. This technological forging process seems to be a continuous phenomenon which poses a problem in many economic studies. The forging process produces a wide range of products, each of which is identified by continuous product dimensions or characteristics of products. Thus, there is no limit in enlisting the products of forging process because of continuous variation in the physical values of the product dimensions. Because of the continuous variability in the physical values of product-dimensions, the cost structure of the firms and of the industry are also likely to be fluctuating as a continuous phenomenon. This problem of continuity and product multi-dimensionality gets amplified as it is a jobbing type or customer's oriented industry.

While the technological forging process is a continuous phenomenon, the economic studies based on inter industry analysis require the discrete and finite processes and products as basic information. Attempts are made to specify the discrete and finite product groups and to derive the distinct average prices and the input structures of those

distinct aggregated product groups in this industry study. Such discrete and finite processes may serve as sectors in the disaggregative commodity wise input output tables and as activities in the linear programming models. For these economic studies, as described in Chapter IV to VII, this chapter attempts to provide detailed information on the technical processes, materials and products of steel forgings industry in India as a requisite knowledge of the industry study. Thus, this chapter deals with (1) General technical features of the industry in India and (2) salient features of the forge production units or firms under investigation. Further technical details of the industry in India and in advanced countries are appended to this chapter.

3.1 General technical features of the industry in India

The stages of manufacturing the forgings are schematically represented in a flow chart of the sequence of operations or processes of a typical, commercial and full-fledged forge production unit. The technical features of the industry are presented here in the same schematic order. Similar to the forgings, there are castings manufactured in foundries catering to the requirements of many engineering industries. Castings are made by pouring molten metal into moulds and allowing it to solidify.¹ Though the two, forging

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See W. Steeds, Engineering materials, machine tools and Processes, Longmans, 1957, p. 88.

and casting processes, are technologically different in respect of manufacturing operations, the nomenclature of them may overlap because of the similiarity in their shapes. Taking into account these features of forgings in relation to castings and the broad technical features of forgings industry,² this section deals with (i) inherent advantages of forgings compared to castings, (ii) technical substitution of castings replacing forgings in the Automative industry of America, but no possible substitution in India, (iii) broad distinction of the two types of forgings and a wide range of them within each of those two types, (iv) raw materials used in forging - selecting and preparing the material and die blocks for forging, (v) heating the material for forging, (vi) forging the material by a suitable method or operation to get rough forgings, (vii) heat treatment facilities, and (viii) other post forging operations like cleaning, finishing, inspection, etc. till the final forgings are shipped to the customer.

² For these technical features of steel forgings industry described in this section 3.1, the following selected books are consulted to assimilate the requisite technical literature and to facilitate the field investigation of the firms (as described in section 3.2). The other sources of information are referred to, at the appropriate places.

(1) Forging Practice by G. Kamen Shchikov and others, translated from Russian by L. Zelikov, Peace Publishers, Moscow.

(2) Rusinoff, Forging and Forming Metals, D.B.Tarapora-vala and Co. Pvt., Ltd., Bombay, 1967.

(3) Tool Engineering Hand Book, II edition, Sec. 54.

(4) Jenson, Jon, E., Forging Industry Handbook (ed.), Director of Marketing and Technical Services, Forging Industry Association, Cleveland, Ohio, 1966. The Ann Arbor Press, Inc., Ann Arbor, Michigan.

3.1.1 Inherent Advantages of Forgings Compared to Castings

The selection of the forging process to produce a desired part is based on one or a number of essential factors. The main distinction between forgings and castings is of relevance here. Forging process aligns fibre like metallic grains in continuous and unbroken lines, utilizing the inherent properties of the metal. This controlled grain flow, characteristic to forgings alone, provides inherent advantages of forging process. The mechanical properties of forgings are likely to provide some economic advantages to the user, by saving the material, energy, and by increasing the strength and longevity of the service life of the users' products. The inherent advantages of forgings in comparison to castings are :

- (1) Greater strength : a part which is forged is substantially stronger than a casting of the same cross sectional area. Because of this fact a forging may be designed with a considerably smaller section of area, thus saving on the amount of metal required and reducing the cost of the part.
- (2) Reduction in weight of finished part : When comparing parts, all designed for the same working loads, it will be found that a forging will be much smaller and lighter in weight. Therefore, when the design calls for greater strength and light weight, a forging will often be selected.
- (3) Ability to withstand unpredictable loads : The grain structure or the grain flow of forgings can be controlled as to density and the slip planes of the grains arranged in such

a manner that they will withstand a high instantaneous stress.

(4) Minimum of machine finish required : In comparing a forged part with a casting of the same part, it is found that tolerances relating to size can be held in a forging to much closer limits than in a sand casting of the same size. In forging no allowance need be made for wastage as must be made in casting. If smaller quantities of parts are needed, sand casting may be less expensive than forging, since the equipment required for sand casting is relatively less expensive.

(5) Saving in Material : Since the machine finish can be held to such low limits, a forging in comparison to a bar stock, or a sand casting, will have relatively less machining scrap.

(6) Elimination of internal defects : Forgings are always made from solid metal bars, eliminating the hazard of internal holes as found in the castings. Internal flaws in castings will result in rejections when such defects are discovered during machining. When defects are not discovered in machining or final inspection, unforeseen failures in service may happen.

3.1.2 Technical substitution of castings replacing forgings in the Automative industry of America but no possible substitution in India

Parts like connecting rods, camshafts and crankshafts which were previously forged are now being substituted by

casting process as the components of automobiles industry in America.³ This is because the foundries in America have developed production techniques to reduce the cost of production of castings, which are able to meet the minimum service requirements of the automobiles. The scrappage rate of old automobiles, keeping pace with the new models and mass production every year, is so high that they get satisfied with the minimum service life of the castings as automobile components. The automotive industry adopted this sort of technical substitution, but still, it is the second major consumer of steel in America (22.6% of the total sales of steel forgings).⁴ The first major consumer of steel forgings in U.S.A. is Aero space craft industry (31.7% of the total sales of steel forgings)⁵, because of heavier strengths and less weight of steel forgings. Aerospace-craft industry has not developed in India to become major consumer of steel forgings. Railway and automobiles are the major consumers of steel forgings in India. The production techniques in foundries are not developed in India to the extent that they can improve the quality of castings and reduce the costs of production of castings to replace forgings.⁶

The markets for these two types of products of the distinct

^{3,6} "Technical Evaluation of the Forging Industry"
Report of a study by the Illinois Institute of Technological Research Institute, Chicago, Illinois, sponsored by the Committee of Hot rolled and Cold finished Bar Producers American Iron and Steel Institute, 633, Third Avenue, New York, 10017.

^{4,5} Jenson, John, E., Forging Industry Handbook, op.cit. See also Appendix to this Chapter III.

processes are distinctly different, for given specifications of the requirements of users in engineering industries. The possible substitution in Automative industry as in America is not in India. The internal demand for automobiles in India is so high that the longevity of the expected service life of the automobile is always preferred. Indian automobiles have to maintain their demand for forgings to fulfill the purchaser's requirements of long service life. Thus, on both the counts of technological reasons and from the users' demand point of view, any possible substitution as in America, is not in India.

3.1.3 Types of forgings

There are broadly two types of forgings : (I) open forgings, and (II) die forgings. These are further classified according to the method of fabrication in four general groups. There are

(I) Open or free or smith forgings

(II) Die forgings :

(i) Drop forgings by drop hammers,

(ii) Press forgings by Presses, and

(iii) Machine or upset forgings by upsetters.

Within each of these types, there are a wide range of forgings identified by the continuous product dimensions or the characteristics of the forgings. There are many forgings identified by quantitative and qualitative product dimensions as continuous variables. The quantitative and qualitative features of the products are because of the wide range of

the technical processes and of materials used for forging purposes. These hundreds of grades of materials and the flexibility in the processes, described in this and in the following section, bring out the wide range of numerous forgings with their variations in the quantitative and qualitative features. However, the general features of the open forgings and die forgings are given below :

- I. Smith or open or Free Forgings : These are produced without the use of impression dies. Dies are the impressions of the forging piece as a replica of the latter. The die impressions of the forging piece are sunk on two die blocks by die sinking machine in Die shop. Open forgings are produced between flat dies and possibly being given its shape by use of hand tools. Often the die face may have a V-shaped, half round or half oval impression. The shaping of the forging part between relatively narrow flat dies depends upon the skill of the hammer-smith, who moves the hot forging stock so as to flow the grains of the metal in the direction desired. Smith forgings are also termed "hand forgings", "flat die forgings", "open forgings", or "free forgings" or "blacksmith forgings". They are specified where the required parts are too small to justify the cost of impression die equipment or where sizes are too large or too irregular to contain them in the usual impression dies.
- II. Die forgings : These are produced by shaping hot plastic metal within a set of closed dies. Three advantages of this method over open or free forgings are : (i) less

skill on the part of the operator is required, (ii) accelerated production, (iii) ability to retain closer tolerances. The product dimensions of die forgings are much more precise than those of hammer forgings. Die forgings are made with much smaller machine allowances, considerably reducing the machining time and the consumption of metal. In many cases, their mechanical properties are better than those of hammer forgings.

3.1.4 (a) Raw Materials used in Forging

Carbon and alloy, structural and tool steels are the usual raw materials in forging. In addition, special steels are also used. In forge shops, steel is received as ingots or as rolled sections. Ingots are used for manufacturing heavy forgings, mainly for processing in forging processes, while rolled billets are used for lighter forgings.

The quality of the forgings is predetermined by the quality of the raw material. In order to judge the quality of the raw material, blacksmiths must have good knowledge of the structure of metals, their defects and the causes for the latter.

3.1.4.1 The Structure of Ingots

The central section of the ingot is used for forging, because only this part is considered of good quality; the central portion weighs about 60 to 80 per cent of the total weight of the ingot. However, this surface part may also have surface defects, which must be removed before forging. These defects include seams, scabs, cracks, swellings and

interposed foreign matter such as sand, slag, etc. Unless they are removed, they will be forged into the work during the forging process, thereby lowering its quality and in some cases causing the forging to be scrapped.

Shapes and Product Dimensions of Ingots

Ingots may be round, square, rectangular. The shape and cross section of an ingot depend on its designation, product dimensions, the grade of steel employed and its further processing, i.e., on whether the ingot is to be rolled or forged.

Roughed, Rolled and Pressed Stock

This is used for forging operations. Roughed stock (blooms) is obtained by rolling the ingots in roughing or cogging mills; rolled stock by rolling the ingots in section rolling mills; pressed stock is obtained by processing the ingots in horizontal presses. Pressed stock is manufactured from non-ferrous metals only, usually of round cross section.

3.1.4.2 Selecting the materials

The first step to proceed on the operations of a forging production unit is the selection of the stock of material.

Forgeable metals are :

- (1) Iron
- (2) Carbon steels - Carbon content in steel does not exceed 1.7%. Steels with carbon content upto 0.25% are low carbon steels, content from 0.25% to 0.50% are medium carbon steels and above 0.50% content are high carbon steels.
- (3) Alloy steels - (Manganese, Nickel, Nickel-aluminium,

Molybdenum, Chromium, Vanadium, Chromium-vanadium, Tungsten, Silicon-manganese). Forgings from these steels have heavier strength, resistance, durability etc.

(4) Stainless steels - meant for corrosion and heat resistance.

(5) Nonferrous metals.

Within this broad group of metals, there are many hundred of grades of steel with different composition of their component elements. Choice of the material is important from the point of view of final costs because hard-to-forge material may result in a greater number of operations, short forging die life, increased rejects, extra finishing and increased tolerances. The grade of steel used for making forgings always determines : (1) the time and temperature required for pre-heating, (2) the number of heats, (3) the method of forging operation, (4) the conditions for cooling the forgings, and (5) heat treatment conditions.

3.1.4.3 Preparing stock for heating and forging

After selection, preparing the stock for forging is the immediate step that follows. Bars, squares and billets are cut, sheared or sawed into the required size pieces by shearing, sawing and abrasive cutting machines, to desired precision. The weight of the piece of the stock is estimated to attain the net weight after forging. Specifications of the material size must make allowance for mismatch, die wear, shrinkage, decarburization, trimming and draft.^{6a} The interior must be

^{6a} Mismatch is the misalignment of a pair of forging dies. Decarburization consists in the reduction of carbon content at

sound and be checked by means of acid etching and micro inspection. Surface finishing is done by chipping, scarfing and grinding machines, as it is required to remove the seams, scabs, cold shuts and other defects which are properly marked. After these preliminary operations, the pieces of the stock are re-heated, rolled to proper sizes and slowly cooled on a hot bed as they are meant for quality forgings.

3.1.4 (b) Die preparation in Die shop for die forgings only

3.1.4.1 Selection of blocks for dies

There are many activities in die shop, the chief of which is the die sinking on alloy steel blocks by the die sinking machines. Selection of blocks' material and size for die preparation in the Die shop, is governed by the size of equipment, size of piece material and the amount of space required to allow for the incorporation of various forming and finishing impressions. When determining a block size for a forging design, the usual practice is to allow two inches of space between the required impressions that are to be incorporated in the block. To this total, two more inches are added on each size at the extreme edges of the proposed impressions to obtain block width. Similar allowances are necessary for block length.

the surface of the metal - the carbon burns away in the furnace. When decarburised, tool steel becomes soft and parts manufactured from such steels have a short life. Trimming is an operation in forge shop to remove flash or excess metal from a forging part by a shearing operation of trimming press either in cold or hot condition. Draft is the amount of taper on the side walls of die impressions to aid the removal of forging from the dies.

3.1.4.2 Die preparation - Operations

The blocks selected undergo many operations for die preparation, though all the operations are not essential for all the dies. Sequence of the operations is not prescribed, as it varies from job to job of die preparation. They are broadly classified under three heads, namely (1) presinking, (2) sinking and (3) post sinking operations.

(1) Presinking operations

The presinking operations are meant for preparing the die blocks to work on die sinking machines. Drilling, planing, grinding, sawing, shaping and locking are some of the presinking operations, carried out by respective machine tools, after the layout is drawn on the die blocks. Then, templates are prepared. A template is a thin plate or pattern used to check the dimensions on the dies.

(2) Sinking operations⁷

The actual die sinking for the impressions of the forging piece on the two die blocks, as the exact duplicate impressions of each other on the pair of die blocks, may consist of one or more stages of the sinking operations. Blocking, edging, fullering, bending, drawing, flash and gutter, cut off, master die, insert, sprue, trimmer and punch out, coining die etc. are the different stages of die sinking operations, to bring out the requisite impressions of the forging piece by the die sinking machines. These

⁷ See the Appendix to this Chapter III for details.

stages correspond with their forging operations in forge shop, to bring out the specifications and intricacies of the jobs. The sequence of the stages is not prescribed in a definite manner, as they depend on the nature of the jobs.

3. Post Sinking Operations

The post sinking operations in the Die shop are to check whether the dies are up to the specifications in all respects and are ready to bring out forgings up to the tolerances. (1) Finishing or bench or sharpening is done by hand grinders. Afterwards, lead casts are made. (2) Lead cast is a sample forging in lead or lead alloy of the die impression, obtained by clamping the two dies together in alignment and pouring molten metal into the finishing impression. Those lead casts are sent to the customer for approval. If the customer approves the lead cast, the dies are said to be ready for forging. (3) The die sinkers have to put as liberal draft angles as up to 8° , so that forgings do not tend to stick to the walls of the dies. (4) The radii and fillets are also made sufficiently large, so that the dies do not break too often.

4. Resinking Operation

Die replacement is a factor set up for reworking on worn out impressions. It is known as resinking activity and is determined by the cost of one reworking, times the number of reworks possible plus the total estimated cost of original set of dies and tools. The estimated die life per sinking is the expected number of forgings, that can be produced before

it becomes necessary to resink the original dies. Dies are normally considered as worn out, when impressions are spread to the extent that it becomes impossible to make forgings within the agreed specifications.

3.1.5 Heating the Stock

After the requisite materials and the dies enter into the Forge shop, heating the material is the first activity in Forge shop. Deformability of metals increases with temperature.

3.1.5.1 Heating process⁸

On being heated in a furnace, the surface of steel becomes covered with a layer of oxides, called scale. The rate of oxidation decreases with increasing carbon content. As the steel becomes hotter, the thickness of the layer of the scale increases. If it falls on the hearth of the furnace, it forms slag deposit. Part of the scale sticks to the steel itself. Loss of metal, when the stock is in furnace due to oxidation, is known as furnace waste. At high temperatures, the oxidation of the steel is accompanied by its decarburisation.

If steel is heated beyond the upper critical point, a growth in size of its grains can be observed under a

⁸ In flame furnaces, heat is transferred to the surface of the metal in two ways - by convection and radiation. By convection is understood the transfer of heat by the direct contact of continuously moving particles of furnace gases with the surface of the object being heated. By radiation is understood the transfer of heat through space from one body to another body at a low temperature. In forge furnace, steel is heated both by convection and radiation, upto 600°C heating proceeds mainly by convection. At temperature above 600°C, however, heat is transferred mainly by radiation. The further diffusion of heat inside the stock takes place, as a result of thermal conductivity.

microscope. Steel with excessive coarse grains is called overheated steel; when overheated steel is forged it will tear and crack. Overheating depends on two factors, viz. the temperature and the duration of heating the steel. Overheated steel can be improved by subsequent annealing, i.e. by slow heating and subsequent slow cooling to remove all working strains and to impart softness to the steel. If a heated piece of steel is allowed to remain for a considerable time in the furnace at a high temperature, it will be burnt and steel becomes weak. Such stock will be rejected as scrap.

The more alloying elements in the steel, the poorer the thermal conductivity of the steel, the greater will be the difference between the furnace temperature and that of the surface of the ingot being heated. The uneven distribution of temperature throughout the cross section of an ingot or piece of stock gives rise to what are called thermal stresses; compression stresses at the surface and tensile stresses in the centre.

The index of utilisation of heat in a furnace is called its efficiency, which indicates that proportion of heat generated by the combustion of fuel which is actually utilised for heating the metal. An efficiency of about 40%, i.e. heat absorbed by the stock as a percentage of the available heat is generally considered satisfactory in the case of furnace used in Forge shop. Thus, properly heating the metal for forging presupposes (a) heating it to the required temperature uniformly throughout its cross section, (b) heating

the steel at the maximum permissible rate without impairing its quality and (c) heating the steel with least possible loss of metal and with minimum consumption of fuel.

3.1.5.1 Forging Process - requisite temperature

As a result of forging at high temperature, the grains of the metal grow simultaneously with the change in crystals. This phenomenon of grain growth, i.e. the combination of small grains to form larger grains, is called collective recrystallisation. Collective recrystallisation tends to lower the resistance of the metal to deformation. Consequently, metals should be forged at temperatures which foster grain growth (recrystallisation) and be completed at temperatures at which recrystallisation no longer occurs. This will ensure fine grained forgings possessing high mechanical properties. Generally, forging temperatures range from 1700°F to 2500°F for irons and steels, and from 1100°F to 1700°F for copper, brass and bronzes. Each specific metallic composition has its own plastic range.

3.1.6 Operations for forging⁹

The number of forging steps required to change a bar or billet at forging temperature into the shape of a forging piece may vary from one or two steps to a series of many operations. The sequence of operations depends upon the size and shape of the part to be forged, the forgeability of the metal composition, the properties to be developed in the part

⁹ See the Appendix to this Chapter III for details.

and the tolerances and other special requirements that may prevail. Edging, fullering, blocking, drawing and bending are some of these forging steps, before the final impressions are brought out. All these stages of forging operations are done by forging hammers/presses/upsetters.

3.1.6.2 Die forgings - Methods of operation

(1) Two methods

Two methods of die forging are practised, namely, (a) die forging in single impression and (b) multiple impression die forging. Single impression die forging consists of forging the work in one (finish) forging impression. Here, the preliminary operations (edging, bending, reducing, etc.) are carried out on other equipment - forge hammers, forging rolls, etc.

In multiple impression die forging, all the impressions from the preliminary stage are contained in one set of dies and the forging process is carried out on one hammer/press only. Die forging by steps (passes) is only a variety of the multiple impression process. In this, the forging is conducted on several hammers/presses, each of which is equipped with a different set of dies designed for one definite operation. Usually the stock is heated only once and transferred from hammer to hammer without reheating. This process of multiple impression of die forgings is widely practised in the large or mass scale production of forgings, as it is more productive and permits the organisation of flow lines for the production of duplicate forgings.

(2) Press and upset forgings compared to drop hammer forgings

Forgings can also be made by the use of push or squeeze pressure with the help of forging machines or upsetters and forging presses as they can be made by impact of the drop hammers. In both of these, closed die impressions are the common principle. The steady force of a press creates a flow of plastic metal into the shape provided by the dies in the upsetters or a forging machine and a press. The pushing or squeezing pressure as developed by the forging machine and/or the forging press differs somewhat in character from the impact pressure of a drop hammer. Impact pressure is exerted at the instant the striking die touches the hot plastic metal and this potential impact energy is dissipated as the blow moves the plastic metal. The energy exerted by the push or squeeze pressure increases in intensity as the plastic metal tends to resist a change in shape and the maximum pressure is exerted at the end of the press stroke. However, the difference in the type of forging pressure does not change the physical or metallurgical characteristics of the forging from that of a forging made by impact pressure. There is economy of time and cost in a forging press and an upsetter compared to drop hammers. Skill of the operator is less required in these compared to drop hammers. The productivity rate and quality of the products are better in these continuous squeezing pressure forging machines and presses compared to impact drop hammers.

3.1.7 Post Forging Operations

Post forging operations are required after the rough hot forgings in the Forge shop are made. They are cooled in air or in pits or in furnaces as desired for slower rates of cooling.

3.1.7.1 Heat Treatment facilities

Forgings are heat treated (1) to remove stresses, (2) to equalise the structure, (3) to increase the hardness and (4) to improve the mechanical properties of steel. Heat treatment consists in (1) Annealing, (2) Normalising, (3) Hardening and (4) Tempering processes.

(1) Annealing consists in heating the forgings in a furnace to a temperature of 750-900^oC, depending upon the carbon content of the steel, with subsequent slow cooling. It results in (1) refinement of the grain of steel, (2) removal of internal stresses, (3) softening the steel, thereby improving its machinability.

(2) Normalising process is similar to annealing with only a difference of degree. It also results in (1) fine grained structure, better than by annealing, (2) improved mechanical properties - increased tensile strength and ductility, (3) removal of internal stresses. A normalised steel is stronger, harder and may be more machinable than an annealed steel.

(3) Hardening : This is done by heating the steel to temperatures equal to those used, for the same carbon content, in annealing and then quenching it in water, or oil or other fluids. It produces a homogeneous structure and a reduction

in the size of the crystal grains of the forgings.

(4) Tempering : This consists of heating a hardened steel to a temperature somewhere between atmospheric and about 695°C and with some alloy steels, then cooling it fairly rapidly by quenching it in water, or oil or other fluid. This process relieves the severe internal stresses produced by hardening process. Similar is the case with 'Retempering'.

3.1.8 Other post forging operations

(1) Cleaning Operations

After the rough forgings are heat treated, they are all put through a cleaning operation to remove the forging scale. Shot blasting is in very general use for this operation. Pickling of forgings to remove scale is an older method. In pickling, an acid solution loosens the scale by chemical action and imparts a dark bluish colour to the surface. Tumbling is another process to remove scale from forgings by impact with each other, together with jacks, saw dust, and abrasive material in a rotating container.

(2) Coining as an operation consists in applying heavy pressure on the forging part in a coining press to obtain closer tolerances or smoother surfaces. This is also termed sizing.

(3) Similarly, straightening, as a process in a press, consists in decreasing the misalignment between various sections of a forging.

(4) Grinding also is sometimes followed on the forgings as it may be required for final finishing touches.

(5) Then hardness check is observed by hardness testing machines.

(6) Usual inspection for cracks etc. is also made.

3.2 Salient features of forge production units under investigation

3.2.1 Nature of Investigation

Initially, a pilot study is conducted on a relatively large independent commercial die forging unit. This has helped in fixing up the problems of product multidimensionality for study. Based on this pre-survey, schedules and questionnaires are prepared for collection of the requisite data from a number of production units to study the problems of multidimensionality and of continuity in the context of input output and allied problems in this industry study.

There are 48 production units in the industry. Only 19 units are the ones most readily prepared to supply the information to the study. These 19 units have been selected for investigation. Seventeen are personally contacted and in the case of remaining two from Madras, their balance sheets data are utilized. Out of these 17 units, 14 units are in West Bengal and Maharashtra States. Contribution of the states to the output of steel forgings during 1964-1965 is clear from Table 3 in Chapter II. West Bengal, Maharashtra and Madras come in order. Thus, the contribution of the states to steel forgings production is also considered in the selection of the units for investigation.

All these forge units can be broadly classified into two distinct groups : (1) Die forging units, (2) open or free forging units. There is a third group of repair and maintenance type forge units, which may be open or die forge units, but the purpose of these third group units is distinguished mainly as they produce repair parts and maintenance replacements of the equipments. The main distinction between open and die forging units is that the former produce open or free forgings without the use of impression dies, while the latter essentially need impression dies' preparation facilities and the closed die forging hammers, presses and upsetters in Forge shop. The nature of products, materials, processes and their capital structure, skills and users are likely to be different from each other. The nature of the details provided by the firms are not uniform to present in tabular form. As such, they are described below serially. However, the following table provides the preliminary details of the 19 forging units.

From the table 3, it is seen that the gestation period between the year of establishment and the first year of production is 3 to 6 years. It is normally 3 years. The accounting periods of the firms are quite divergent, while in general, financial year is followed.¹⁰

¹⁰ These features are important particularly in Chapter IV. The detailed capital structures and inputs structures, refining them with the requisite adjustments, are brought out in Chapter IV. Hence, those distinct features are not dealt with in this Chapter III. Similarly, the product dimensions ranges and their independent input structures brought out from these available distinct firms' data, are presented in Chapters VI and VII. So, those features are not dwelt upon here.

Table 1. Details of forging units under investigation (Period of inquiry - April 1967 to March 1968)

Sr. No.	Code name of the Unit	Year of establishment	First year of production	Accounting period	Production in 1964-65 (In tonnes per annum)	Capacity in 1964-65	Nature of the Unit
1	2	3	4	5	6	7	8
<u>I. Die Forging Units</u>							
1	A	1917	1920	January to December	1920	1920	Captive unit in a Heavy Engineering firm.
2	B	1950	1953-54	April to March	948	2400	Independent commercial forge unit
3	C	1950	1953-54	July to June	1800	1800	- do -
4	F	1958	1961-62	April to March	⊕	⊕	Captive unit in a steel plant
5	E	1960	1963-64	April to March	⊕	⊕	- do -
6 and 7	G and H	1960	1963	January to December	1000	1000	G is independent and H is a captive unit in a Heavy engineering plant.
8	D	1963	1966-67	July to June	No production as it started in 1966-67		Independent and full-fledged commercial forge unit.
9 and 10	X and Y	(During III Five Year Plan but exact years not available)		April to March	1916	4500	Independent and captive units
<u>II. Open or Free Forging Units</u>							
11	M	1952	1955-56	April to March	360	360	Captive unit in a Heavy Engineering plant
12	L	1959	1964-65	April to March	No production as trials are going on		Captive unit in Mining and Allied Machinery Plant
13 and 14	J and K	1960	1966-67	April to March	No production as it started in 1966-67		Captive units in Alloy Steel plant and in Heavy engineering corporation.
<u>III. Repair and Maintenance type Forge Shops (All are open forging units)</u>							
15 to 19	N,P, Q,R, and S	1957-58	1960-61	April to March	1500	1500	Captive units in steel plants, heavy engineering plant and ship building plant

Source : From the firms' data collected on investigation.

⊕ The production statistics are shown under Iron and Steel rather than under forgings in official statistics. See footnote 10(a).

X and Y firms are not personally contacted, but their balance sheets data are utilized.

Out of 19 units, 11 belong to West Bengal with nearly 5000 tons of production,^{11a} 3 to Maharashtra with nearly 6000 tons of production,^{11b} 2 to Madras with nearly 2000 tons of production, and the rest of the units producing nearly 1000 tons of production. Thus, nearly 14,000 tons of production is covered,^{11c} which may serve as nearly 20 to 25% of the coverage of total tonnage production in the industry in India. Out of 19 units, only 5 are independent units, while the rest are captive units in Heavy engineering plants, steel plants, mining machinery and ship building plants.

3.2.2 Die forging units and their salient features

As the nature of the products and the processes of the units E and F in steel plants producing wheels sets and

^{11a} 5000 tons in West Bengal is exclusive of that of E and F (See the asterisk in the table). E and F are the public sector projects in the steel plants, producing wheel sets and sleepers for railways. Their production statistics are shown under "341-1 Iron and Steel" in Annual Survey of Industries reports. There are 53 items of Products and by products of 341-1 Iron and Steel, listed in the said reports, while these two are out of 53. The percentage of wheel sets gross output to the gross output of 341-1 is 1.51% and that of sleepers is 2.03%. Similarly the inputs details for 341-1 are as many as 54 listed, while for wheel sets and sleepers are as less as 15 or 16 that can be listed. From these view points these two products can be distinguished from 341-1.

^{11b} The 6000 tons in Maharashtra is inclusive of a relatively large unit covered under investigation. And its production figures are not given in the table as its production started in 1966-67 but not by 1964-65.

^{11c} The 14,000 tons is an approximate figure for the difficulties of estimation of exact figures, while some units production is shown under 341-1, some others under 341-3. The production of public sector projects of E, F, J, K, L, N, P and Q are shown under 341-1 in ASI reports. It is difficult to specify the coverage, while the total tonnage production in the industry as a whole in India is itself an approximate figure because of similar difficulties of estimation.

sleepers respectively are slightly different from those of all other die forgings units, the distinct features of these two plants,¹² their processes and products are of priority, as a continuation of the earlier section. These two plants are covered under this study as their basic process of production is forging, conforming to the definition of forging process. For historical and some organizational reasons, they have become part and parcel of steel plants.

Firm E : It caters to the needs of railways. It consists of heavy forging press, rolling, wheel and Axle machining, forging hammers and manipulators and assembly department, capable of producing an annual tonnage of 57,000 tons of 45,000 finished wheel sets. It includes the axles of 20 tonne roll bearing type and 16 tonne plain bearing type. About 30,000 sets have to be manufactured for Broad gauge and the balance of 15,000 sets for metre gauge wagons. The weight of each wheel set for the broad gauge is 3.7 tonnes and for metre gauge is 0.63 tonnes. The manufacture of 45,000 wheel sets requires annually 75,000 tonnes of wheel ingots and 23,500 tonnes of axle blooms, both being supplied by the steel plants. 1000 axles and 7 to 8 thousand wheels are the die life with 100% utilization of die life.

Each ingot is nicked by an oxyacetylene torch process and an ingot breaker breaks it into blocks (blanks) of suitable length for forging. The top portion of the ingot, which is

¹²All the details of the two plants are collated from their booklets and reports.

about 20% of the total cannot be made use of and has therefore to be rejected and remelted. This portion is usually converted into wheel tyres. The wheel blanks are then heated in a rotary hearth furnace and forged in two stages, consisting of slabbing and finishing operations. In normal conditions, approximately 50 wheels can be turned out per hour. The central hole is then punched prior to rolling in the vertical rolling mill. Thereafter, the wheel is brought to the Dish-
ing press, where the wheel is coned. The wheels are then normalized by the heat treatment processes.

The axles are manufactured in the Axle shop. After cutting the blooms received from blooming mill of steel plant, into suitable lengths for forging, each bloom is forged, heat treated, straightened and forging scales are removed by shot blasting the axles. Then they are again passed on to a hot straightening press, swan to length, machined, centered and recessed. Finally, they are inspected for any defects. The finished wheels and axles of proper size are brought together and assembled. Thereafter, roller bearings are fitted as required and the wheel sets are finally despatched.

Table 2 gives the piece weights of wheels, axles and wheel sets at different stages of operations.

Firm F : It is a sleeper plant, supplying sleepers to Railways. The materials for sleepers are the sleeper bars rolled in the continuous Billet mill of steel plants. An electrically driven sheet cuts the bars into the required size on the Roll table from where the cut sleeper bars are

Table 2. The piece weights of wheel sets at different stages of operation

S.No.	Capacity of piece and description	Block weight M.T.	Forging wheel weight M.T.	Finish- ing wheel weight M.T.	Bloom weight M.T.	Forging Axle weight M.T.	Finished Axle weight M.T.	Assembled wheel set weight M.T.
1	20 ton wheel set Broad Guage (BG)	0.60	0.55	0.48	0.55	0.54	0.41	1.37
2	11 ton wheel set (B.G.)	0.61	0.56	0.48	0.54	0.53	0.40	1.36
3	10 ton wheel set (B.G.)	0.32	0.29	0.235	0.25	0.24	0.16	0.63
4	12 ton wheel set (M.G.)	0.32	0.29	0.235	0.30	0.29	0.198	0.668
5	915 mm wheels	0.51	0.46	-	-	-	-	-

Source of these data is the firm itself, obtained from the officials of that firm.

lifted to a furnace, which has a continuous output of 15 tonnes per hour. Each bar for a Broad gauge sleeper weighs 171 lbs. (pounds). After being heated in the furnace, bars are discharged on the walking bins or the skids and each bar in turn is placed against the female or bottom sleeper forming die with the help of levers. The hydraulic press table is pushed to forge the sleeper. Thereafter, by another movement, four holes are punched in the sleeper. The sleeper is then taken out from the female die, placed on the descaling conveyor and the scales are removed with wire brushes. While sleepers are moving in the conveyor, they pass through a jet of water which washes the scales and lowers the temperature. Then the sleepers are dipped in tar. They are then transferred to the cooling and inspection conveyor and finally stocked with the help of a pneumatic hoist. The sleepers are inspected according to the Indian Railway Standard Specification.

The maximum achieved production is 320 sleepers per hour while the capacity is said to be 207 sleepers per hour. 60,000 tons per year is the capacity of sleeper plant on two shifts basis. The die life is nearly one lakh sleepers, while the actual utilization is 300% of the estimate.

Firm A : It supplies screw couplings to Railways, other die forgings to tea machinery, jute machinery, diesel road rollers, milling machinery, printing machinery and maintenance equipment.

Firm B : It caters mostly to the locomotive engines, auto parts etc. Most of the steel consumption in the firm is that of customers' steel supplied.

Firm C : It caters to the needs of automobiles, diesel engines and railways. It does not have a good die shop as they prefer to get the die impressions sunk by sub-contractors of small units specializing in die shop activities. Steel cutting is also subcontracted similarly.

Firm G : Pipe fittings are one of the specialized products of this unit. The production compositions in 1965 and 1966 of this firm are given in Table 3.

Firm H : The production compositions during 1967 are given in Table 4.

Firm D : It is fully equipped with all facilities including the crankshaft machining facilities, while all the above die forging units do not have the latter facility. It is one of the leading units, producing import substitutables. The sales distribution over using industries during July 1966 to June 1967 of this firm is given in Table 5.

3.2.3 Open or Free forgings units

Firm J : It is designed for a cogging output of 12,000 tonnes per year, of which 4,000 tonnes will be for finished forging. The estimated load of forge shop on different quality steels is presented in Table 6.

The principal forging operations performed either on the hammer or press are described below.

Table 3. Production compositions in 1965 and 1966 of Firm G

Sr.No.	Description	1965 Production				1966 Production			
		M tons	%	Value in '000 Rs.	%	M tons	%	Value in '000 Rs.	%
1	Automobile parts	305	40.13	770	34.53	450	40.18	1435	40.42
2	Diesel Engine parts	155	20.39	410	18.39	275	24.55	630	17.75
3	Forged flanges	85	11.18	350	15.70	90	8.04	560	15.77
4	General forgings	10	1.32	25	1.12	80	7.14	280	7.89
5	Jigs, fixtures, etc.	10	1.32	40	1.79	7	0.63	25	0.70
6	Press Tools	5	0.66	20	0.90	3	0.27	10	0.28
7	Dies and punches	15	1.97	165	7.40	30	2.68	340	9.58
8	Hand tools	10	1.32	30	1.35	-	-	-	-
9	Other products	165	21.71	420	18.82	185	16.51	270	7.61
Total		760	100.00	2230	100.00	1120	100.00	3550	100.00

100

Source : The firm itself provided the data.

Table 4. Production compositions in 1967 of Firm H

<u>Users</u>	<u>No.</u>	<u>%</u>	<u>M.T.</u>	<u>%</u>
<u>Carbon steel</u>				
1. Wagons and Coaches	208,617	96.94	654.965	70.99
2. Cranes	3,951	1.84	186.400	20.20
3. Others	2,628.5	1.22	81.239	8.81
Total	215,196.5	100.00	922.604	100.00
<u>Alloy Steel</u>				
1. Wagons and Coaches	1	0.00	0.060	0.00
2. Cranes	110	3.83	7.066	26.55
3. Others	2,768	96.17	19.601	73.45
Total	2,879	100.00	26.727	100.00
<u>Total</u>				
1. Wagons and Coaches	208,618	95.66	655.025	69.00
2. Cranes	4,061	1.86	193.466	20.38
3. Others	5,396.5	2.18	100.840	10.62
Total	218,075.5	100.00	949.331	100.00

Source : From the firm data.

Table 5. Sales distribution of die forgings of Firm D

S.No.	Using Industry	Tonnage	%	Value in lakhs of Rupees	%
1	Oil Engines	1650	75.00	99.29	73.23
2	Motor vehicles	425	19.32	28.67	21.14
3	Scooters and motor cycles	80	3.64	4.90	3.61
4	Locomotives	30	1.36	1.90	1.40
5	Tractors, pumps, other Agricultural M/c and others	15	0.68	0.84	0.62
	Total	2200	100.00	135.60	100.00

Source : From the firm itself.

Table 6. Estimated load of Forge Shop in different quality steels of Firm J

Type of steel	Forging		
	For process Ingots/tons	For finish Ingots/tons Finish/tons	
1. High speed steel	2950	550	350
2. Carbon tool steel	250	-	-
3. Alloy steels and die steels	3800	400	250
4. Die blocks	-	800	500
5. Construction steels	500	2250	1500
6. Stainless steels	500	-	-
Total	8000	4000	2600

Source : Booklet of the firm published.

- (1) Cogging of ingots
- (2) Forging down to (a) Rounds, Squares, Hexagons, Octagons, square edged flat slabs (b) die blocks
- (3) Upset forgings of (a) Rings and discs, (b) step forgings.

These forgings are to be used in different critical applications, such as, rotor bodies, shafts, axles, connecting rods, pistons, piston rods, die blocks, gears, pinions, shear blades, cutters, extrusion dies etc. The internal soundness of critical products is vigorously checked by special ultrasonic testing equipment. Structural homogeneity is achieved by proper soaking of the ingots prior to cogging, by suitably selecting reheating stages and proper finishing temperature. Homogeneous structure of alloy steel forgings results in uniform physical properties and better machinability. Tool steel forgings require specifically fine grain size. Cooling furnaces and mica boxes are provided for controlled cooling of the forgings to guard against the development of high thermal and transformational residual stresses. Electrode salt baths are also provided for iso annealing of small and medium size forgings for critical applications.

Firm K : Its main users are heavy engineering machinery units producing over head cranes, blast furnaces, heavy wagons, heavy machine tools, heavy electricals, ammunition requirements and steel plants equipments' requirements. This total project is designed with modifications over the following

stages. The I stage is expected to reach the capacity of 14,000 tons per year by 1967-68, the II stage to reach the capacity of 27,700 tons per year by 1971, the III/1 stage to reach the capacity of 33,000 tons per year by 1973 and III/2 stage to reach the capacity of 46,000 tons per year by 1975, when the 6,000 ton press will be working on one shift basis. The actual production achieved during 1966-67 is 330 tons only and the scheduled for 1967-68 is 1610 tons. The I and II stages together are to establish fully a light forge shop for the manufacture of a piece weight of 500 kg, III/1 stage is expected to establish the medium heavy forge shop for the manufacture of forgings of a rough piece weight upto 30 tons and III/2 stage to establish a heavy forge shop for the manufacture of a rough piece weight upto 100 tons. Piece weight ranges-wise production of the light forge shop as designed in project report are presented in Table 7.

Firm L : Its standard products are centrifugal pumps, conveyors, mine ventilators, winders, coal cutters, friction pumps, gear boxes etc., serving the requirements of public sector projects of heavy engineering equipment units, mining and allied machinery, steel plants and railways' locomotive engines. It consists of all facilities of equipment producing 1800 tons in 1966-67.

Firm M : It caters to the railways rolling stock, wagons, boilers, etc. Its capacity is 1800 tons per year. It has no production due to recession in demand during 1966-67.

Table 7. Light forge shop production in tonnage per year according to piece weight ranges and forging capacities of firm K

Piece weight ranges in Kg.	3 ton hammer	2 ton hammer	1.6 ton hammer	1.0 ton hammer	0.63 ton hammer	0.40 ton hammer	0.25 ton hammer	0.16 ton hammer	25 mt Die forging hammer	1.6 ton die forging hammer	500 ton forging Machine	800 Ton forging machine	160 ton forging Press	100 ton forging Press	Total forgings
Upto 1 Kg.	-	-	-	-	-	-	100	200	-	-	-	-	12	35	347
1 - 4 Kg.	-	-	-	-	-	-	300	64	-	460	5	-	50	-	879
4 - 10 Kg.	-	-	-	-	-	700	150	-	10	400	100	50	-	-	1410
10 - 25 Kg.	-	-	-	-	956	92	-	-	66	20	95	80	-	-	1309
25 - 50 Kg.	-	-	850	28	100	-	-	-	400	-	20	200	-	-	1598
50 - 100 Kg.	-	310	500	500	-	-	-	-	842	-	-	-	-	-	2152
100 - 250 Kg.	250	800	1200	-	-	-	-	-	200	-	-	-	-	-	2450
250 - 500 Kg.	2500	-	-	-	-	-	-	-	-	-	-	-	-	-	2500
Total	2750	1110	2550	528	1056	792	550	264	1518	880	220	330	62	35	12645

Source : Project report of the firm K.

3.2.4 Captive Repairs and Maintenance

Type Open Forge Shops is

Firm N : This forge shop with a capacity of 2,100 tons per year. Besides forgings, this shop produces 500 tons of steel balls for the coal pulverizing mill. Forge shop production on 2 shifts basis is given in Table 8.

Table 8. Annual Production according to piece weight ranges and forging capacities of Firm N

Piece weight of forging in Kg.	Hammer capacities				Press	Total in tons
	3 Ton	2 Ton	1 Ton	0.4 ton (2 Nos.)		
300-1000	800	-	-	-	-	800
100-30	500	700	-	-	-	1200
50 - 100	-	300	200	-	-	500
25- 50	-	-	200	-	-	200
10 - 25	-	-	100	100	-	200
Upto 10	-	-	-	300	-	300
Total	1300	1000	500	400	-	3200
Balls and other non-standard products					350	350

Source : From the firm itself.

This serves the different shops of all steel plants distributing nearly 95% of its production. The balance of 5% is to cater to heavy machine tools, heavy electricals, etc.

Mechanical delays are the main cause of loss of production hours.

In the steel plants, (1) the coke ovens and by-products shop is served by clamp, grisley shafts, shaft for hammer crusher, shop head rivet, half coupling, blank, body, bottom bearing block, pin, piston, rotor shaft cover, (2) the Sinter plant is served by runner, bolt, nut etc. (3) Blast furnace plant is served by link, motor half coupling, rosanant grizzle bar, stationary grizzle bar, body block, axle, tie rod, screw, forged blank, clamp for ball, ring, blender support, blank for stage stopper, support, nozzle flange, hook, shaft, eye for shovels, connecting bolt, roller, crow bar, wedge etc. (4) steel melting shop is served by shackle handle, suspension rod, Loco coupling link, traverse, clamp, chisel tool bit, lower ring, hanger sample spoon handle, link, slide block, (5) Blooming mill is served by counter weight rod, bending of foundation bolt, T-guide etc. (6) rail and structural mill is served by guide fixing bolt, fork, spindle shaft, (7) Billet mill is served by distance bush, plate, tie rod, bending of plate, bottom row fixing bolt, eye bolt etc. (8) Merchant mill is served by bolts and shafts. Similarly, all other shops in the steel plants are being served in general, by a variety of open forgings and some may be more specific to the shop. The distribution of the total value of production in this forge shop over different shops of the steel plants is given in Table 9.

Firms P, Q, R, S : These are very small shops producing

Table 9. Distribution of the value of production of repairs and maintenance type forge shops over the different shops of steel plants over years

Shop	1960-61		1965-66		1966-67		1966-67		1965-66	
	P		P		P		N		N	
	Value in Rs.	Per-centage	Value in Rs.	Per-centage	Value in Rs.	Per-centage	Value in Rs.	Per-centage	Value in Rs.	Per-centage
1. Coke oven	4177	2.73	18347	3.23	63436	12.47	141492	4.75	9120	0.58
2. Blast furnace	25746	16.82	38702	6.80	55771	10.96	137984	4.63	216461	13.84
3. Steel melting	20803	13.59	181779	31.96	141639	27.83	619865	20.83	399884	25.55
4. Blooming Mill	21669	14.16	25103	4.41	20310	3.99	219867	7.39	114842	7.34
5. Billet Mill	17568	11.48	27529	4.84	20722	4.07	56395	1.89	17378	1.11
6. Sleeper Plant	5804	3.79	13337	2.34	17684	3.48				
7. Section Mill	159	0.10	23026	4.05	16173	3.18				
8. Foundry and Pattern Shop	257	0.17	24853	4.37	27009	5.31	141931	4.77	84180	5.28
9. Sinter Plant							55005	1.85	32025	2.05
10. Rail and Structural Mill							74785	2.51	140788	9.00
11. Rolling Mill			9375	1.65	17195	3.38	18653	0.63	3169	0.20
12. Refractory Material Plant			17902	3.15	16102	3.16	60803	2.04	30242	1.93
13. Scrap and Salvage and slag							9070	0.30	3069	0.20
14. Wheen and Axle Mill			33826	5.95	34297	6.74				
15. Merchant Mill			11694	2.06	17699	3.48	215494	7.25	114963	7.35
16. Steel Straightening Shop			5103	0.90			4982	0.17	3279	0.21
17. Machine Shop			4260	0.75			5191	0.17	5165	0.33
18. Tool Room			9052	1.59						
19. Civil Engg. Dept.			3928	0.69			257	0.00	4105	0.26
20. Power and Blooming	1168	0.76	3117	0.55	5244	1.03			147845	9.45
21. Oxygen plant			276	0.05	369	0.07				
22. Water Supply and Pump House	270	0.18	1925	0.34	3633	0.71	2956	0.13	4219	0.27
23. Communications					341	0.07	17587	0.59		
24. Rail Transport	11180	7.30	13533	2.38	14527	2.85	18551	0.62	4619	0.30
25. Auto Transport			60	0.01	554	0.11				
26. Central Laboratory	1756	1.15			1469	0.29				
27. Instrumentation and Elec. Tech. Lab.									6343	0.41
28. Wire and Rod Mill			19935	3.50	20076	3.95	27809	0.93		
29. Gas facilities							1010	0.03		
30. Plant Central Garage	8764	5.73	1529	0.27	2186	0.43	397	0.01	2974	0.19
31. Crane Dept.	12233	7.99	986	0.17						
32. Others	21496	14.05	79624	13.99	12443	2.44	1146470	38.51	219903	14.05
Total	153050	100.00	568801	100.00	508879	100.00	2977554	100.00	1564573	100.00

Source: From the firm itself.

nearly 650 tons altogether in 1966-67. The products and their distribution over different shops of steel plants and others are similar to that of firm N.

3.2.5 A few production planning problems in a jobbing type industry

The following production planning problems are essential because of wide range of products and materials with flexibility in the equipments, caused by the problems of product multidimensionality and of continuous dimensions. These technical details on the products, materials and processes are essential for the studies relating to substitution possibilities, optimisation problems, disaggregative input output tables, at the economy and/or industry level and for production planning and control at the firm level.

(1) Utilized capacities and bottle-necks on processes

As this industry is a jobbing type intermediate product industry depending upon the fluctuating specifications of the customers, it is more likely that unutilised capacities on some and bottle-necks on other processes will result in. Planning the jobs on equipments becomes difficult because of imbalance in capital structure. The very definitions of optimum capacity, optimum production pattern, measure of imbalance in capital structure and of unutilized capacity¹³

¹³ See Mathur, P.N., Valavade, S.P., and Kirloskar, M.V., 'Optimum capacity and imbalance of capital structure : the case of Machine Manufacturing Industries', published in Economic Analysis in Input Output Framework.

See also Kirloskar, M.V., Techno-Economic Study of Electrical Machinery Industry, unpublished thesis.

become difficult when market constraints of jobbing type products are numerous and uncertain.

In the analysis of a firm's detailed time requirements and available hours data, it is found that the upsetter requires 6863 hours whereas 4800 hours are available, the black smith hammer requires 5632 hours compared to 4800 hours available, the two straightening presses require 10922 hours compared to 9600 hours available, and the 7 hammers taken together require more or less the all available hours. Similarly, one may find that the die shop activities are becoming bottle-necks within the die shop for the preparation of dies and to be sent to the forge shop. Similarly, one may find that a single magnaflux equipment is becoming bottle-neck for inspection of the forgings in the same firm.

While the linear programming (L.P.) methods for the study of unutilized capacities and allied problems are suggested for a finite number of activities, the application of linear programming method to an illimitable list of products in a jobbing type industry is still on an experimental level. The only way is to group the maximum possible number of products into finite and unique process-product groups or activities with respect to the homogeneity of product dimensions (as done in Chapters VI and VII), and to make use of those finite processes or activities for the programming problem.

(2) Efficiency factors

The term 'efficiency' is defined by comparing the actual

performance with respect to a standard norm. Norms are generally fixed based on time motion studies of a standard technology with respect to know-how, equipment and skills. The standard technology may be the best available technology at a point of time which may not be accessible to each forging unit. Norms adopted by a particular firm may not be the same with others' norms if they adopt different technology. But each firm can have norms as, within a firm, it can have efficiency factors of the operators, processes and materials of a given technology.

A firm has classified the die preparation jobs and found the percentage efficiencies as percentage of the ratio of estimated or expected hours to actual hours, for the preparation of both top and bottom dies during March 1967 to June 1967. The averages of 4 months are given below.

	<u>New Sinking (%)</u>	<u>Re-sinking (%)</u>
Medium jobs	107.94	72.19
Easy jobs	84.76	70.49
Difficult jobs	66.82	120.30

Similarly, in Forge shop, the averages of 3 months (February 1967 to April 1967) are given as - Medium jobs 71.58%, Easy jobs 97.21% and difficult jobs 54.60%.

In the Forge shop of another firm, the efficiency factors of operators (hammermen) during the winter and summer seasons, on a job x, are relatively more on piece rated jobs compared to daily rated jobs.

Operators (Hammermen)

	A	B	C
<u>Daily rated jobs</u>			
Winter	80%	60%	65%
Summer	75%	55%	60%
<u>Piece rated jobs</u>			
Winter	92 to 95%	75%	75%
Summer	85%	70%	70%

In another firm, Billet shear has 35%, cold saw 90%, Long lathe 57%, Milling Machine 70%, Shaping Machine 60%, Planing Machine 52% as efficiency factors on an average.

(3) Average Yields and inefficiency factors on materials and products

Index of average yield is expressed as a percentage of piece weight or net weight to the gross weight of the material. The difference between gross and net weight of a piece of forging is the scrap, flash and other wastages. The weight of the latter to the net weight gives the inefficiency factor expressed as percentage indices of the products. Nearly 219 types of die forgings are considered in the analysis. The average yields on materials range between 95.15% and 25.58%, while the inefficiency factors of products range between 0.85% and 290.91%. The details are useful both for production planning and control at the firm level and for the disaggregative input output studies to make necessary adjustments.

(4) Requirements of Steel materials and planning to assign the die blocks to the ordered forgings

Nearly 219 different types of die forgings are considered in the analysis. Requirements of numerous grades and specifications¹⁴ of steel are computed by multiplication of total annual requirements of die forgings to the gross weight. Similarly, the requirements of pairs of die blocks with different specifications of block sizes and grade of the alloy steel are computed by the division of the annual requirements of forgings to the estimated die life (number of pieces that it can turn out with one sinking impression die). As the number of die blocks are discrete, these quotients are rounded off to the nearest integer values. These details are an additional information for the disaggregative input output tables and they become the requisite information if the input output tables are to be constructed treating each material specification as an activity or a sector.¹⁵

These details are of immense use for production planning and control at the firm. If only one sinking is possible on the die, 447 pairs of the die blocks are required, if only two sinkings are possible on the die, 285 pairs of die blocks are required and if 3 sinkings are possible, 262 pairs of die

¹⁴ There are hundreds of grades and specifications of steels with different chemical compositions and mechanical properties.

¹⁵ This attains importance when each specification of the material (steel) is providing a distinct and independent input output vector.

blocks are required to be kept in stock, if all 219 orders are to be met in that year. All these analytical results are based on the assumptions that orders are not fluctuating within that year once they are placed and that the estimated die lives are of 100% utilization, as the determining variable for die block requirements.

The range of die life for blocks varies from 2000 to 25000, while the range of annual requirements of forgings varies from 300 to 72000 for these 219 orders. The latter is much broader in range than the former. If the orders of 300 forgings requirements are assigned to 5000 die life blocks, as observed in a firm, the manufacturer has to be assured of the same order for 16 to 17 years successively to utilize one sinking die life of the block. Many planning tools and exercises can be adopted with different assumptions on the number of repetitions of the orders, given the actual utilization of the estimated die lives on one sinking, on two sinkings and so on for production planning and control of the activities at the firm level.

3.3.5 Summary

While section I gives the general technical features of steel forgings industry in India, both of die forgings and open forgings, section II gives the salient features of the firms under investigation. These two sections are a requisite background for the main problems of product multidimensionality and continuity in this industry study. These are supplemented by the Appendix. Though the survey of investigating the firms

is subject to limitations, either with respect to coverage, the nature of the units, basis of selection of the units or the period of inquiry, the details of individual firms provide a wide range of the products, users, materials and processes involved in this industry. These details support the main theme of this study, "Problems of product multi-dimensionality and continuous product dimensions in the process analysis of steel forging industry in the inter-industry frame works". The disaggregative technical details on productivities, inefficiencies, and annual requirements of the materials, efficiency factors on the operative equipments and of operators, optimum production pattern and unutilized capacities in this jobbing type industry will serve as additional information to the disaggregative studies.

Appendix to Chapter III

Detailed technical features of steel forgings industry
in India and in advanced countries

The main operations or processes materials and products of the industry are explained, summarily, in the text of this chapter III, in the context of quantitative and qualitative features of a wide range of forgings, produced by the continuous forging process. Here, it is intended to provide more technical details of some (i) of a few processes of steel forgings industry in India and (ii) of innovations in processes of steel forgings industry in advanced countries. These two sections will serve as additional information to this industry study. All these details will be a requisite information for disaggregative economic analysis of the industry studies with different economic aspects, especially, the substitution possibilities of processes or equipments, materials and products.¹

A.I More technical details of some of the processes
of steel forgings industry in India

(1) Sinking Operations

The actual die sinking may consist of any one or more of the following operations done by the die sinking machines as parts of the sinking operations :

¹ The sources for the first section of this Appendix are the same as those given in the first section of the main text of the chapter III.

(1) Blocking : It is a sinking operation in the Die shop and a forging operation in the Forge shop to impart the general and preliminary shape to attain the final and exact shape. A blocker is that portion of the die sunk in the Die shop.

(2) Edging : It consists of forging the metal between a pair of oval dies and distributing the metal roughly to the final shape in the Forge shop. An edger is that portion of the die sunk in the Die shop.

(3) Fullering : It consists in reducing the cross section of the stock in Forge shop. It is the opposite of edging in that it removes the metal away from the centre of the tool. A fuller is that portion of die sunk in the Die shop.

(4) Bending : It is a movement of the various parts of the stock so that the required asymmetrical shape of the part is obtained. That portion of the die, sunk in Die shop is shown as bender and is meant for bending operation in the Forge shop.

(5) Drawing : It consists in reducing the stock size at one end only as part of the forging process in the Forge shop. That portion of the die on which drawing operations can be done is sunk in the Die shop as part of sinking operations.

(6) Flash and gutter : It is a portion of die sunk in the Die shop to provide for the excess metal as it passes through flash pan during the forging operations.

(7) Cut Off : A pair of blades, either milled in the corner of forging dies or inserted in the dies in die shop are used in forge shop to cut away a forging from the stock after the finishing blow.

(8) Master Die : A duplicate model of the original piece of die sunk in the Die shop for repetitive jobs is known as Master die.

(9) Insert : It is a piece of steel used to fill in a cavity or to replace a portion of the die. That portion of the die sunk in the Die shop is insert die.

(10) Sprue : The portion of the die which is machined out to permit a connection between multiple impressions and the forging bar. It is sometimes called gate.

(11) Trimmer and Punch out : Trimming is an operation in the Forge shop to remove the flash. The dies used for this operation are sunk in the Die shop and are known as trimmer. Blades are attached to the Trimmer dies to punch out the excess metal around the perimeter of the forging.

(12) Coining : It is an operation of applying heavy pressure on the surface of the part to obtain closer tolerances in a coining press. The dies used in this coining press are prepared in the Die shop and they are known as coining dies.

(13) Other minor sinking operations consisting of Dowel, twister, NECK and BUST etc. are done by Die sinking machines, boring machines and vertical turret lathes.

(2) Types of Furnaces

There are four types of forge furnaces with four

criteria. (1) As regards heating, furnaces are classified into box type, semi-continuous and continuous furnaces. In the box type furnaces, the temperature is the same in the entire working chamber, but in continuous furnaces it varies, rising from the beginning of the working chamber to a higher temperature at the exit. (2) As regards charging and discharging methods furnaces are further classified into continuous and periodically operated furnaces. (3) Depending upon the type of fuel burnt in the furnaces, they are classified as : coal fired, gas fired, oil fired furnaces. (4) As regards heat sources, furnaces are classified as flame and electric furnaces.

(3) Heating Conditions

Capacity of the furnace is the weight of metal that can be loaded at one time. Productivity of a furnace is the weight of metal that can be heated in the furnace to the required forging temperature in any unit of time. Thus, productivity which increases with capacity of a furnace depends on the rate of penetration of heat on the metal. For example, at about 1150°C heat penetrates in steel at the rate of $1/2$ inch in 20 minutes. With a well designed furnace, the output is generally reckoned at 40 to 80 lbs. (on an average 60 lbs.) of mild steel per square foot hearth area per hour. Brass will take 50% and copper 40% of this time. For high carbon and alloy steels, however, initial prewarming and slower rates of heating are essential. Undue thermal shocks should be avoided, as uneven heating or cooling involves local volume

changes in the mass and results in metal cracking. The harder the structural constituents of the metal, the more is it susceptible to cracks.

The atmosphere maintained in the furnace is also important. In general, a slightly oxidising atmosphere containing an excess of about 2% oxygen is maintained. A neutral atmosphere is ideal but not practical. If the atmosphere is highly oxidising, not only scaling becomes heavy but also decarburization takes place. A reducing atmosphere on the other hand tends to ruin the quality of steel as the unburnt hydrocarbons and hydrogen cover the surface of the steel and gives rise to a pitted surface of the product. Gas or oil fired furnaces provided with conveyors or rotary hearth permit ideal heating cycles and are more conducive to high production, especially when the job is repetitive. Electric resistance furnaces with neutral atmosphere, accurate temperature control and flexibility of operation serve as excellent heating units but can be used only for special products because of their high cost. A 400 KW can deliver 4" x 4" x 12" long steel billets at the forging heat at the rate of one ton per hour.

(4) Drop Forging Hammers

Heavy machine parts cannot be forged by hand since the comparatively light blows of a hand or sledge hammer are unable to produce a great degree of deformation of the metal being forged. Moreover hand forging is a lengthy process and requires repeated heating of the metals.

Forging under hammers or in presses is further divided

into hammer forging when the work is forged with the aid of flat dies and stamping or die forging when the forgings are made in stamps, i.e. the blocks containing impressions of the forging to be made.

Hammers are classified as mechanical and air and steam hammers. In their turn the former is classified into lever spring, pneumatic and friction hammers. Air and steam hammers are classified into single and double action hammers. The part of the hammer which serves as a rigid support during forging is called the anvil block. The heavy falling part of the hammer is called the ram. The lower part of the ram which comes in direct contact with the forging is called the bottom die. The heavier the falling part of a hammer, and greater the height and velocity of the fall, the greater will be the force of the blow of the hammer.

The capacity or tonnage of a hammer is determined by the weight of its falling parts. For instance if the falling parts of a hammer weigh 100 Kgs., the hammer is rated as a 100 Kg. hammer; if the falling parts weigh 5000 Kg., the capacity of the hammer is said to be 5 tonnes. The force of the blow of the hammer is transferred through the forging to the bottom die and then to the anvil block. The greater the capacity of the hammer, the greater will be the force of the blow and consequently greater must be the weight of the anvil block in order to preserve the stability of the hammer. Each blow of the hammer strikes the anvil block, which transmits its vibrations to the foundation. Of course, heavier the foundation is, the less susceptible will it be

to vibration, but only very large foundations can be completely free from vibration.

The blows of the drop hammer cause the metal to flow and compact itself in the impression of the forging dies to the shape contained in the impressions. One of the dies is fastened securely to the ram (striking weight) of the drop hammer and the second is fastened to the anvil cap (base). The dies are fastened that they can be given proper alignment between the ram and the anvil. The steps in the dies are also designed to control the direction of the grain flow.

In respect of power transmission, there are three types of drop hammers, namely (a) the board drop hammer, (b) airlift or self-contained pneumatic hammer and (c) steam drop hammers. The power consumption averages from $3/4$ to 1 H.P. for every 100 lbs. falling weight. The capacity of board drop hammers usually varies from 100 to 10,000 lbs. and drop is 3 to 8 feet. Steam drop hammers range in size from 250-50,000 lbs. The height of board drop hammer ranges from 2 $1/2$ ' to 5 feet.

The Board drop hammer is operated and controlled by means of a foot treadle. All blows are of equal intensity. After the blow is struck, a pair of rolls come together and grip flat boards fastened to the top of the ram to lift the ram and die to the top striking position.

The airlift gravity or self-contained pneumatic hammer operates similarly to a board drop hammer, except that an

air cylinder assembly on the top of the hammer is substituted for the rolls and boards. The cylinder raises the ram and die and permits their free fall for the forging blow.

The steam drop hammer is operated by steam or compressed air pressure through a cylinder on the top of the hammer. On steam drop hammer, the energy of blows can be regulated to suit from a light tap to a full blow. The operation is controlled by a foot treadle.

There is also a Trim hammer which has a rotating shaft on the top of the hammer. The speed of rotation of the shaft may be regulated through a cone clutch system and the operator is thus able to impart heavier blow at faster rates or lighter or slower blows by increasing or decreasing the rotation of the shaft.

The ratio of anvil weight to falling weight is important and should depend largely upon the material being forged. On any hammer operation, some energy is lost in movement of the anvil under the forging impact. The larger the anvil, the less will be its movement and the more effective will each blow be. In a counterblow hammer the loss of energy is minimised as both the anvil and the ram move simultaneously one from below and the other from above. The energy required for completing the job to a better configuration and specifications will be less compared to other hammers mentioned above.

(5) Presses and Upsetters

There are mechanical presses for accurate sizing,

coining and the production of relatively simple symmetrical forgings. It consists of a rigid frame, a crank driven guided ram and the base directly under the ram. A fly wheel of substantial weight is fixed to the crankshaft. Size of these presses ranges from 200 to 2000 tons and they may be single or double acting.

In Hydraulic presses, pressure is received by fluids like water or oils. Steam intensified hydraulic presses are used for large forgings. It ranges from 200 to 15,000 tons capacity.

A forging machine or an upsetter can be considered as a special design of a double acting forging press operating in a horizontal position. Forging machines are rated by the diameter of the largest bar size that they can handle. They range in size from 1/2" to 9". This rating, however, does not indicate the range of forgings that a machine is capable of producing. The dies and tools most commonly used in the forging machine consist of a pair of rectangular blocks or inserts and one or more heading punches depending upon the number of passes required. The mating faces of the two die blocks have suitable grooves in the horizontal position for gripping the bar stock. The punch end contains some or all of the die impressions. The remaining impressions are contained in the gripping dies. When the part to be made requires more than one pass, the first forging pass is usually located in the top position in the die, the second pass is directly below and the third pass is then below the second

pass. As a rule, where several forging passes are used, all the operations are performed in one heating of the forging stock. Another form of forging machine die is the sliding type of die, useful where stock must be upset at a considerable distance from the end of the bar.

The following table provide an idea of the possible substitutions on different equipments in forge shop.

Comparison of Press and Hammer Capacity

Rated size of Hydro- lic forging press (Tons)	Max. ingot size (inches)	Rated size of steam hammer
300	12	3000
500	16	5000
750	24	10000
1000	30	16000
1500	40	25000
2000	48	50000

Source : 'Estimating Manual for Forge Shop', prepared by the Collaborators and the Indian Technicians of a leading forging unit, based on their studies.

A. II. Technological innovations in processes, production methods, demand pattern of steel forging industry in advanced countries ^{2/}

(1) Scale free direct gas fired furnaces

In America, a scale free direct gas fired furnaces has

² A brief summary of the technological innovations in the processes is attempted here, while a detailed report of

recently been developed.³ The operation of this furnace requires from 40 to 50% more fuel than a comparable conventional furnace. However, since scaling is reduced to below 1% by weight, the additional cost of the fuel may be paid for by saving the material, die wear and subsequent cleaning costs. Work at British Iron and Steel Research Association (BISRA)⁴ on this principle raised the efficiency of the furnace from 11.5 to 14.4%. When insulating refractory brick was installed, the efficiency increased to a maximum of 19.8%.

(2) Electric Induction Heating Furnaces, Simulators etc.

Electric induction heating requires a close coordination of the various parts of the production line but yields good results because of lower rate of scale formation, better temperature control and uniform rate of production. Induction heating equipment linked with the forging machine can be operated economically as the higher cost of heating is offset by increased production.⁵ Simulators can be used to accurately

a study, Technical evaluation of the Forging industry, has been brought by the Illinois Institute of Technology Institute, Chicago, Illinois, sponsored by the Committee of Hot rolled and Cold finished bar producers in American Iron and Steel Institute, 633, Third Avenue, New York 10017. The period of investigation for this report is 'May 1st to Nov. 30th, 1962'.

³ Turner, C.A., "Scale free heating, Technical Report", 549-62 T.P., Selas Corp., Sept., 1962.

⁴ Anonymous, BISRA Annual Report, 1961-1962.

⁵ Korber, W., "Induction heating for horizontal forging machines" (1959), Germany.

plot heat transfer from the outer surface of the forging billet to its centre, thus assuring proper forging temperature throughout the billet. It can predict heat time and heat input needed to achieve complete temperature uniformity in a steel part and has been used for the prediction of die temperatures during heat treatment.⁶ A new Swedish furnace equipped with novel electric heating elements is capable of working with a protective atmosphere.⁷ Salt bath heating has some attraction, in that the salt offers protection against oxidation and conceivably could serve as a forging lubricant. But this is not successful because of maintenance problem of the furnaces and salt.

(3) Main distinction in uses of hammers and presses

It is considered that the hammer is the only suitable tool for production of components of elongated shape and the press is more or less reserved for axially symmetrical components. The basic difference is that, when forging on drop hammer, all operations from bar to final shape are carried out by a multitude of blows in several impressions of the same die set. In the case of press forging, preforming operations are concentrated on special machines (forging rolls, upsetters, benders, etc.) and the press is reserved for blocking and final forging.

⁶Feng, C.L., "Computer helps speed heat cycles", Metal Progress 80, (1961), No. 2, pp. 79-82.

⁷Tholander, Erik, "An Electric Forging Furnace with new heating elements", (1960, Germany).

(4) Extrusion Forging Process of recent origin has many advantages, primarily for the production of axially symmetrical components of suddenly changing cross section (valves, turbine blades, axles, etc.) and for hollow bodies (shells, hubs, etc.). It is an extension of the field of cold forging (pressing) to larger components.

(5) Roll Forging

Conventional roll forging is on two high rolls, forming cut billets or rods in several steps to approach a shape which will then be suitable for drop forging or pressing. Recent development on this is unidirectional rolling, in which, the preheated billet runs through one pair of rolls deforming it along part of its length - e.g. for reducing the central portion of a connecting rod. Productivity is extremely high upto 5200 times that of a drop hammer.

(6) Hydraulic presses : A unique hydraulic press is the 11,000 ton press which has a 11,000 ton main vertical ram, two opposed 6000 ton horizontal side rams, and 3000 ton auxiliary ram for piercing to produce offset forgings. These cored forgings require less machining and save the material.

(7) Shaping and sinking die impressions

(a) Electro-forming is based on the same principles as electroplating used for shaping shallow die cavities only.

(b) Chemical milling, another new process chemically attacks exposed and unmasked surfaces to remove metal from curved surfaces inaccessible by conventional milling.

(c) Ultrasonic machining : Hard materials such as

tungston carbide, hardened steels and ceramics can be cut and relatively small, precise and intricate details with dimensional tolerances as close as $\pm .0002$ " can be brought out.

(d) Electric discharge machining (spark erosion) :

It is used extensively in high production die shops for die sinking. In this process, the work piece is connected to the positive and the tool to the negative D.C. power source. Both tool and work piece are submerged in a suitable die-electric liquid. With proper care, the work piece dimensions may be held to tolerances closer than 0.001 ". Spark erosion is faster than conventional machining. Rough cut metal removal rates may be as high as 0.3 cubic inch per minute, dropping to about 0.01 cubic inch per minute for finish cuts.

(8) Mechanization and Automation : Automation is evident in open die-forging industry to position the work between the dies. Manipulators having a memory of more than 200 operations have been developed. In all the automated machines, die design becomes much critical to control the metal flow which leads to the need for a more scientific and mathematical approach to die design.

(9) Quality control : Inspection for forging defects by magnetic crack detections is done by Detroflux test and Magnaflux test equipments. Testing for internal soundness by X-ray is not wide spread since radiography is not sensitive enough to detect small flaws. Information on samples

of forgings is sufficient for running production and statistical techniques of quality control can be used to locate sources of trouble.

(10) U.S.A. and U.S.S.R. innovations in the product methods and demand pattern

The amount of steel used for the production of forgings is given as 5-6% in U.S.A. and 8% in U.S.S.R. Of the total, approximately 67% is used for closed die-forgings in U.S.A. and 57% in U.S.S.R., thus the amount of steel consumed for closed die forgings amounts to 3 1/2 to 4% of the total steel production of U.S.A. and 4 1/2% of that of U.S.S.R. The relatively low percentage in U.S.A. is attributed to widespread use of cast components in Automotive industry.

There is an increasing tendency for presses, specialized forging, cold forging and Roll forging in U.S.S.R. as seen from Table Iobelow.

Table I0. Forging production prediction in U.S.S.R.(percentages)

Production Method	1958	1960	1965	1970	1980
Closed die forging :					
Hammer	39	30	22	15	4
Presses	1	4	11	16	20
Horizontal forging	12.8	15	13	12	10
Specialized forging	3.7	6	8	12	23
Roll forging	0.5	1	6	9	15
Cold forging	-	-	2	3	5
Open die forging	43	44	38	33	23

Table II. Percentage share of average dollar sales by the commercial forging industry to major end use markets over the period 1960-65 in United States of America (U.S.A.)⁸

1. Aero space	31.7%
2. Automotive and Trucks	22.6%
3. Construction, Mining, materials handling equipment	12.3%
4. Tractors, other agricultural machinery and implements	5.3%
5. Ordnance (except missiles)	4.6%
6. Rail-road	3.5%
7. Plumbing, fixtures, valves and fittings	3.0%
8. Petro-chemical	1.9%
9. Mechanical power transmission equipment including bearings	1.3%
10. Internal combustion engines (stationary)	0.9%
11. Metal working and industrial machinery	0.9%
12. Steam engines and turbines	0.7%
13. Motors and generators	0.6%
14. Motor cycles and bicycles	0.5%
15. Refrigeration and Air conditioners	0.5%
16. Others	<u>9.2%</u>
Total	100.0%

⁸ Source : Jensen John E., Forging Industry Handbook (ed.), Director of Marketing and Technical Services, Forging Industry Association, Cleveland, Ohio, 1966.

Steel forgings in U.S.A. are consumed mostly by the Aero space or Aircraft production industry because of less weight and heavier strengths of the quantitative and qualitative features of their steel forgings. Automotive and trucks took second place, mostly because of some possible substitution of castings replacing the forgings as components of this major consuming industry.

CHAPTER IV

**INPUT AND CAPITAL STRUCTURES AS PARAMETERS OF
INSTANTANEOUS PRODUCTION FUNCTIONS OF FIRMS AND
TECHNOLOGICAL PROCESSES IN STEEL FORGINGS INDUSTRY**



4.0 Introduction

In the light of investigation of firms and their technological processes, products and materials of steel forgings industry in India, as depicted in the earlier chapter III, here, the inputs and capital structures of the firms and intermediate processes, as the technological parameters of the economic production functions of the production units, have been examined in the context of Leontief Input output analysis. The theoretical frame and the empirical analysis of this instantaneous production function approach have been dealt with broadly under the following :

- (1) a discussion on the development of different analytical approaches or methods to explain the production theories of firms or of an industry,
- (2) a discussion on the nature, uses and limitations of Leontief input output analysis as a production function approach to a firm or an industry,
- (3) A discussion on the conceptual and empirical problems along with their associated adjustments carried out for refinement in the evaluation of inputs and capital structures of firms and intermediate processes in steel forgings industry in particular and in the preparation of input output tables of an economy in general.
- (4) Analysis of the inputs and capital structures of the firms and intermediate processes in this industry.

4.1 Production theories - discussion on Development of the analytical approaches¹

About two centuries ago, Francois Quesney² propounder of physiocratic school, published his "Tableau Economique" (1758), in which the idea of the compartmentalized treatment of necessarily interdependent production activities was first formally advanced. But the idea remained dormant until the time of Leon Walras³ (1874) who employed a similar approach to state the interdependence among the production sectors of the economy in terms of the competing demands of each industry for factors of production and of the substitutability among their outputs in consumption. The main use of his mathematical formulations is to demonstrate the existence of determinate solutions for the quantities and prices in the system under the assumptions of maximising behaviour. But these formulations too remained as a theoretical analysis until 1930's, when W.W.Leontief⁴ gave a

¹ Here, a brief presentation of the development of the analytical approaches to production theories is attempted. For a critical review, see Mathur, P.N., "Input output frame work for explorations in theoretical and empirical economic research", Artha Vijnana, June 1969, Vol. XI, No. 2, pp.133-148.

² Reproduced in facsimile for the British Economic Association, Macmillan and Company, London, 1894. Original in France, 1759.

³ Walras Leon, Elements d'Economie Politique Pure, Lausanne, 1874 (first edition), Fourth edition, R.Pichon et R.Durant-Auzias, Paris, 1926.

⁴ Leontief, W.W., Structure of the American Economy, Harvard University Press, Cambridge, Mass., 1939.

Second edition, Oxford University Press, New York, 1951. For the mathematical formulations, refer to Part II, pp.33-68 of the second edition. Reproduced and summarised in Economic Activity Analysis ed. Oscar Morgenstern. Chapter: 'Models of general equilibrium' by J.Balderston, pp.3-42. John Wiley and Sons, Inc. Chapman and Hall, Ltd., London, New York, 1954.

practical tool of analysis to derive a set of parameters for his model from a single point observation of each of the inter-industry transactions in the economy. This inter-dependent multisectoral instantaneous production function approach provides at any point of time only the equilibrium production points with a set of fixed coefficients observed in the economy. Later on, Dantzig and Koopmans⁵ (1951) developed the mathematical technique of activity analysis or linear programming in the field of inter-industry economics to study the production theories of a production unit as well as of the economy as an interdependent sectoral system. These analytical approaches are of modern production theories.

On the other hand, traditional Marshallian partial equilibrium analysis specifies the relationships between the economic variables of a sector, through sets of supply and demand functions, assuming no significant change in the economic variables of other sectors. The main distinction between traditional production theory of partial equilibrium or of general equilibrium analysis and modern production theory of Leontief general equilibrium analysis or inter-dependent multisectoral instantaneous approach, may be described as follows :

A production process is described as a transformation

⁵ Activity Analysis of Production and Allocation, ed. Koopmans, John Wiley and Sons, 1951, and Koopmans, T.C., "Three essays on the State of Economic Science", McGraw Hill Inc., New York, 1957. (Input output analysis is discussed on pp. 101-104 and on pp. 38, 72, 187-197, 203, 212).

of one set of variables - the inputs or the factors of production, into another, the outputs. The quantitative relationships between inputs and outputs are determined by the set of all available technological alternatives. In the traditional production theory, among all the available input output combinations technically possible, the firm chooses one which maximises the difference between total revenue and total costs under *ceteris paribus* conditions. All available transformation possibilities are stated in the form of one or more well behaving 'production functions' with continuous partial derivatives through the entire relevant range, attaining a local maximum.⁶ Since a fully detailed description of the actual shapes of all the transformation (production) functions of all firms in the economy is a nonfeasible proposition, the theory of production of the firms and of individual industries had to be reformulated in terms of discrete instantaneous production functions observed at and applicable to different points of time. The latter approach gives only one way of producing the given amount as the best process with invariant proportions of factors of production in the short run. The Leontief system can be considered as a multi-industry counterpart of Marshall's short run partial analysis and may be labelled as short run general analysis.⁷ Thus,

⁶ Leontief, W.W., Essays in Economics, Theories and Theorizing, Chapter - 'Mathematics in Economics', pp. 23-24 and the Chapter - 'The Problems of quality and quantity in Economics', pp. 45-57.

See also Barna, Tibor, 'The interdependence of the British Economy' in The Journal of Royal Statistical Society, Series A (General), Vol. CXV, Part I, 1952, p. 30.

⁷ Mathur, P.N., *op.cit.*, Artha Vijnana, pp. 138-139.

the inter industry disaggregative analysis serves better than the partial equilibrium analysis to a detailed study of the production theory of firms, processes and of an industry in the context of interindustry system of an economy.

4.1.1 The Walrasian general equilibrium approach in comparison with the Leontief's instantaneous approach as an empirical tool of the former to the production theory of firms, processes and of industry

There is no counterpart in the Leontief system to Walrasian market supply functions for factors and demand functions for goods.⁸ In the simplest static open Leontief model total outputs demanded are found in terms of the levels of final demand. Walras' utility functions for the individual also have no counterpart in the Leontief's open system as the consumption levels are specified outside the open model.⁹ In the closed Leontief model, they conform to the strict fixed coefficient requirement.

Input output analysis is like general equilibrium analysis in that it encompasses all products and industries at the disaggregative level of classification of the sectors and serves as an empirical tool to the latter. However, input output analysis is unlike general equilibrium theory in that

⁸ Balderston, J., 'Models of general Economic Equilibrium' in Economic Activity Analysis, ed. Morgenstern, John Wiley and Sons, Inc., Chapman Hall, Ltd., London, New York, pp. 3-30.

⁹ Leontief, W.W., Structure of American Economy, 1919-39, 2nd ed. 1951. (See for logical and mathematical formulations) pp. 33-34, 203-204.

it is not in itself an equilibrium system.¹⁰ Leontief's attempt was indeed to render the Walrasian system, which had a remote majesty¹¹ but was empirically unworkable, to manageable proportions by constructing a model of interdependence - as against the Walrasian interfirm and interpersonal dependence - which required relatively fewer parameters to be determined from a single point observation.

From these viewpoints, it is preferred in the following analysis to find the fixed coefficients as equilibrium production points. These fixed coefficients serve as parameters of interdependent, multisectoral instantaneous production functions of firms or of industry.

4.2 Input output analysis - its nature and uses to a firm or industry

The system of balance equations and the economic logic behind them are often found in Economic literature,¹² to derive the production levels, price proportions vectors, employment levels, wages, interest and profit relationships, the effects of foreign trade vectors etc. and the conditions

¹⁰ Christ, Carl F., 'A review of input output analysis' in Input Output Analysis - An Appraisal, Studies in Income and Wealth, Vol. XVIII, National Bureau of Economic Research, Princeton University Press, 1955, pp. 143.

¹¹ Bharadwaj, R., 'Methodological Survey of the Application of input output in Developing Countries', Artha Vijnana, June 1969, Vol. XI, No. 2, pp. 149-166.

¹²(a) Leontief, W.W., 'Input output analysis' in Input Output Economics, ed. Leontief, New York, Oxford University Press, 1966.

(b) Bharadwaj, R. and Mathur, P.N., 'The Input output economics - a resume', in Economic Analysis in Input Output Framework, ed. P.N.Mathur and R. Bharadwaj, Poona, 1967.

(c) Barna, Tibor, 'The interdependence of the British Economy' in the Journal of Royal Statistical Society, series A (General), Vol. CXV, Part I, 1952, pp. 35-37.

for internal consistency and viability of both closed and open input output models. In these balance equations, instead of the traditional production function of an industry i of the type $X_i = f(x_{i1}, x_{i2} \dots x_{in})$, the technical set up of each industry, is described by a series of as many homogeneous linear equations as there are separate cost factors.¹³

$$x_{i1} = a_{i1} x_1, \dots, x_{in} = a_{in} x_i \quad (i=1, 2, \dots, r)$$

The complete set of coefficients a_{ij} arranged in the form of a matrix $[a_{ij}] = A$, corresponding to the input output flow table $[x_{ij}] = X$, is called the 'structural or technical coefficients' matrix, whereas $[I-A]$ matrix is the technology matrix. Each column vector of $[I-A]$ provides the process of a unique input output combination to produce the unit output level of the corresponding activity or a sector. The inputs are represented by negative sign, whereas the output is shown by positive sign for the sector concerned in $[I-A]$ matrix. In the flow input output table $[x_{ij}]$, the figures entered in the column of the table describe the inputs consumed by the corresponding sector, whereas the row elements give the distribution of the output of the row sector as inputs of column sectors. Similarly, the column vector of A matrix provides the input structures of the corresponding sector and the elements of row vector of A matrix provide the distribution of the output of the corresponding row sector per unit outputs of the different using column sectors. It

¹³ Leontief W.W., The Structure of American Economy, 1919-1939. An empirical application of equilibrium analysis. Part II. The Theoretical Scheme, pp. 33-65, New York, Oxford University, 1951.

is these column input structures, serving as technological parameters of instantaneous production functions, of the activities or sectors and their stability that we attempt to evaluate in this study. Once the consistency and stability of the column input structures are established, the row vector elements will be evidently given as they are.

Although, in principle, the intersectoral flows can be thought of as being measured in physical units, in practice most of the input output tables are constructed in value terms at constant prices or at basic prices, as the aggregation of the different units of measurements of the sectors becomes difficult. The input output table is said to be at basic prices as good as at physical units, if the physical units are expressed in terms of one rupee worth of the amount, as a single unit of production of all the sectors, at the prices prevailing at the time of the table construction.

4.2.1 Uses of A matrix to a firm or an industry

If one needs to know how much of labour or how much of imports or any other sector's output is required directly in producing a unit output of a particular sector, one can find answer by constructing production accounts and there is no need for input output analysis. But if one unit of the output of an industry is to be delivered to final demand, it is necessary to produce - (1) the original unit of output, ~~the~~ (2) all direct inputs to make this possible, (3) all the indirect inputs required for the chain relationship of the inputs and outputs of interdependent industries to fulfill

the direct inputs of the industry concerned. All these are being taken into account by the convergent series of $[I-A]^{-1}$ matrix which is equivalent to $I + A + A^2 + \dots$, usually known as matrix multiplier. Information of this kind is clearly useful for the purpose of industrial decisions, which cannot be reached by direct observation or by production accounts alone. The product of the matrix multiplier and a vector of final demand of different compositions, will provide different sets of output levels estimates, which are also a useful information to a firm in the market research departments. A businessman can compare his company's marketing position with that of an industry, of which it is a part, and note possible areas of additional market potential. To the extent that an individual firm deviates from its industry's average, "the industry of which the firm is a part" approach is less than satisfactory.¹⁴

¹⁴ (a) Tiebout, Charles, M., "Input output and the Firm: A technique for using National and Regional Tables", The Review of Economics and Statistics, Vol. XLIX, May 1967,

(b) Leontief, W.W., "Modern techniques for Economic planning and projection", in Leontief, W.W., Essays in Economics, Theories and Theorizing, Oxford University Press, New York, 1966, pp. 237-247.

(c) Barna, Tibor, "The interdependence of British economy", The Journal of Royal Statistical Society, Series A, (General), Vol. CXV, Part I, 1952, pp. 37-40.

(d) Evans, Duane, W., "Marketing uses of Input output data", (1951), Bureau of Labour Statistics (mimeographed), Journal of Marketing, July 1952, pp. 11-21.

(e) Evans, Duane, W. and Hoffenberg, M., "The nature and uses of interindustry relations data and methods", in Input Output analysis-an appraisal (ed.) NBER, Princeton University Press, 1955, pp. 53-123.

4.2.2 Dynamic analysis to a firm or an industry

Every industry requires, apart from the flow requirements of production in the sector, some stocks to carry on productive activity. If an industry increases its output, its demand for the products of other sectors of the economy goes up, not only on account of increased current input requirements, it will also absorb additional inputs to enable to increase its necessary stock holdings. In the case of diminished output, it is necessary to distinguish between inventory holdings and investments of the more fixed kind. The first can be used up through transformation into inputs on a current account, while the fixed stocks cannot be adjusted downward through the same simple process of absorption on current account. Under the first category, stocks of raw materials, goods in process, semifinished and finished products will fall, while, under the later category, buildings, plant and machinery transport equipment and other fixed assets will be included. When the stock requirements of an industry go down in proportion to diminished output, the fixed equipment are not diminished accordingly. Instead the difference between the technically necessary and actually available stocks results in the appearance of unused or idle capacity.¹⁵ In the case of a subsequent upturn, the current input requirements of the industry will naturally at once begin to grow in proportion to its increased output. Besides, the inputs are required to be replenished in accordance with their stock requirements, which are based

¹⁵ Leontief, W.W., The Structure of American Economy, 1919-1939, An empirical application of equilibrium analysis, Oxford University Press, New York, 1951, pp. 212-214.

on both fixed capital coefficients and working capital coefficients. These capital structures involving time dimension are the parameters of the expanded differential balance equations of dynamic input output analysis.¹⁶

4.2.3 Dynamic analysis for an economy

Due to basic linearity, Dynamic input output model has been conceived as a summation of one or more Leontief Trajectories. Each Leontief trajectory may be considered as an independent economy growing at its own pace and is not conditioned by the growth or otherwise of any other part of the economy. Apart from meeting input and capital requirements, each Leontief trajectory throws out a vector of final demand to be consumed exogeneously. A Leontief Trajectory growing at the technically feasible highest rate of growth is known to have balanced growth without throwing out any final demand to have a unique structure of production, which is often termed as turn pike.¹⁷ If the structure of production does not correspond to the structure of this highest growth factor, investment should first be so directed to achieve this.

¹⁶ See (a) Mathur, P.N., "A modified Leontief dynamic model and related price system", Econometric Annual of the Indian Economic Journal, Vol. XIII, 1965.

(b) Leontief, W.W., "An open dynamic system for long range projection of economic growth", in Economic Analysis in Input Output Framework (ed.) Mathur, P.N. and Bharadwaj, R., Poona, 1967.

(c) Leontief, W.W., "Dynamic analysis" Chapter in Studies in the Structure of American Economy - Theoretical and Empirical Explorations in Input Output Analysis, ed. Leontief and others, pp. 53-93.

¹⁷ Mathur, P.N., "Input output framework for explorations in Theoretical and empirical economic research", Artha Vijnana, Vol. XI, No. 2, pp. 144-146.

The dynamic analysis can also take into account the year to year changing technology and consumption pattern.¹⁸ While it is not attempted to review all aspects and applications of dynamic input output models, attempted by various authors,¹⁹ for different purposes, the main tool of the dynamic analysis are presented in this industry study.

¹⁸ Ibid.

¹⁹ Apart from those already referred to in this chapter, the following applications are of significant importance :

(a) Mathur, P.N., "An application of Dynamic input output model for planning".

(b) Mathur, P.N., "Use of shadow prices in a developing economy".

(c) Bhatia, V.G., "Measurement of Economic development and growth potential".

(d) Panchmukhi, V.R., "Planning for import substitution: Some methodological and empirical results."

(a) to (d) all in Economic Analysis in Input Output Framework, ed. by Mathur, P.N., and Bharadwaj, R., Poona, 1967.

(e) Smith, H.M., "Uses of Leontief's open input output models" in Activity Analysis of Production and Allocation, ed. T.C.Koopmans, pp. 132-141, John Wiley and Sons, Inc., New York, 1951.

(f) Mathur, P.N., "Two concepts of capital output ratios and their relevance for development" Artha Vijnana, Vol. 4, No. 4, 1962.

(g) Grosse, R.N., "Structure of Capital", in Studies in structure of American Economy - Theoretical and Empirical Explorations in input output analysis, ed. by Leontief and others, New York, Oxford University Press, 1953.

(h) Mathur, P.N., "Expected Production and its Pattern, 1985-86".

(i) Mathur, P.N., "Explorations in making programme of full capacity utilization".

(h) and (i) in Artha Vijnana, June 1969, Vol. XI, No. 2, pp. 306-331.

(j) Mathur, P.N., "An appropriate system for deflation of sectoral income in a developing economy", The Review of Income and Wealth, series 13, No. 1.

(k) Mathur, P.N., "An efficient path for technological transformation of an economy" in Structural Interdependence and Economic development, ed. by Tibor Barna, 1963.

4.2.4 Nature of capital matrices - Average and incremental capital structure

Basic to these dynamic models is the fixed capital coefficients per unit capacities of the sectors and the working capital coefficients per unit outputs of the sectors as the Capital structural matrices. Considering the latter separately as they involve less time dimension, similar to current input structures, the average fixed capital coefficients are given by $b_{ij} = \frac{S_{ij}}{X_j}$ where S_{ij} are the stocks of i -th good held by j -th industry, and X_j is the capacity of sector j , both at a point of time t . In the dynamic models, in principle, it is the incremental capital coefficients, given by $b_{ij} = \frac{\Delta S_{ij}}{\Delta X_j}$, that are of significant role. These are to be obtained from the project reports or from engineering data or from new plants' financial data. If two points data are available, then also they may approximate to

$$b_{ij} = \frac{[S_{ij}(t+1) - S_{ij}(t)]}{[X_j(t+1) - X_j(t)]}$$

But such an estimation has serious limitations if there is capital imbalance within the industry. In the absence of getting incremental coefficients by any of the above methods, one may consider that they may approximate to average capital coefficients. To allow for changes in flow and capital coefficients with the industrial growth, it is necessary to distinguish between average technical coefficients of an industry, of a firm or of a process reflecting an existing capacity and incremental coefficients or marginal coefficients, characterizing those portions of capacity which are being added in the

course of current growth and replacement.²⁰

4.3 Assumptions and Limitations of input-output analysis

The predictive value of the input output analysis for any problem depends on the stability of the technical coefficients during the period between that of table construction and of application of the model. Computation of the stable technical coefficients of an industry, which are crucial to depict the structure of the economy in terms of the interdependence of the sectors, is of utmost importance for all practical uses and theoretical conveniences.

There are at least six situations²¹ of theoretical

²⁰ Carter, A.P., "Incremental flow coefficients for a dynamic input output model with changing technology" in Structural Interdependence and Economic development, ed. by Tibor Barna, London, Macmillan and Co., New York, 1963. pp. 277-301. See also Carter, A.P., "Capital coefficients as Economic Parameters" in National Bureau of Economic Research, (ed.), Studies in Income and Wealth, Vol. 19, 1957.

²¹ Apart from others, summary of the following is attempted:

- (a) Eckstein, O., "The input output system - its nature and use" in Economic Activity Analysis, ed. by Oscar Morgenstern, John Wiley and Sons, Inc., Chapman and Hall, Ltd., London, New York, pp. 43-78.
- (b) Sevaldson, Per, "Changes in input output coefficients", Structural Interdependence and Economic development, ed. by Tibor Barna, London, Macmillan and Co., Ltd., 1963, pp. 303-327.
- (c) Chenery H.B. and Clark, P.G., "Interindustry Economics" Chapters 2 and 4, pp. 13-54 and pp. 81-136. New York, John Wiley and Sons, London, 1964.
- (d) Christ, Carl F., "A review of input output analysis" in Input output analysis : An appraisal, studies in income and wealth, Vol. XVIII, NBER, Princeton University Press, 1955, pp. 139-143.
- (e) Dorfman, R., "Nature and significance of input output", The Review of Economics and Statistics, May 1954.
- (f) Samuelson, P.A., "Abstract of a theorem concerning substitutability in open Leontief models", pp. 142-146.
- (g) Koopmans, T.C., "Alternative proof of substitution theorem for Leontief models in the case of three industries".

Continued/..

interest and of practical importance under which the technical coefficients become unstable as given below:

First, is when a plant or an industry is subject to economies of scale. Leontief's assumption of constant returns to scale is contrasted on the ground that functions more complex than simple proportions of instantaneous production functions, are necessary to describe the production processes, particularly in capital based industries having longer gestation periods.

Second, is when substitution between inputs takes place. This is because substitution between inputs may take place in the long run, when relative prices change. P.A.Samuelson proved a proposition about substitution, namely : the absence of substitution among inputs in the open input output analysis does not need to be assumed, for it is already implied in the assumptions of efficiency in production, constant returns to scale, absence of joint products and the existence of just one scarce primary resource (i.e. a scarce resource that is not produced). The theorem says, in effect, that even though the production functions allow substitution among inputs, it does not take place, no matter how the final bill of goods is changed, because the achievement of efficiency in production always leads to a unique set of input output ratios for each

- (h) Arrow, K.L., "Alternative proof of substitution theorem for Leontief models in the general case". All (f), (g) and (h) are in Activity Analysis for Production and Allocation, 1962, ed. by Koopmans, T.C.
- (i) Holzman, Mathilda, "Problems of classification and Aggregation" in Studies in Structure of American Economy - Theoretical and empirical explorations in Input output analysis, ed. by Leontief, W.W. and others.

industry. Some economists admitted the possibility of alternative techniques of production to produce a product by several different processes or input output combinations. If this modification alone is made, the assumption of constant returns to scale being retained, then the open form of input output analysis turns into linear programming analysis. This is strictly true only if the number of alternative processes for producing a product is finite. If the number of alternative processes is infinite, they form a smoothly curved production surface, then the open form of input output analysis becomes the traditional continuous production functions theory.

Thirdly, there are practical problems of product mix arising as a result of horizontal integration of identical technological processes or firms producing multiple products for the sector specification in input output tables, while the composition of the final demands of the products are fluctuating. Here, the assumption is that the product mix of all aggregated firms remains the same over a period. If the composition of products in the firms is fluctuating very much and each of those products has separate final demand and independent input structures, it is essential to distinguish those products as independent sectors in the input output analysis. Leontief's assumption of no joint products is thus contrasted for practical problems.

Fourthly, there are practical problems of process mix, arising due to vertical integration of separate technological processes in a firm or an industry while the techniques of

individual processes are changing. If the processes are separately identified as sectors, then the input structures of processes or sectors can be corrected in the light of changes in technique and the individual processes. The assumption that the economy will operate always at the currently available best practice technology, is not a feasible proposition, because a developing economy operates with an admixture of old and new techniques all through the period of its technological transformation.

Fifthly, while the day to day operation of a modern economy is determined primarily by the static input output analysis models, the exploration and explanation of its longer run developments must be approached through the stock flow relationships of structural time lags and of technological changes in the equipment itself. Because of these dynamic elements also, structural coefficients are likely to vary. Those dynamic elements are properly to be identified and taken care of, through suitable dynamic input output models approximating to reality rather than on hypothetical considerations.

Sixthly, the practical problems in respect of different capital intensities, managerial organizations, working conditions, of production units. Market imperfections also cause the instability of input structures of an industry.

Seventhly, the problems of product multidimensionality, and of continuous changes in product dimensions as discussed in Chapters VI and VII, also cause variations in the input structures of firms and of the industry, especially in the case of

jobbing type industries. Assumptions of no joint products and a single process to produce a single product, may at best take care of the problems of product mix and process mix by a suitable choice of classification and aggregation. But they can not take care of the problems of product multidimensionality and of continuous product dimensions for which reliance on the empirical studies of production functions of individual industries from the engineering data is the only alternative.

4.4 Conceptual and practical problems in the empirical evaluation of capital and input structures of firms, processes and industry

While there are various studies²² to analyse and to test the assumptions underlying the instantaneous production functions of Leontief input output analysis, they are not attempted for review in this industry study. But it is attempted to discuss the practical and conceptual problems in the empirical computation of the structural coefficients in the preparation of usual input output tables in general and in this industry study in particular. In the context of developing economies, they are of particular interest. All such problems are common to the firms and processes of an industry, taking into account individual technologies and industrial practices, to improve the stability of technical parameters of a sector. The need for disaggregative input output tables stems from the fact that each process or the stage of operation may have its own unique

²² See (a) Chenery, H.B. and Clark, P.G., Interindustry Economics, Chapter 6, Testing the Validity of input output assumptions, pp. 157-184.

(b) Hatanaka, M., Workability of Input Output Analysis, Germany, 1960.

input output combination producing an unit level of that operation or activity.²³

4.4.1 Incremental and average coefficients

Four general types of estimates of incremental coefficients are as follows :

- (i) "New plant coefficients" : Estimates derived by observing the performance records of new plants.
- (ii) "Cross section estimates" : Estimates inferred statistically from observed changes in the coefficients of older establishments' capacity expansion.
- (iii) "Industry time series coefficients" : estimates inferred statistically from observed changes in the coefficients of the industry as a whole and expenditures on new plants' equipment as addition to the industry's capacity levels.
- (iv) Technical parameters of economic production functions linked to the engineering production functions, based on engineering variables and their properties which are linked to the economic variables.²⁴

²³ Here, the terms, activity, process, stage of operation are synonymously used as they may refer to an equipment or a series of equipment, though distinctions of them are observed in Koopmans, Barna Tibor and Manne A.S. and Markowitz.

²⁴ Chenery, H.B., "Engineering production functions" The Quarterly Journal of Economics, Vol. LXIII, Nov. 1949, pp. 507-531.

Chenery, H.B., 'Process and Production functions from engineering data in Studies in Structure of American Economy - Theoretical and empirical explorations in input output analysis, Oxford University Press, New York, 1953, pp. 297-325.

Because the relevant data are scanty generally in underdeveloped countries, it is not always possible to construct and choose these alternative types of estimates. They may also serve as supplementary to each other, for different applications of the dynamic input output analysis.

4.4.1.1 Incremental coefficients - an approximation

Most of the firms under investigation are of recent origin as seen from Table I of Chapter III, and the growth of the industry, as observed in Chapter II, is also of very recent origin. Replacements and additions to capital stock do not arise as most of the units are 6 to 7 years old. All these new units borrowed modern technology, though the possibility of holding some second hand imported equipments for the reasons of foreign collaborations cannot be ruled out. As there are no significant technological changes during this short period of 6 to 7 years either at the industry level or in any of the firms' processes, all the derived average coefficients may serve as incremental coefficients, with the assumption of only new capital and new technical knowhow are installed during the period.

4.4.2 Classification and aggregation²⁵ for sector specification

In the construction of input output structure of the

²⁵ Apart others already referred on this problem, see (a) Yamada Isamu, Theory and applications of Interindustry analysis, Tokyo, Japan, Chapter 2 - Aggregation problems, pp. 16-48.

(b) Balderston T.B., and Within, T.B., "Aggregation in the input output models" in Economic Activity Analysis (ed.) by Oscar Morgenstern, pp. 79-114.

sectors in an economy, the usual practice is to follow either an industrial or a trade classification scheme to specify the sectors of the economy. The industrial classification attempts to group together economic activities which are akin in terms of the technological process adopted. The unit of classification is an 'establishment', which is engaged in one or predominantly one kind of economic activity. Similarly, for the trade or commodity classification, the unit of classification is the commodity that enters into trade. Obviously, these two classifications serve different purposes. If the units of production are of single process type, and produce a single product, then two types of classifications would have satisfied the definition of the most disaggregative sector for input output analysis.

But, in actual practice, this hypothetical situation does not hold good as there are many multiproduct and multiprocess units of production. These give rise to problems of productmix, processmix and product multidimensionality for the purpose of sector specification. These practical problems are dependent on the industry or trade classification schemes for sector specification. This is so because the classification

(c) Leontief, W.W., "Some basic problems of empirical input output analysis" in Input output analysis - An Appraisal, Studies in Income and Wealth, NBER, Princeton University Press, 1955, pp. 9-49.

(d) Barna, Tibor, "Classification and Aggregation in input output analysis".

(e) Malin Vaud, Edmond, "Aggregation problems in Input output models", both (d) and (e) are in The Structural Interdependence of the Economy, ed. by Tibor Barna, John Wiley and Sons, Inc., New York, 1954, pp. 175-202.

(f) Holzman, Mathilda, "Problems of classification and Aggregation" in Studies in Structure of American Economy, ed. Leontief and others, op.cit., pp. 326-359.

(g) Barna, Tibor, "The interdependence of the British Economy" in the Journal of Royal Statistical Society (General), Series A, Vol. CXV, Part I, 1952, pp.40-42.

schemes are some statistical aggregation of the processes and products of the production units to form sectors, mostly based on horizontal integration, vertical integration, exclusiveness, demand complementarity, price proportionality and partial horizontal or vertical integration principles for different purposes. They depend on data availability on the individual sectors. All these principles of aggregation are not complements to each other in specifying a homogeneous sector.

4.4.2.1 The disaggregative input structures

The practical problems of allocating the actual inputs into the frame of the classification chosen, have been encountered by various researchers.²⁶ These difficulties are also due to insufficient knowledge of the certain inputs due to different procedure of describing the financial accounts of different firms. Lack of reliability on them also bring insurmountable difficulties of classification and aggregation. However, maximum possible details of the transactions are collected at the firm level to compute the disaggregative input structures (see Table 4 in Appendix A). As the most disaggregative input table for 1963 under preparation of Gokhale Institute of Politics and Economics (G.I.P.E.) is based on 241 G.I.P.E. sectors, the input structures of firms and processes are presented with a suitable aggregation of the

²⁶ See the articles in Economic Analysis in Input Output Framework, ed. by P.N.Mathur and R. Bharadwaj, Poona-1967, and in Artha Vijnana, June 1969, Vol. XI, No. 2, especially those relating to the construction of flow and capital input output tables.

inputs, according to G.I.P.E. 241 sector classification. The corresponding ASI classification is also given for reference sake.

4.4.3 Concept of output of an enterprise or a firm

It is the aggregate of products of labour suitable for industrial and personal consumption produced by an enterprise as a result of its industrial production activities during a defined period.

4.4.3.1 Different types of products as accounting concepts of the firms

(i) Finished products are those, which are manufactured by the firm for delivery outside. (ii) Semifinished goods are those, that have to be further processed (by a technological process) in other shops or have to be transported to the assembly shop of the same firm. Semifinished goods like the finished goods have to conform to established norms or technical specifications. In forging units, die blocks waiting for customers' approval to deliver to forge shop and all rough forgings held at other shops for further requisite operations are semifinished goods. At each stage, they have to conform to requisite technical specifications and tolerances. (iii) Goods in process are those, the productions of which have not yet been completed at a given moment and are still in process in the shop. As the die blocks preparation involves long gestation period, the die blocks will be in continuous process of the activities of the die shop at any given moment.

4.4.3.2 Gross output of an enterprise consists of all finished, semifinished goods and goods in process turned out during the reporting period by the enterprise, using its materials as well as materials supplied by customers. It represents the final results of industrial production activities of an enterprise and it is the output corresponding to all inputs consumed during the year.

Accounting data for Gross output of a firm as a balancing identity

	Opening balance	Manufac- tured during the year	Sold or awaiting sale dur- ing the year	Closing balance
1. Finished goods	F_o	F_m	F_s	F_c
2. Semifinished Goods	S_o	S_m	S_s	S_c
3. Goods in process	G_o	G_m	G_s	G_c
Total	O	m	s	c

$$\text{Gross output} = m = s + c - o$$

Non-availability of data on either stocks is considered as that the difference between the closing and opening balances of them is zero. If the total production alone is given without any details either on sales or on stocks, then the total production is taken as gross output.

4.4.4 Secondary products and joint products²⁷

It is occasionally customary to classify establishments according to their primary products, with the result that, when establishments and/or inputs are aggregated to form sectors, the output of the sector may consist of one or more primary products, several secondary products and joint products. While several classes of secondary products can be distinguished, only those classes of secondary products whose production is technologically independent of the primary product may be referred to here as secondary. Products, which are the output of a single process same as of the primary product, fall into the category of joint products.

As we are to deal with only one joint product, scrap, for which there is no primary product industry, in the computation and presentation of input structures of firms in this industry, all those problems and methods are not attempted for review but only one method is followed. Scrap is treated as a dummy industry product, against which sector, it is shown as a negative input in the column vector of steel forgings and as a negative output of row vector of scrap or dummy industry.

²⁷ (a) Stone, Richard, Input output and National Accounts, Organization for European Economic Cooperation, 1960.

(b) Problems of input output tables and Analysis, United Nations, Studies in Methods, Series F, No. 14, New York, 1966.

(c) Edmonston, "Treatment of Multiple Process Industries", The Quarterly Journal of Economics, Vol. LXVI, Nov. 1952.

In the gross output, scrap has not been included while computing the input structures. For comparison purposes, another set of input structures based on the gross output inclusive of scrap value, also are arrived at. There is not much divergence between the two sets of input structures and only the former set of input structures are presented.

4.4.5 Subcontracting jobs

Subcontracting may be defined as the practice of one firm contracting with another to manufacture some part of an entire product and/or to perform certain services of industrial nature, like finishing, machining, shot blasting, steel cutting etc. for which materials might be supplied and some cash payments might be made for these subcontracting jobs. These subcontracting jobs are broadly known as (1) work done by others and (2) work done for others in the accounting terms of the firms. One of the methods followed is to consider the 'net work done for others' to be in the nature of value added and adjust the value of total output accordingly in the construction of input output tables.²⁸ In such cases, inputs like fuel and auxiliary chemicals are divided by adjusted value of the gross output and primary materials are divided by the original gross output. This is, however, an approximate procedure since the netting process assumes both 'work done for others' and 'by others' to be similar in their input structures. In this detailed industry study,

²⁸ Mathur, P.N. and Others, Input output flow table (32 x 32), 1963 (at Purchasers' prices), Artha Vijnana, June 1969, Vol. XI, No. 2, pp. 183-184.

the following list of subcontracting jobs are adjusted for outputs and inputs based on the nature of job and the industrial practices on such jobs.

4.4.6 (1) Work done by others

(a) Machining done by others : Generally the machining jobs are subcontracted to small establishments employing less than 10 persons and using power. Small establishments have specialized on a few equipments, such as lathes, milling, drilling, planing and shaping machines with skilled labour on the machines. The establishment charges for these small units are relatively less as it contains a maximum of one manager and ten labourers. They do specialisation on particular jobs like lathe work, tooling, drilling, piston rod machining, shaping, planing and other machining jobs. In general, small establishments are widely spread all around industrial complexes as ancillary shops to big manufacturers. Forging firms also give some of their machining jobs to these small establishments, depending upon the urgency of the job and nonavailability of equipment and tools at that time. The practice of subcontracting is also because of certain economies of getting a job done by small establishments of specialized nature, compared to their doing the same job in their large shops.

In the accounts of forging units under investigation, the total value of 'Machining charges done by others' is shown as a single expenditure item and no details of the inputs of this expenditure are known. If the actual input

structures of these subcontracting jobs are available, they will be of immense use to refine the input structures of the sectors in the construction of input output tables. However, the details of the inputs that would cover the machining charges if the same jobs are to be done by the forging firm, are collected. These estimated inputs are added to the corresponding inputs of the firm to correspond with the value of gross output.

(b) Steel cutting done by others : A forging firm not having the facility of steel cutting equipment finds it convenient and economical to subcontract this job to small establishments, specializing in sawing, shearing and cutting steel and other alloys. Similar method for adjustment in the corresponding inputs of steel cutting, as it would have been done by the firm, is followed in this case also, to correspond with the gross output.

(c) Repairs and maintenance done by others and by themselves : As there are various types of repairs and maintenance activities, the details of the inputs corresponding to each of these types of repairs and maintenance are not known and they are likely to vary depending on their nature. For lack of these details, no adjustments are carried out on the corresponding inputs. It is shown as a single row sector element which is distinguished from the 'repairs and maintenance done by themselves' treated as a separate row sector element in the column input structures of 'steel forgings' sector.

4.4.5 (2) Works done for others

(a) Forgings done for others when steel is supplied by customer : Some customers are particular in supplying their own steel to the forging unit to manufacture their forging requirements. In such cases, the forging unit charges a price, exclusive of the steel price on those forgings, which is usually known as fabrication charges. As such the total value of production of the unit is less to the extent of the total cost of steel supplied by customers and used in process during the year. Similarly, the total cost of steel in the accounts of forging unit is also less to the extent of cost of steel supplied by customer and used in process during the year. But, the total of all other inputs' values is more to the extent of those fabrication charges.

One can think of two alternative adjustments to this problem : (i) Deduct the corresponding additional inputs' values of these jobs from the corresponding total inputs values inclusive of the former, so that the net resulting inputs details will correspond with the output exclusive of fabrication charges, as if those jobs are not done by the firm. Apart from the difficulty in identifying the corresponding inputs' values, such an adjustment is not so useful as some firms are doing more of these jobs depending mainly on customers' steel.

(ii) Add an estimated cost of steel supplied by customers to the total value of steel, and to the total value of production, so that all inputs including steel will correspond with

the gross output of the forging firm. The estimation of steel is the cost of steel if it had been purchased by the forging unit. Tonnage of customers' steel consumed is known from the records of the firm and approximate prices of the requisite steel specifications are suggested by the officials of the firm, for estimation of the value of customers' steel. The second method of adjustment is carried out for the reasons of its merits.

(b) Shot blasting done for others : Shot blasting is a process done on two types of special equipments to remove the scale and slug on the surface of forgings and castings. One type of equipment is known as wheelabrator and the other is a heavy shot blaster. Only two firms under investigation have got these special equipments, with different capacities. This is a work of industrial nature, performed on customers orders for goodwill and other reasons, not connected with the regular production activities. As the firm finds spare capacity on these equipments after shot blasting their own forgings, it earns by accepting these subcontracting jobs. These receipts of shot blasting done for others are shown as a single item in the current accounts of forging firm. These receipts are not included in the total value of production of the forging unit. But the inputs used in this process are included in the corresponding inputs. As such, the inputs and outputs of the firm are not corresponding to each other. To arrive at the proper input structure on comparable basis with other firms' input structures, it is necessary to make

adjustments on the input structure of the firm if it has not incurred those inputs corresponding to the shot blasting jobs done for others. The estimated values of inputs (being suggested by the officials of the firm) corresponding to shot blasting done for others are deducted from the corresponding total inputs values of the firms. The resulting inputs correspond to the gross output of the firm.

(c) Crankshaft machining done for others when crankshafts are supplied by customers

The crankshaft machining facility is a special feature of a single firm. Because of spare capacity available on those equipments, the forging unit accepts others' crankshafts for machining and get the receipts for the service. The adjustments for this problem are just similar to that of shot blasting done for others as the nature of the problem in both the cases is the same.

4.4.5 (3) Role of subcontracting jobs for sector specification and the stability of input structures

While there may be economies or diseconomies in subcontracting the types of jobs listed in relation to manufacturing or performing the services with their own all ancillary shop facilities within the forging units, both of these pose different problems in respect of sector specification and the stability of input structures. If one distinguishes each specialised process by horizontal integration of similar processes, like machining, shot blasting etc. as a sector, then there will be problems of product mix as the final

demands of the distinct products that are processed are fluctuating. If the fullfledged forging units equipped with all ancillary shop facilities are aggregated as a sector then there will be problems of process mix because of the changes in techniques in vertically integrated different processes.²⁹ In practice, some jobs are subcontracted, while others done within the factory for the same process like machining, shot blasting etc. Because of the different industrial practices, the problems of stability in input coefficients due to different levels of scale of operation of the subcontracting units are often not taken into account.

Such of these problems are insurmountable for classification of the units of analysis when the reality is quite far from the rigidities of the aggregation or disaggregation for sector specification in the input output analysis.

4.4.6 Producers' and Purchasers' Prices

The transactions in the input output tables are generally valued at either the price received by the producer or at the price paid by purchaser. The difference is composed of marketing costs, which include such items as transport costs, ~~which include such items as the~~ wholesale and retail trade mark ups, insurance and ware house costs and net indirect taxes. The sum of these components of the difference between producer price values and purchase price values of the transactions, is broadly termed as distributive margins.

²⁹ Holzman, Mathilda, "Problems of classification and Aggregation" in Studies in Structure of American Economy - Theoretical and Empirical Explorations, ed. by Leontief and Others, op.cit., pp. 342-344.

of producers' to purchasers' prices of the inputs specially used in this industry are not known from any study, as this industry is to be specified at a more disaggregative level than Venkatramiah's 21 x 21 sectors study. His study, however, provided the ratios of producers' to purchasers' prices of the inputs of 200 ASIC sectors, aggregated over all using industries.³² They are used to deflate the input structures so that both the inputs and outputs correspond to producers' prices. Similarly, by getting a single purchasers' price of steel forgings irrespective of its variations in respect of different users, the ratio of purchasers' to producers' prices of steel forgings is used to inflate the input structures, so that both the inputs and outputs correspond to purchasers' prices. The latter set of input structures of steel forgings at purchase prices is attempted as these can be incorporated in the Input Output Table for 1963 at purchasers' prices.³³

4.4.7 Adjustments to changes in prices

These adjustments in input structures, whether at producers' prices or at purchasers' prices, are needed, especially when the input output table of one particular year (1963) is required to be made use of, for any objective of the study. To compare the input structures of different firms over years

³² Unpublished ratios are used here as they are the ratios used for 241 x 241 G.I.P.E. sectors input output table for 1963. The ratios utilized are given in Table 11, Appendix A.

³³ See, in Chapter V, the aggregated 66 x 66 sectors input output table at purchasers' prices of 1963.

As the distributive margins are institutional rather than technological in nature, a separate sector specification for the distributive margins grouped together, is not so stable as other sectors in the context of input output analysis. While there are relative merits of both the sets of tables at producers' prices and purchasers' prices, input output tables at producers' prices are generally preferred for the stability of input structures of the sectors.³⁰ For want of data on distributive margins for each using industry to make adjustments on input structures at either of the prices, one may have to assume that the ratio of producers' to purchasers' prices will remain same for all using industries. However, a recent study³¹ brought out the percentage distributive margins at producers' prices in the organized manufacturing sectors in India 1963, at an aggregated level of 21 x 21 sectors.

In this industry study, we have the gross output at producers' price, whereas the inputs are at purchasers' price. Data on the details of these distributive margins on the inputs or on the outputs are not available as the firms do not account for them separately. Even the ratios

³⁰ (a) United Nations, Problems of Input output tables and analysis, Studies in Methods, Series F, No. 14, New York, 1966.

(b) Bawa, U.S., and Gupta, T.R., "Purchasers' Prices, Producers' Prices and Margins in the Organised Industries in India - 1959" in Economic Analysis in Input output Framework (ed.), P.N.Mathur and R. Bharadwaj, Poona, 1967.

³¹ Venkatramiah, P., "Distributive margins in the large scale manufacturing industries", Artha Vijnana, June, 1969, Vol. XI, No. 2, pp. 200-210.

of producers' to purchasers' prices of the inputs specially used in this industry are not known from any study, as this industry is to be specified at a more disaggregative level than Venkatramiah's 21 x 21 sectors study. His study, however, provided the ratios of producers' to purchasers' prices of the inputs of 200 ASIC sectors, aggregated over all using industries.³² They are used to deflate the input structures so that both the inputs and outputs correspond to producers' prices. Similarly, by getting a single purchasers' price of steel forgings irrespective of its variations in respect of different users, the ratio of purchasers' to producers' prices of steel forgings is used to inflate the input structures, so that both the inputs and outputs correspond to purchasers' prices. The latter set of input structures of steel forgings at purchase prices is attempted as these can be incorporated in the Input Output Table for 1963 at purchasers' prices.³³

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³² Unpublished ratios are used here as they are the ratios used for 241 x 241 G.I.P.E. sectors input output table for 1963. The ratios utilized are given in Table 11, Appendix A.

³³ See, in Chapter V, the aggregated 66 x 66 sectors input output table at purchasers' prices of 1963.

also, these adjustments to price variations of inputs and outputs are required. For this purpose, 1963 is taken as the base year as it also refers to the year for which the latest input output table is available. Otherwise, all these input structures represent at current producers' prices as instantaneous production functions of the firms and processes. These structures are for the years 1963 to 1967, while only a few firms have input structures for some of these 4 to 5 years, without any uniformity of the accounting periods. Many of the firms have the structures for the latest year 1966-67.

The detailed price data on inputs and outputs of steel forgings industry for different years 1963 to 1967 are scanty to make proper adjustments on column input structures and on row input coefficients of steel forgings. However, efforts are made to collect price indices of aggregate inputs and outputs from two sources and the necessary adjustments are carried out.³⁴

4.4.8 Competitive and complementary imports³⁵

The competitive imports, which could be produced indigenously but whose input structures are not known, are assumed

³⁴ See Chapter V. Two sources of data : (1) Index numbers of whole sale prices in India (Revised series) for the years 1963 to 1967, Office of the Economic Advisor, Ministry of Industry, Government of India, New Delhi. (2) Statistics for Iron and Steel Industry in India, Hindustan Steel Limited, Ranchi, India, 1966.

³⁵(a) Problems of input output tables and analysis, Studies in Methods, Series F, No. 14, United Nations, New York, 1966. (b) A System of National Accounts, Studies in methods, series F, No. 2, Rev. 3, United Nations, New York, 1968.

to have the same input structure as their indigenous production. As such, the inputs of competitive imports are clubbed with those of corresponding indigenous sectors' outputs. There is an error in not treating separately the competitive imported inputs and indigenously produced inputs, mostly because such a detailed data are not available in the census reports (Annual Survey of Industries). If these indigenous and competitive imported inputs are separable, the latter can be treated as negative final demand also.

In this study it is attempted to show the imported inputs distinguished from the indigenous inputs whenever the details are available for presentation without the need of aggregation. This may serve the purpose of noting the import content of the inputs structure of this industry (See Table 4, Appendix A). If the distinction in treating the competitive and complementary imports in the input output tables is not made, firstly, errors in classification arise and its repercussions on the results; secondly, the analysis has to work as if those complementary imported goods also have the same input structure as those of competitive goods. In this study, there are no complementary imports.

4.4.9 Capital coefficients

The increments of assets, that is investment, associated with maintaining and increasing capacity are required to be distinguished in computing fixed capital coefficients. By linking these with the current table, it would be possible to convert this investment demand, like any other component

of final demand, into additional output requirements.³⁶ Similarly, the inventories of working capital coefficients table provide for the additional stocks, needed to sustain the capacity of industry, as well as for the inputs actually absorbed in the production.

Since the industry, in practice, is likely to have a product mix of its own, there would arise a necessity of aggregating different capital goods, though they are produced in the same industry. The prices may serve as weights for aggregation of the capital goods to get the replacement value³⁷ at the current producers' prices. Otherwise, the purchase values in different periods may be adjusted to the replacement values at current prices. Even the estimation of capacity becomes difficult as it is a function of the varying productmix of its own.

(1) The concept and measurement of capacity

The concept of capacity is related to the maximum amount which an industry can produce with its existing endowment of fixed factors. The concept of capacity presupposes some normal form of working, such as two shifts of eight hours a day with the machinery running at a given (norm) speed. It is reasonable to suppose that in perfect competition the engineering design of the plant with a homogeneous product

³⁶ Stone, Richard, Input output and National Accounts, The Organization for European Economic Cooperation, 1960.

³⁷ Koti, R.K. and Somayajulu, V.V.N., "Replacement value of capital employed in the Third Division manufacturing industries of Maharashtra, 1959 - A disaggregative study". Artha Vijñana, June 1969, Vol. XI, No. 2, pp. 270-287.

would ensure production at which average cost would be minimum. In such a case, the sum of the capacities for all establishments in the industry would give a measure of industry's capacity. In practice, an establishment may produce more than one product so that the limiting fixed factors depend on the product mix, which in turn depends on the relative profitability of the different products.

Klein³⁸ has suggested an approach to the measurement of minimum average cost from the cost function, which necessarily passes through successive phases of decreasing and increasing marginal cost, given by a sigmoid curve. But the data for such an investigation are difficult to get.

In this study, the capacity is taken as the maximum production possible with the installed equipment under normal conditions during the period. For this purpose, in some cases, the project report capacity is taken, while in other cases, the total scheduled production, or the maximum achieved production, or the actual production of the period is made use of, as there are no data uniformly available from all firms over the years.

(ii) Maintenance of capacity : Depreciation and replacement

The gross capital ratios assume that a piece of equipment continues to be used at the same degree of utilization and efficiency until it is discarded, while the net capital

³⁸Klein, L.R., with the assistance of M.David, "The measurement of capacity", Cowles Foundation discussion paper No. 49, 1958. See also Klein, R., "Some theoretical issues in the measurement of capacity", Econometrica, Vol. 28, No.2, 1960, pp. 272-86.

ratios assume that depreciation allowance do provide an accurate measure of the life and age of machinery.³⁹

(iii) The extension of new capacity arises because of the fact that the technical changes may alter the structure of the plant. An entirely new plant may be built; a balanced extension may be added to an existing plant; an unbalanced extension may be made consisting, for example, of removing a bottleneck; or capacity that has been idle for sometime may be brought back into service.

In this industry study, as all firms are of recent origin, the replacements of equipment capital and extensions of new capacity do not arise.

Gross values of fixed capital goods are taken for the purpose of computing fixed capital coefficients per unit capacity of the firms. Similarly, the working capital coefficients per unit output of the firms are also computed.

4.4.10 Some assumptions and limitations regarding original financial data are necessarily to be stated in computing these inputs and capital structures :

(1) It is assumed that the firms under investigation, computed their accounts in a comparable fashion, though in practice this is not so.

³⁹ An analysis of the age composition and expected life with reconditioning and without reconditioning of the capital goods, providing the investment pattern and the replacement demand of all disaggregative capital goods, is attempted in a study by R.K.Koti and V.V.N.Somayajulu, "Capital goods in Machinery and Metal Products Industries", presented to the "Industrial Economics Seminar" held in Bombay.

- (2) The financial accounts open to investigation are assumed to be reasonably accurate records of the firm's actual transactions.
- (3) Many repairs which may add years to the life of the machines, are not considered part of capital accounts, rather are entered in the current accounts.
- (4) The different firms are assumed approximately of the same degree of integration for comparison of capital structures between firms and over years.
- (5) No price adjustments to different capital goods over the years 1963 to 1966-67 are carried out, as the price data on capital goods are scanty and this period of 4 years is not known for significant price changes of capital goods.
- (6) Measurement of capacity uniformly to all firms could not be attempted due to paucity of requisite data.

4.5 Analysis of the input and capital structures of firms and processes

The structural parameters of instantaneous production functions of the firms and processes in steel forgings industry in India, usually termed as input and capital structures, are evaluated at a very disaggregative level, after making all requisite adjustments for refining them. The structural coefficients of current inputs are presented at producers prices in Table 1 and tables in Appendix A. The structural coefficients of fixed and working capital are presented in tables 2, 3 and Appendix A tables 5 and 6, without adjusting

for distributive margins, as such data are not available from any source.

Here, it is intended to bring out the importance of the distinct products of the firms, as distinguished in Chapters VI and VII, with respect to quantitative and qualitative features of the product dimensions, and their impact on the distinct structural parameters of the firms. The following 3 tables present a relatively aggregative input and capital structures of (i) Die forging firms, (ii) open or free forging firms, (iii) wheel sets unit and (iv) sleepers unit. They relate to the latest year 1966-67 for which more detailed data are available from the individual firms. Only one firm has the latest year as 1965-66, while other firms have the latest year as 1966-67. It is for these latest years of the firms, the details on product dimensions of the forgings of the firms are also available. Only those firms are chosen for presentation in table 1 for which data on product dimensions are analysed in Chapters VI and VII. Input structures of 4 die forging firms, 3 open forging firms, one wheel sets unit and one sleepers unit are presented in table I. Fixed capital and working capital structures of the units, for which data are available, out of the listed 9 production units, are presented in the respective tables 2 and 3.

4.5.1 Classification for Inputs

While the detailed inputs and capital structures are

presented in the disaggregative tables (Appendix A) most of the input details are aggregated for presentation, according to the Gokhale Institute of Politics and Economics (G.I.P.E.) 241 sector classification is also adopted for classifying the inputs of the firms and product groups in Chapter VII. Based on the 241 sectors classification scheme, the most disaggregative input output table for 1963 is being prepared by Mathur, P.N. and others. However, no classification scheme is adopted, in the following analysis, for fixed assets and working capital assets as the available data are very aggregative.

4.5.2 Analysis of input structures

Steel is the major input in this industry. Steel input coefficient varies from 0.315849 to 0.347310 for die forgings' firms and from 0.235187 to 0.469924 for open forgings' firms. The ingots and blooms' input coefficients for wheel sets and sleepers units are as high as 0.454224 and 0.477926 respectively. Based on the variations in steel input coefficients, the die forging firms are necessarily to be distinguished from open forging firms. These are required to be distinguished also due to distinct technical features of their processes, products and materials as enlisted in Chapter III. Because hundreds of grades of steel specifications are being used in the industry, some firms specialize in some products requiring particular sets of steel grades. Due to capacity limitations of equipments and other ancillary facilities, the quantitative and qualitative features of product dimensions, viz. piece

weight and tensile strength, and/or the nature of the products, are restricted to certain ranges of these product dimensions. These have been examined in Chapters VI and VII. The input structures of the wheel sets unit and of sleepers unit are distinguished from each other and all other firms as seen in Table I. The broad details of the steel inputs, viz., carbon, alloy, die blocks, die tool, ingots, blooms, and their input structures are given in the detailed tables in Appendix A.

Regarding fuels, die forging firms are using mainly oils like furnace oil, light diesel oil and high speed diesel oil, while the open forging firms, wheel sets unit and sleepers unit are using gases like coke oven gas, blast furnace gas, etc. This is partly because of locational factors also. The fuels' coefficients vary from 0.016848 to 0.052117 for die forging firms, from 0.030219 to 0.167572 for open forgings firms and are as low as 0.014127 and 0.005429 for wheel sets and sleepers units respectively. These differences are also to be explained by the product dimensions. Similar variations between firms are clear regarding coefficients of electricity, consumable stores or productive supplies, repairs and maintenance as they may be accounted for the variations in the product dimensions' ranges of the firms. These are examined in Chapter VII.

4.5.3 Analysis of the capital structures

Plant and machinery coefficient per unit rupee worth

capacity ranges from 0.537415 to 1.086299 for 3 die forgings' firms and from 0.647051 to 0.887256 for 2 open forgings' firms. Similar distinctive features of die forgings, open forgings, wheel sets and sleepers units are clear from tables 2 and 3 in respect of other fixed assets and working capital structures respectively. These differences are partly due to various levels of vertical integration of the processes in the different shops of the firms. These distinct technical features of the firms may get reflected in the product dimensions of their products. These have not been examined in the present study as the data are very aggregative, scanty and not uniform over firms and assets.

4.5.4 Concluding remarks

The similarity of some input and capital structures is partly because of the levels of aggregation and the nature of evaluation methods due to conceptual and practical problems enlisted in this Chapter IV. The distinctive discrepancies in the nomenclature and nature of inputs used by the firms are mainly due to nature of the products of the individual units. The distinct quantitative and qualitative features of the product dimensions and their ranges in the firms may make a difference in the nature of their products. Such detailed current input structures and capital input structures - both of working capital and fixed capital, are basic to the disaggregative dynamic input output models in planning for investment and production scheduling in the individual plants, industries and the economy.

Table 1. Input structures of firms in steel forgings industry during 1965-67 at producers' prices

Sr. No.	GIPE Sector No.	ASIC Sector No.	Description of Inputs	Die Forgings Firms				Open or Free Forgings Firms			Wheel sets unit E(1966-67)	Sleepers Unit F (1966-67)	
				A(1966-67)	B(1965-66)	C(1966-67)	D(1966-67)	J(1966-67)	K and L (1966-67)	N (1966-67)			
				Y									
1	62	280-1	Printing and Stationery	-	0.000163	0.000980	0.002788	-	-	-	-	-	
2	90	321	Fuel oils	0.017290	0.016848	0.023488	0.052117	0.001175	-	-	-	-	
3	91	329	Coke oven gas etc. and Blast furnace gas	0.000614	-	-	-	0.029044	0.167572	0.139167	0.014127	0.005429	
4	69-77	311	Chemicals	0.000896	-	0.000074	-	-	-	-	-	-	
5	110	341-2	Steel	0.315849	0.347310	0.344515	0.323774	0.469924	0.235187	0.336777	-	-	
6	169, 170, 171	370-2, -1	Telephone charges	-	0.000140	0.001034	0.003248	-	-	-	-	-	
7	200	511	Electricity charges	0.006527	0.014254	0.015624	0.009309	0.019906	0.037509	0.002716	0.014291	0.001852	
8	200	512	Oxygen and Acetylene	-	0.001643	-	-	-	0.135769	0.174175	0.000919	0.000178	
9	233	-	Consumable stores or productive supplies	0.001506	0.007645	0.008796	0.046807	-	0.015646	0.022114	0.022423	0.001137	
10	235	-	Repairs and Maintenance	0.001231	0.000716	0.031897	0.006926	0.091361	0.037293	0.044084	0.030358	0.013748	
11	236	-	Safety Equipment	-	0.000352	-	0.003153	-	-	-	-	-	
12	238-239	-	Transport	-	0.004578	0.008305	0.016837	-	-	0.016282	0.007137	0.000168	
13	241	-	Water	-	-	0.000566	0.000225	-	-	0.004711	0.003724	0.000150	
14	240	-	Distributive margins	0.073752	0.084265	0.122543	0.143194	0.031078	0.010580	-	0.069735	0.090361	
15	-	-	Scrap	-0.001676	-0.016159	-	-0.016273	-0.023783	-0.004082	-0.013788	-0.113405	-0.003909	
16	109	341-1	Ingots and Blooms	-	-	-	-	-	-	-	0.454224	0.477926	
17	93	331-2	Refractories	-	-	-	-	-	-	-	0.002084	0.000090	
18			Gross value added	0.584011	0.538245	0.442178	0.407895	0.381295	0.364526	0.273762	0.494383	0.412870	
			Total	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	

Note. The (-) cells represent either zero quantity or nonavailability or both. However, they are treated as zero quantities for the purpose of analysis.

Table 2. Fixed capital coefficients of firms in steel forgings industry during 1965-67 (all on 3 shifts basis capacity)

Sr. No.	Description of fixed capital	Die forgings firms			Open or Free forgings firms		Wheel sets units	Sleepers unit
		A(1966-67)	C(1965-67)	D (1966-67)	J (1966-67)	N (1966-67)	E(1966-67)	F (1966-67)
1	Plant and Machinery	0.537415	0.631197	1.086299	0.887256	0.647051	N.A.	N.A.
2	Electrical installation	0.007013	0.008304	0.048630	0.047721	0.001996		
3	Transport equipment	0.037160(a)	0.037160(a)	0.037160	0.032705	0.032705(b)		
4	Engineering Instruments	0.001272(a)	0.001272(a)	0.001272	0.037709	0.037709(b)		
5	Buildings	0.072785	0.025993	0.113465	0.147502	0.147502(b)		
6	Land	0.022653	0.028460	0.006979	0.000387	0.000387(b)		
7	Factory equipment and office equipment	0.002877	0.002815	0.018828	0.040040	N.A.		
8	Furniture and Fittings	0.000393	0.007377	0.006483	0.000834	0.000834		
9	Railway Road sliding	N.A.	N.A.	0.008251	N.A.	N.A.		
10	Motor cars and commercial vehicles	N.A.	0.023820	0.007972	N.A.	N.A.		
11	Scooters and cycles	N.A.	0.000792	N.A.	N.A.	N.A.		
12	Other fixed assets	N.A.	N.A.	N.A.	N.A.	N.A.		
Total		0.681568	0.767190	1.335339	1.194154	0.868188	N.A.	N.A.

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N.A. Not available or there may not be any quantity in the respective cells. However, some adjustments are made for some cells as follows:

Note

(a) Transport equipment and engineering instruments fixed capital coefficients in Firms A and B are not available and the respective coefficients of Firm D are introduced.

(b) As N is a captive unit, the details on transport equipment, engineering instruments, buildings and land are not available and the firm J's coefficients on the corresponding items are introduced for firm N also.

Table 3. Working capital coefficients of firms in steel forgings industry during 1966-67

Sr. No.	Description of working capital	Die forgings firms	Open forgings firms		Wheel sets unit	Sleepers unit
		D (1966-67)	J(1966-67)	N(1966-67)	E(1966-67)	F (1966-67)
1	Fuels like furnace oil, light diesel, high speed diesel oil, lubricants, etc.	0.006700	0.003797	N.A.	N.A.	N.A.
2	Steels - carbon, alloy, die block, die tool	0.503576	0.427959	N.A.	0.020804	0.029989
3	Semi-finished goods	0.344703	0.156307	N.A.	0.178111	N.A.
4	Finished Forgings	0.061659	0.047010	0.039121	0.066583	0.135816
Total		0.916638	0.635073	N.A.	0.265498	0.165805
Power equipment		0.000145	0.000133	0.000110	0.000310	0.000025

CHAPTER V

**ROLE OF STEEL FORGINGS AS A SEPARATE SECTOR
IN THE INTER INDUSTRY STRUCTURE - AN APPLICA-
TION OF THE INPUT OUTPUT TABLE OF INDIA FOR
1963 WITH THE DERIVED RESULTS AND INTER-
PRETATION**



5.0 Introduction

In the light of the input structures of steel forgings' production units, evaluated at purchasers' prices of 1963 in the earlier Chapter V, here we examine the direct and indirect repercussions of incorporating this industry as a separate sector in the available 1963 input output table at purchasers' prices. This chapter deals with

- (1) The role of steel forgings industry as a sector in the input output analysis and in the available input output tables for Indian economy.
- (2) Price adjustments and aggregation attempted to arrive at the sector of steel forgings to be incorporated in 1963 input output table.
- (3) Application of the input output table for 1963 - results and interpretation.
- (4) Summary and limitations of this study.

5.1 The role of steel forgings industry as a separate sector in the input output analysis and in the available input output tables for Indian Economy

5.1.1 Need for disaggregation of classification schemes for input output analysis and the latest available tables

Steel forgings are the intermediate products like castings, structural etc. each of which is having distinct technologies and uses, in the context of technology matrix depicting the structure of production of the different sectors in the economy.¹ The intermediate demand for steel

¹ The role of Technology matrix as a tool to study the structure of the economy is seen, firstly, in Leontief W.W., Structure of American Economy, 1919-1939. An Empirical Application of Equilibrium Analysis, New York, Oxford University Press, 1951. Parts III and IV.

forgings is more and more with the advancement and growth of new and old engineering industries, especially in a developing economy. It attains importance when the industrial complex is diversified and expands so disproportionately that each industry is to be distinguished as a separate sector in the input output tables, to take into account the effects of the intermediate demand (given by structural coefficients matrix) and final demand (given exogeneously) on the total output requirements of individual industries.² If one is interested to know the demand for forging quality steels, (a particular set of grades and specifications of the steel, out of hundreds of such specifications), it cannot be obtained by merely knowing the total output requirements of steel or of iron and steel as an aggregate. The case for distinguishing the individual industries as separate sectors in the input output analysis arises, firstly, because of the different technologies of the individual industries, each of which representing a stable input output combination, secondly, of the distinct users' requirements differently of the outputs of individual industries and thirdly of distinct final demands of the individual industries. An aggregated sector of the

See also Barna, Tibor, "The interdependence of the British Economy", in The Journal of Royal Statistical Society, Series A (General), Vol.CXV, Part I, 1952.

²See Ghosh A., Experiments with Input Output Models. An Application to the Economy of the United Kingdom, 1948-55, University of Cambridge, Department of Applied Economics, Monograph 9, Cambridge University Press, 1964, Chapters 3 and 4, pp. 10-43.

individual industries, which are to be distinguished for either of those reasons, conceal the nature of those influences on the direct and indirect requirements. They become less stable with disproportionate growth in the individual industries. However, aggregation is often suggested for ease in handling the data. As it involves some loss of information and accuracy, the disaggregation of the individual industries as separate sectors in the input out analysis is also suggested.³ At least the classification schemes, which are the basis for the specification of sectors in the construction of input output tables, should be able to distinguish the individual industries, so that any further aggregation is always possible.

In the Annual Survey of Industries classification (ASIC) Scheme adopted in India, "34-3 Iron and Steel Castings and Forgings" is treated as a single industry-group. Based on this digital classification scheme, about 200 manufacturing sectors are distinguished by the Gokhale Institute of Politics and Economics (G.I.P.E.). The remaining 41 G.I.P.E. sectors pertain to Agriculture, mining, services and other miscellaneous sectors. The most disaggregative input output table at purchaser's prices of 1963 is under preparation at G.I.P.E. It distinguishes these 241 sectors. But, even this table

³ While there are many references already listed in the earlier Chapter IV on aggregation and disaggregation for sector specification, particular mention may also be made of Isamu Yamada, Theory and application of inter industry analysis, Japan, 1961, Chapters 2 and 3, pp. 16-60.

does not distinguish the steel forgings separately from 'Iron and Steel Castings and Forgings'. An aggregated table of this is that of 32 x 32 sectors table at Purchasers' prices⁴ of 1963, which has '34-Iron and Steel' as a single sector, inclusive of 341-3. Similar is the case with the Planning Commission's aggregated table of 29 x 29 sectors at producers' prices⁵ of 1959 and with the Indian Statistical Institute's (I.S.I.) Table for 1960-61.

5.1.2 Importance of steel forgings industry in the interindustry structure of the economy

Steel forgings as intermediate products place mainly intermediate demand within the interindustry structure as they are the main components of the using industries' products. The growth of the demand for steel forgings rests with the growth of the using industries' products and the latter's unit output requirements of steel forgings. The final demand of the steel forgings sector is the net of exports minus imports, when the changes in stocks are taken as zero. There

⁴ Mathur P.N. and others, "Input output table (32 x 32), 1963 at Purchasers' Prices", Artha Vijnana, June 1969, Vol. XI, No. 2, pp. 181-199.

⁵ "An Input Output Table of the Indian Economy for 1959", Economic Division, Planning Commission, Government of India in Economic Analysis in Input Output Framework, ed. Mathur P.N., and Bharadwaj, R., 1967.

⁶ The first of these tables was for the year 1951-52, published in National Income Conference Vol. I, Indian Conference on Research in National Income. Two more tables, one for 1953-54 and the other for 1955-56 were prepared by Dr. A.K. Chakravarti (unpublished). These three tables were at market prices of 36 x 36 sectors. The I.S.I. table of 30 x 30 sectors at producers' prices of 1960-61 was prepared by Manne, A.S. and Rudra, A., published in Sankhya, series B, Vol. 27, pp. 57-144. This table is disaggregated to 77 x 77 sectors at 1960-61 producers' prices by M.R. Saluja, published in Sankhya, series B, Vol. 30, pp. 97-122.

is no private or public consumption and capital formation created by this sector. Thus, it is the intermediate demand of steel forgings that stimulates the growth of the economy depending upon the growth of using industry's products and their unit output requirements of steel forgings.

5.1.2.1 Growth of using industries and their unit output requirements of forgings

The growth of the using industries is represented by the indices of their values of production (gross outputs) over the years 1960 to 1964 with 1960 as base. The using industries' gross outputs and the indigenous production of steel forgings in the large scale units as reported in the Annual Survey of Industries (ASI) reports for years 1960 to 1964, are taken into account, to compute the respective indices. Similarly, the A.S.I. reports provide the statistics relating to the consumption of steel forgings by different using industries. The requirements of steel forgings per rupee worth of gross output of using industries during the period 1960 to 1964 are computed and presented in Table I along with the indices of gross outputs of using industries and of indigenous production of steel forgings over the years 1960 to 1964.

The indices of using industries' gross outputs and of steel forgings' production are in current prices of the respective years. Similarly the unit output requirements of steel forgings per rupee worth gross output of using industries' products are also in current prices of the respective

years. No adjustments for price changes during the period 1960-1964 are made as the purpose is only to indicate broadly the differential growth of the using industries' requirements for forgings rather than to give quantitative estimates of the demand for forgings. The proportions of unit output requirements are to be adjusted for the distributive margins (purchasers' prices - producers' prices) as the inputs of the steel forgings are in purchasers' prices and the gross outputs of using industries are in producers' prices. If these adjustments are made on both the inputs and outputs, these proportions can be termed as row input vector of steel forgings sector either at producers prices or at purchasers' prices in the context of respective input output tables.

All the using industries can be broadly grouped under two major groups of A.S.I. classification, namely (1) 380 - transport equipment, (2) 360 - Non-electrical machinery. Most of these engineering industries, with the exception of railways, have started their production during the period, 1960-1964. A few of them are growing rapidly during this period. For example, they are (1) construction machinery, (2) conveying equipments - buckets, elevators, skip hoists, cranes etc. (3) tractors, harvestors, etc. (4) air and gas compressors and vacuum pumps, (5) paper machinery. These are new industries in the general industrial complex of the economy and they started consuming forgings as late as 1962 to 1964. Their unit output requirements are relatively low

during the period 1960-1964, as observed in Table I.

Railways require 0.036 to 0.082 rupee worth of wheel sets and sleepers per rupee worth gross output of the railways' locomotives and rolling stock. This is an old industry starting from the middle of 19th century. The growth during 1960-1964 is not spectacular (an increase of 30% to 90% only) as seen in Table 1.

Motor vehicles require 0.03 to 0.05 rupee worth of forgings per rupee worth gross output of motor vehicles. The growth of motor vehicles, as represented by the computed indices, is not spectacular (an increase of 77% only) during 1960-1964. However, the Indian made vehicles out of total vehicles' population in India is about 8% in 1954, 30% in 1957, 48% in 1960, 57% in 1963 and 74% in 1966. The growth in indigenous production of motor vehicles since the inception of five year plans (1950-51 onwards) as seen in Table 2 is likely to put a high demand on forgings.

Diesel engines or internal combustion engines require 0.02 to 0.04 rupee worth of steel forgings per rupee unit gross output of diesel engines during 1960-1964. The levels of indices of value of gross output of this industry have been doubled from 1960 to 1964. This growth is more in Maharashtra state, especially from 1964 onwards, as observed on the field investigation of the sales orders of forge units.⁶

⁶ A typical firm in Maharashtra sells 73.22% of its total value of production soldout and 75% of its total tonnage sold out, to oil engines or internal combustion engines, 21.14% of value and 19.32% of tonnage sold to motor vehicles,

Table 1. Growth of Using Industries and their unit output requirements of steel forgings over the years 1960 to 1964

S.No.	GIPE 241 Sector clas- sifica- tion	ASIC Sector	Description of the Sector (using industry group)	Requirements of steel forgings per unit rupee worth out of using industries' products during the years					Indices of gross value of production of using industries during the years with base 1960 = 100				
				1960	1961	1962	1963	1964	1960	1961	1962	1963	1964
1	129	360-3	Internal combustion engines	0.006788	0.043630	0.036939	0.039126	0.029895	100.00	112.51	129.18	144.17	200.05
2	130	360-4.1	Textile machinery	-	0.000554	0.000028	-	0.000156	100.00	127.64	157.55	223.96	267.80
3	131	360-4.2	Jute machinery	-	-	0.008739	0.000074	0.000372	100.00	152.35	240.10	293.87	199.27
4	132	360-4.4	Sugar machinery	0.007742	0.009404	0.007460	0.011738	0.008998	100.00	181.80	209.18	158.20	273.85
5	133	360-4.5	Tea machinery	0.009328	0.002518	-	0.000845	-	100.00	91.57	155.21	186.11	64.73
6	138	360-4.11	Paper machinery	-	-	-	-	0.005289	-	100.00	176.84	652.06	585.16
7	139	360-4.12	Construction machinery	-	-	0.009936	0.000706	-	100.00	138.94	212.13	307.75	778.53
8	140	360-4.13	Oil mill machinery	-	-	-	0.008727	0.000994	100.00	62.41	145.05	267.72	372.08
9	143	360-5.1 and-5.2	Conveying equipment - buckets, elevators, skip hoists, cranes	-	-	0.018317	0.000371	0.000211	100.00	149.63	364.55	637.90	1246.96
10	145	360-5.11	Power driven pumps, reciprocating centrifugal etc.	0.000023	0.000015	-	-	0.000373	100.00	118.80	101.60	134.38	168.65
11	146	360-5.12	Air and gas compressors and vacuum pumps	0.005200	0.007046	0.007732	0.016276	0.016414	100.00	147.61	193.69	318.77	500.45
12	149	360-6.1 and-6.2	Ball roller, tapered bearings and speed reduction units	-	-	0.000105	0.003214	0.022458	100.00	138.50	214.93	269.64	325.99
13	150	360-7	Machine tools	-	0.003974	0.005749	0.013907	0.001195	100.00	145.74	201.96	268.17	350.42
14	151	360-8.1	Tractors, harvestors, etc.	-	-	-	0.010535	0.008154	100.00	92.98	3547.45	388.90	7403.44
15	152	360-8.2	Agricultural implements	-	0.005284	-	0.003234	0.002710	100.00	125.85	132.33	146.17	205.80
16	153	360-9 and-10	Earth moving machinery (Bull dosers, Forklift trucks, etc.)	-	0.013977	0.002392	0.004209	0.028136	100.00	87.95	93.96	142.44	93.33
17	159	360-13	Others of nonelectrical machinery	0.013418	0.011171	0.015031	0.006588	0.011416	-	100.00	87.86	113.64	137.14
18	172	381-1	Shipbuilding and repairs of ships	0.003750	0.005673	0.006261	0.001501	0.001609	100.00	79.20	90.20	94.93	96.92
19		382-1	Rly Locomotives	0.065534	0.025029	0.058267	0.062459	0.055317	100.00	184.71	104.83	114.57	130.32
20		382-2	Rly rolling stock	0.004192	0.010656	0.015019	0.019833	0.018840	100.00	119.66	137.27	172.42	190.63
21	176	383	Motor vehicles manufacturing	0.016634	0.049409	0.033601	0.047460	0.054231	100.00	117.08	120.65	133.80	177.41
Indigenous production of steel forgings in large-scale units-Indices of value of prodn.									100.00	342.77	792.06	3500.20	4790.84

Source. Annual Survey of Industries reports for 1960 to 1964. Central Statistical Organisation, New Delhi.

**Table 2. Motor vehicles in production in India during
1951-1966. (All in numbers)**

Year	In production			Total
	Cars and Jeeps	Commercial vehicles	Two or - three - wheelers	
1951	3478	2181	-	5659
1952	2093	2681	-	4774
1953	3677	2754	-	6421
1954	7455	5300	-	12755
1955	12865	9262	955	23082
1956	17327	14301	6286	37914
1957	16232	16033	9207	41472
1958	11664	15290	7527	34481
1959	16548	20353	8126	45027
1960	24598	27518	17374	69490
1961	28714	25740	25354	79808
1962	30923	26894	25285	83102
1963	23815	28482	26581	78878
1964	33618	33517	37840	104975
1965	35273	37408	50988	123669
1966	38356	34174	52993	125523

These have been collected from "Automobile Ancillary Industry, 1967", published by All India Automobile and Ancillary Industries Association, pp. 5-7.

Footnote 6 continued from page 186

3.62% of value and 3.64% of tonnage sold to Scooters, Motor cycles etc., 1.40% of value and 1.36% of tonnage sold to Railways, 0.62% of value and 0.68% of tonnage sold to Tractors, other agricultural machinery, implements and pumps during 1966-67. Another firm in West Bengal sells 88.38% of tonnage sold to Railways, 6.12% to motor vehicles, and 4.25% to Tea machinery. Another firm in Bihar sells 24% of value of production sold to Cement machinery, 22.90% to Electrical machinery, 22.50% to Iron and steel and castings and forgings etc., 10.25% to heavy engineering handling equipment like cranes, etc., 10% to Machine Tools, 5.35% to Railways and 5% to all other non-electrical machinery products. This analysis of the survey results throws light on the regional variations in the demand pattern as the concentration and nature of using industries are different in different regions. In general, diesel engines are more concentrated in Maharashtra (Western region), Railways equipment in West Bengal (Eastern region), while the motor vehicles production is spread on both the regions, also on southern region (Madras State) and northern region (Delhi).

Next to the three leading industries, there are a good number of non-electrical machinery industries, growing rapidly during 1960-1964 as the basic industries for the growth of engineering industrial complex of the economy. Their rupee worth unit output requirements of forgings range between 0.004 and 0.032 during 1960-1964.

The growth of the indigenous production of steel forgings in large scale units as observed from the indices during 1960-1964 in Table I, is no less than that of using industries' gross outputs.

5.1.3 Row Vector of Steel forgings sector compared to the row vector of iron and steel castings and forgings sector at purchasers' prices of 1963 and 1964.

This comparison of two row vectors is to distinguish the users and their unit output requirements adjusted to purchasers' prices of 1963 and 1964. The four vectors (row input coefficients) are presented in Table 3.

The years 1963 and 1964 are the latest years for which data are available from A.S.I. reports. The 241 sectors input output table for 1963 at purchasers' prices is being prepared by Mathur P.N. and others. The same 241 sectors classification is chosen for presentation of the row vectors at purchasers' prices. The row vectors are presented also for 1964 as there are a few industries with no available statistics or with no production during either 1963 or 1964. These row vectors exclude the railways as users of forgings. The railways' demand for wheel sets and sleepers are shown under the row vectors of 'Iron and Steel' sector in the

Table 3. Row vectors of 341-3 (ASIC) Iron and Steel forgings sector distinguished from those of steel forgings sector for 1963 and 1964 at purchasers prices

Using industry or sector		Description of using industry or sector	Row input coefficients of Iron and Steel castings and forgings sector during		Row input coefficients of steel forgings sector only during	
GIPE 241 sector classification	ASIC sector		1963	1964	1964	1963
1	2	3	4	5	6	7
97	332-4 and-6	Misc. glassware and wool	0.000060	0.000789	-	-
118	350-4	Enamelling, Japaning, laquering, galvanizing, plating and polishing metal products	0.000242	0.000199	-	-
120	350-6	Welding metal products, manufacturing except machines and transport equipment	0.095243	-	-	-
127	350-13 and-14	Weights and other metal products of "	0.000174	0.000526	-	-
129	360-3	Internal combustion engines	0.027739	0.087024	0.020628	0.026997
130	360-4.1	Textile Machinery	0.007927	0.011274	0.000125	-
131	360-4.2	Jute machinery	0.084129	0.060172	0.000279	0.000056
132	360-4.4	Sugar machinery	0.032802	0.023253	0.006299	0.008217
133	360-4.5	Tea machinery	0.003670	0.030916	-	0.000592
134	360-4.6	Mining machinery	0.004168	0.005428	-	-
135	360-4.7 and-8	Metallurgical and cement machinery	0.039388	0.054280	-	-
136	360-4.9	Chemical machinery	0.005669	0.004758	-	-
137	360-4.10	Pharmaceutical machinery	0.004889	-	-	-
138	360-4.11	Paper machinery	0.042128	0.058419	0.003702	-
139	360-4.12	Construction machinery	0.077594	0.030295	-	0.000558
140	360-4.13	Oil Mill machinery	0.018306	0.029668	0.000746	0.006545
141	360-4.14	Rice, dal flour mill machinery	0.019347	0.013091	-	-
143	360-5.2 and-5.1	Conveying equipment - buckets, elevators, skip hoists, cranes etc.	0.020976	0.019252	0.000148	0.000260
144	360-5.4 and-5.6	Mixers and reactors - kneading mills, turbo mixers, centrifugal machinery	0.002401	0.011506	-	-
145	360-5.11	Power driven pumps, reciprocating centrifugal etc.	0.084348	0.062727	0.000261	-

Continued/..

Table 3 - Concluded

1	2	3	4	5	6	7
146	360-5.12	Air and gas compressors and vacuum pumps	0.041312	0.036411	0.011490	0.011393
149	360-6.1 and 2	Ball roller, tapered bearings and speed reduction units	0.005803	0.090011	0.014598	0.002089
150	360-7	Machine tools	0.073279	0.045327	0.000932	0.010847
151	360-8.1	Tractors, Harvestors, etc.	0.076097	0.013073	0.006116	0.007901
152	360-8.2	Agr. implements	0.003587	0.004136	0.002033	0.002426
153	360-9 and 10	Earth moving machinery (bull dosers and Fork lift trucks)	0.004367	0.023916	0.023916	0.003578
154	360-11.1	Typewriters and duplicators	0.016150	0.016774	-	-
155	360-11.2 and 11.6	Calculating machines and other commercial office equipment	0.045664	0.030120	-	-
157	360-11.5	Sewing and knitting machines	0.008282	0.000744	-	-
159	360-13	Others of non-electrical machinery	0.006434	0.007991	0.007991	0.003953
161	370-1.2 and 1.3	Electric motors and fans	0.021615	0.040174	-	-
162	381.1	Shipbuilding and repairs of ships and other vessels drawn by power	0.002349	0.001223	0.001223	0.001141
176	383	Motor vehicles - manufacture of	0.028693	0.037962	0.030369	0.028476
178	391-1	Surgical instruments - manufacture of	0.033868	0.026961	-	-
181	391.3	Scientific instruments - manufacture of	0.002765	0.003470	-	-
233	-	Other consumable stores	0.000041	-	-	-
234	-	Components and accessories	0.000769	-	-	-
235	-	Repairs and Maintenance	0.000324	-	-	-
236	-	Other industries	0.001790	-	-	-

preparation of input output tables for India as they are treated as part of Iron and Steel in the official statistics (A.S.I. reports).

There are 39 G.I.P.E. sectors as users of 'Iron and Steel castings and forgings'. Out of these 39 sectors, there are only 19 G.I.P.E. sectors as users of steel forgings. Even for these 19 sectors, the row input coefficients of steel forgings sector are far lower than those of the combined "341-3 Iron and Steel castings and forgings" sector. The major demand of "Iron and Steel castings and forgings" together as seen from its row input coefficients, is from (1) Metal products, (2) Jute machinery, (3) Metallurgical and cement machinery, (4) paper machinery, (5) construction machinery, (6) power driven pumps, reciprocating centrifugal etc., (7) Air and gas compressors and vacuum pumps, (8) Machine tools, (9) tractors, harvestors, etc. and (10) Calculating machines. Their row input coefficients range between 0.04 and 0.10 (approximately). Only 7 out of these 10 industries require steel forgings with their row input coefficients ranging between 0.000056 and 0.011490. Thus, the row vectors of 'steel forgings' and of 'Iron and Steel castings and forgings' are dissimilar. This stresses the need for distinguishing the 'steel forgings' as a separate sector, when the users requirements and their growth are dissimilar from those of a combined sector 'Iron and Steel castings and forgings'.

5.2 Aggregation for sector specification and price adjustments attempted to incorporate steel forgings sector in 1963 input output table at purchasers' prices

While every aggregation implies certain loss of information and accuracy for the purpose, it is an inevitable price, as otherwise it would be impossible to list each process of unique product. A balance must be struck between the homogeneity requirement and the number of sectors in the preparation of input output tables, bearing in mind the difficulties of handling the data.

A jobbing type industry like forgings industry is circumscribed by the problems of continuous change in product dimensions and of product multidimensionality. Similar may be the case with other jobbing type industries like castings, structurals etc. It is merely an approximation to consider them as discrete processes or the combinations of them as discrete processes to incorporate as sectors in the input output tables.

The 241 x 241 sectors input output table of India for 1963 at purchasers' prices is not readily available for analytical use, as (i) it does not include small scale units' input vectors of different sectors, (ii) the column vectors of agriculture and mining sectors are still under preparation. This table also has a combined sector "111 - Iron and Steel Castings and forgings" under 241 G.I.P.E. Sectors classification. This is same as 341-3 ASIC sector. The column vector of this combined sector is presented in Table 4.

Table 4. Column Vectors of (i) 66 - Steel forgings sector in A (66 x 66), (ii) 45 - residual Iron and Steel sector in A (66 x 66) and (iii) 111 - Iron and Steel castings and forgings sector in A (241 x 241), all at purchasers prices of 1963

S.No.	GIPE 66-sector classifi- cation	ASIC sector No.	Description of the sector	Column vector of 66 - steel forgings sector in A (66 x 66)	Column vector of 45 - residual sector in A (66 x 66)	Column vector of 111 - Iron and Steel cast- ings and forgings sector in A (241 x 241)
1	2	341-1	Basic Iron and Steel	-	0.21571608	0.29233100
2	19	231	Spinning, weaving and finishing of textiles	-	0.00033471	0.00020000
3	25	251	Saw mills, planting and other wood mills	-	0.00036043	-
4	30	280	Printing, publishing and allied industries	0.00431100	0.00431100	0.00431100
5	34	311	Basic industrial chemicals, excluding fertilisers	0.00091900	0.00272434	0.00146200
6	36	313	Manufacture of paints, varnishes and liquerors	-	0.00156137	0.00079100
7	37	319	Manufacture of miscellaneous chemical products	-	0.00020303	0.00390900
8	38	321	Petroleum refineries	0.07185700	0.00430987	0.00777400
9	39	329	Manufacture of miscellaneous products of petroleum and coal	0.05430700	0.01277055	0.02698900
10	40	331	Manufacture of structural clay products	-	0.00192036	0.00398800
11	45	341	Iron and steel industries - residual	0.28396900	0.00635630	0.00344000
12	46	342	Nonferrous basic metal industries	-	0.01451449	-
13	47	350	Manufacture of metal products	0.01676100	0.00624113	0.00529200
14	59	399	Manufacture of industries not else- where classified	0.02488600	0.02713362	0.04045200
15	60	511	Electric light and power	0.04024700	0.01880389	0.01429700
16	61	11	Mining - coal	-	0.00237912	0.00921300
17	62	01	Agriculture	-	0.00067226	0.00162200
18	63	71	Railway transport	0.00924400	0.00924400	0.00924400
19	64	72	Road transport	0.00924400	0.00300617	0.00924400
20	66	-	Steel forgings	-	0.00351209	-
Total				0.51574500	0.33607481	0.43455900

An aggregation scheme of the 241 sectors leading to 65 x 65 matrix is the disaggregative input output table at purchasers' prices of 1963. This is readily available for application. It distinguishes "2 Basic Iron and Steel" from "45 - Iron and Steel industries other than 2 - basic Iron and Steel". The latter 45th sector is inclusive of Iron and Steel castings, forgings, structurals etc. To represent steel forgings as a separate 66th sector in this table of 66 x 66 sectors, column and row vectors of "66th steel forgings" sector and of "45th Iron and Steel industries excluding 66th and 2nd sectors (as a residual 45th sector)" are required to be constructed at purchasers' prices of 1963, following the 66 sectors classification⁷ scheme for inputs and outputs.

The row input coefficients vector of 66 - steel forgings sector at purchasers' prices of 1963, obtained in the earlier section of this chapter, are based on reports of Annual Survey of Industries (ASI) data on inputs and outputs. The coefficients are aggregated to reclassify the inputs from 241 sectors classification to 66 sectors' classification. Thus, there are 6 sectors as users of steel forgings following 66 sectors classification.

The row vector of "45 residual of Iron and Steel industries exclusive of 2nd and 66th sectors", is also constructed, following 66 sectors' classification, as a difference of the corresponding row input coefficients of the combined

⁷ See Appendix for 66 - Sectors classification scheme corresponding to other classifications.

"45 - Iron and Steel industries other than basic iron and steel" and of the "66 steel forgings".

5.2.1 Construction of column input coefficients vectors of "66 - Steel forgings" and of "45 - residual Iron and Steel" sectors

The input structures of the production units or firms in steel forgings industry for the years 1963 to 1966-67 are arrived at producers' prices in the earlier Chapter IV. All these input structures are brought to the base year 1963 at producers' prices, with the necessary adjustments for the variations in prices of inputs and outputs of the respective years.

The sources of data for prices and price indices of the inputs are : (i) wholesale price indices of (a) fuel, power, light and lubricants, (b) chemicals and (c) metal products (as an approximation to consumable stores) from the "Index numbers of wholesale prices in India (Revised series) for the years 1963 to 1967, Office of the Economic Advisor, Ministry of Industry, Government of India, New Delhi, and (ii) the prices of light steel bars for the years 1963 to 1967 from "Statistics for Iron and Steel", published by Hindustan Steel Limited, Ranchi, India. As most of the steels used in the forgings industry are steel bars, these prices are taken as approximate indices in the absence of any other detailed prices on different steels. These two sources of data enable the price adjustments on the inputs.

The adjustments on outputs are carried out as follows.

Average prices per ton of firms' output are computed as a ratio of the value and quantity of output. The price indices of output of steel forgings for the years 1963 to 1967 are constructed as the percentages of average prices of the firms during 1963-1967 with 1963 as base. Thus, the inputs and outputs are brought to the base year 1963 producers' prices. The input structures of firms at producers prices of 1963 are computed and are presented under 66 Sectors classification.

The input structures of each firm for different years, adjusted to the base year 1963 producers prices are aggregated, as a simple average of the coefficients of the respective years. The simple average is preferred as the variations in the yearly outputs of each firm are not significant. There are, thus, 7 die forging firms' input structures and 3 open forging firms' input structures, all at producers prices of the base year 1963. The input structures of wheel sets unit and of sleepers unit are not taken into consideration for aggregation of the firms' input structures, as they have been treated as part of "Basic Iron and steel industries" in the preparation of the available input output tables.

The die forgings industry's input structures are arrived as a simple average of the concerned input structures of the 7 firms and open forgings industry's input structures are arrived at as a simple average of the concerned input structures of 3 firms. Then, the total steel forgings industry's input structure is a simple average of two sets of concerned input structures of the open forgings' industry

and of the die forgings' industry. The steel forgings industry's input structures at producers' prices of 1963 are adjusted to purchasers' price/producers' price ratios of inputs and output, so that the input structure of the steel forgings industry refer to 1963 purchasers' prices. Though, in general, output weighted averages of the input structures of the firms are preferred, here, the simple averages are preferred as (i) the variations in the outputs of firms within the broad categories of open forgings firms and die forgings firms are not significant; (ii) the number of units under each of the two categories may not be true representation of the industry, and (iii) to give equal emphasis to both of these two categories of open and die forgings. Historically, open forgings' firms are more, while the die forgings' firms are growing only during the III and IV Five Year Plans. In our analysis, the number of firms for die forgings are more than for open forgings. Because of these limitations of the survey and as the industry is likely to have both the die forgings and open forgings with equal weightage, it is assumed that the simple averages of the input structures may be a better approximation in arriving at the steel forgings industry's input structure at 1963 purchasers prices.

The column vector of "45-residual of Iron and Steel industries exclusive of basic iron and steel and of steel forgings" is also constructed as follows : the combined 45th sector's column vector coefficients are multiplied by the

gross output of 45th sector at purchasers prices. The 66th sectors' column vector coefficients are similarly multiplied by the gross output of 66th sector at purchasers prices. Then the corresponding input values at purchasers prices are subtracted from each other. The derived differences in inputs' values of the 45-residual sector are divided by the difference in the gross outputs at purchasers price of the two sectors. Thus the 45th residual sector's input coefficients vector or column vector of "Iron and steel castings structurals etc." sector is obtained.

5.2.2 Comparison of column vectors of three sectors in the disaggregative tables

The row and column vectors of "66th - steel forgings sector" and "45 - residual Iron and Steel industries" are thus distinguished from each other, to be incorporated in the 66 x 66 sectors input output table of India at purchasers prices of 1963. The column input coefficients vectors of (i) 66 - steel forgings sector in A (66 x 66), (ii) 45-residual Iron and Steel industries sector in A (66 x 66), and (iii) 111 - Iron and steel castings and forgings sector in A (241 x 241) are presented in Table 4, following 66 sectors' classification for the inputs of the three sectors.

The 45-residual Iron and Steel sector requires inputs from 20 sectors, out of which inputs of 17 sectors are required by Iron and Steel castings and forgings sector. Out of these 17, inputs of 10 sectors only are required by steel forgings sector. Even for these 10 sectors, the input structures

of the three sectors are dissimilar. It also stresses the need for distinguishing the steel forgings sector from the combined sectors because of the distinct features of the major inputs like the forging quality steel inputs, fuel oils, coke oven gas and other fuels, electric light and power inputs of steel forgings sector. Inputs like printing and stationery, railways and road transport are similar but they are minor inputs in respect of their coefficients in the three column vectors. Thus the column vectors of the two aggregated sectors are dissimilar from each other and from the column vector of steel forgings sector.

5.3 Role of indirect requirements of "Steel forgings" and of "Iron and Steel excluding basic iron and steel and steel forgings" - Application of technology matrices, results and interpretation

Given $[A]$ technical coefficients matrix of say 66 sectors, $[I-A]^{-1}$ gives the direct and indirect requirements of the outputs of 66 sectors to sustain the unit levels of the final demand of 66 sectors. In the expansion of $[I-A]^{-1} = I + A + A^2 + A^3 + \dots$, I is the identity matrix of unit levels of direct requirements (or unit final demands); $[A]$ gives the first stage indirect requirements to produce the unit levels of final demands or of direct requirements; $[A^2 + A^3 + \dots]$ gives the total indirect requirements exclusive of first stage indirect requirements. If F is the column vector of final demands of 66 sectors, then $[I-A]^{-1} F$ gives the total direct and indirect requirements of 66 sectors to sustain the final demands of 66 sectors.

5.3.1 Intermediate demand of steel forgings and share of captive and/or small scale units

The results of the application of technical coefficients matrices of A (66 x 66) and of A (65 x 65) are summarily presented in Table 5. There are 6 using industry groups or sectors out of 66 G.I.P.E. sectors, with their first stage indirect requirements of steel forgings per rupee worth of the gross outputs of 6 sectors, while all 66 sectors place their total direct and indirect requirements of steel forgings per rupee worth final use of the 66 sectors. The gross outputs of the 6 using industries inclusive of small scale and large scale⁸ units, are adjusted to purchasers prices of 1963. The elements of the inner product of the row input coefficients vector of steel forgings and the gross outputs vector of the using industry groups give the intermediate demand of steel forgings at purchasers prices by the respective using industries. The non-electrical machinery and the motor vehicles place the major share of the total intermediate demand of steel forgings.

To know the share of indigenous production of steel forgings in the total intermediate demand of steel forgings, the analysis is as follows :

(1) Total intermediate of steel forgings at purchasers' prices of 1963 (is as given in Table 5): Rs. 18,28,88,691.

⁸ Source: A.S.I. (census) reports for large scale and National Sample Survey (sample part) reports for small scale industries' gross outputs. The former are published by the Central Statistical Organisation, New Delhi and the latter are published by the Directorate of Economics and Statistics, Delhi.

Table 5. Direct and Indirect requirements of 66-steel forgings, 45-residual iron and steel and 45-Iron and steel in the respective matrices for 1963

S. No.	G.I.P.E. classification	ASIC sector	Description of the sector	Row input coefficients of 66-steel forgings sector in $A(66 \times 66)$	Gross output (large scale + small scale) in Rs.vector X	Intermediate demand of steel forgings in $[AX]$ vector	Row vector of 45-residual sector of Iron and steel in $A(66 \times 66)$	Row elements of 66-steel forgings in $[I-A]^{-1}$ (66×66)	Row elements of 45-residual sector of Iron and steel in $[I-A]^{-1}$ (66×66)	Row elements of 45-combined sector of Iron and Steel in $(I-A)^{-1}$ (65×65)
(1)	(2)	(3)	(4)	(5)	(6)	(7)=(5)x(6)	(8)	(9)	(10)	(11)
1	3	360-3	Internal combustion engines	0.02699700	229784652	6203496	0.06677588	0.02910432	0.07931436	0.09983633
2	4	360-7	Machine tools	0.01084700	213744242	2318484	0.09268314	0.01186530	0.09793215	0.10628302
3	45	341-2,3,4	Iron and steel industries	0.00351209	1752741396	6155628	0.00635630	0.00357239	1.00801324	1.01331060
4	48	360	Nonelectrical machinery	0.05411300	1782626188	96463250	0.01899200	0.05526102	0.03725202	0.07539137
5	50	381	Shipbuilding and repairs	0.00114100	106958202	122039	0.00102572	0.00177417	0.00487693	0.00562680
6	52	383	Motor vehicles manufacture	0.02847600	2515303903	71625794	0.03187200	0.03211649	0.04588605	0.06524035
7	2	341-1	Iron and Steel basic				0.01219571	0.00026065	0.01441949	0.01449193
8	24	243	Wearing apparel-manufacture of				0.00125652	0.00015356	0.00276898	0.00277885
9	28	260	Furniture and Fixture-manufacture of				0.01535461	0.00011219	0.01821966	0.01831467
10	33	300	Rubber products - manufacture of				0.00025742	0.00003200	0.00058607	0.00058860
11	41	332	Glass products "				0.00003649	0.00009320	0.00025231	0.00025214
12	46	342	Nonferrous basic metals				0.00030819	0.00005390	0.00065760	0.00066024
13	47	350	Metal products-manufacture				0.01621220	0.00013675	0.01996697	0.02007085
14	49	370	Electrical machinery				0.00713811	0.00050102	0.00885143	0.00888100
15	51	382	Railroad equipment				0.00010835	0.00052254	0.00493117	0.00493975
16	53	385 and 389	Motor cycles and bicycles and others				0.03637336	0.00016636	0.03938851	0.03959504
17	54	391	Scientific and surgical instruments				0.00314561	0.00004112	0.00408079	0.00410151
18	59	399	Industries not elsewhere classified				0.01368109	0.00006884	0.01443236	0.01450791
19	66	-	Steel forgings				0.28396900	1.00109045	0.28710021	-
20	1	311-1	Fertilizers					0.00009574	0.00021134	0.00021062
21	5-18	201-220	Food industries					0.00050439	0.00911757	0.00915982
22	19-23	231-241	Textiles and footwear					0.00092283	0.00131608	0.00129089
23	25-27	251-259	Wood industries					0.00004305	0.00192999	0.00082315
24	29-32	271-293	Paper, printing, leather products					0.00012641	0.00223761	0.00224743
25	34-40	311-331	Chemicals, coal, petroleum refineries and structural clay products					0.00122748	0.00363746	0.00363745
26	42-44	333-339	Cement and non-metallic mineral products					0.00050616	0.00122782	0.00122567
27	55-58	392-395	Optical goods, watches, jewellery, musical instruments					0.00008480	0.00178267	0.00179332
28	60-65	511,01, 11,40,71,72	Electricity, Agriculture, Mining, Construction, Transport					0.00338644	0.01097179	0.01106794
Total				0.12508609		182888691	0.60774170	1.14382357	1.72141263	1.52632725

(2) Total intermediate demand of steel forgings at producers' prices of 1963 (is obtained by multiplying the (1) by the producer price/purchaser price ratio (0.73) adjustment factor) : Rs. 13,35,08,744.

(3) Indigenous production of large scale units in steel forgings industry at producers prices : Rs. 1,71,86,390.

As some of the indigenous production might have been exported, the exports of steel forgings during 1963-64⁹ are deducted from (3).

(4) Indigenous production at producers' price (large scale) - Exports of steel forgings = Rs.1,71,86,390 - 4,51,068
= Rs. 1,67,35,322.

(5) Imports of steel forgings during 1963-64 = Rs.2,93,73,964.

(6) = (4) + (5) = Supply of steel forgings excluding that of captive and/or small scale units for internal demand of steel forgings : Rs. 1,67,35,322 + Rs.2,93,73,964 = Rs.4,61,09,286.

(7) Indigenous production of captive and/or small scale units in steel forgings industry = (2) - (6) = Rs. 13,35,08,744 - Rs. 4,61,09,286 = Rs. 8,73,99,458.

(8) $\frac{\text{Large scale indigenous production of steel forgings at producers prices of 1963}}{\text{Total intermediate demand of steel forgings at producers prices of 1963}} \times 100 = 12.87\%$

(9) $\frac{\text{Captive and/or small scale indigenous production of steel forgings at producers prices of 1963}}{\text{Total intermediate demand of steel forgings at producers prices of 1963}} \times 100 = 65.46\%$

⁹Imports and Exports of steel forgings are estimated for financial years in Chapter 2. Those estimated figures for 1963-64 are assumed to hold good for the calendar year 1963 also.

Imports and exports at c.i.f. and f.o.b. prices are treated as if they are at producers prices in the analysis.

$$(10) \frac{\text{Foreign trade balance or} \\ \text{(imports - exports)}}{\text{Total intermediate demand}} \times 100 = 21.67\%$$

Thus the captive and/or small scale units' production of steel forgings in India is significantly high compared to large scale production and/or to imports (exports are negligible) of steel forgings in India. The captive and/or small scale units production is not accounted in A.S.I. reports or in any of the official and unofficial reports.¹⁰

5.3.2 Role of first stage indirect requirements of intermediate products

(11) Total of row input coefficients of 66 steel forgings sector in A (66 x 66) matrix at purchasers prices of 1963 : 0.12508609 giving the first stage indirect requirements per rupee worth gross outputs of using industries.

(12) Total of row elements of 66 - steel forgings sector in $[I-A]^{-1}$ (66 x 66) matrix at purchasers prices of 1963 : 1.14382357 giving the total direct and indirect requirements of steel forgings per rupee worth final use of 66 sectors.

(13) The total indirect requirements exclusive of the

¹⁰ Because the captive and/or small scale units production statistics are not available, the percentages of large scale units indigenous production to the total internal demand of forgings exclusive of the output of captive and/or small scale units, are computed in Chapter II. The percentage obtained in Chapter II will tally with the percentage computed in Chapter V when the total intermediate demand is exclusive of the output of captive and/or small-scale units in steel forgings industry. However, it is a notional estimate in view of the fact that only 34.54% of production or supply (inclusive of imports) is available in published reports and the residual is considered as that of captive and/or small scale units in this industry.

first stage indirect requirements of steel forgings is
 $0.14382357 - 0.12508609 = 0.01873748$.

The relative high proportion of the first stage indirect requirements in the total indirect requirements (86.97%) is mostly because the intermediate products like steel forgings have higher proportion of intermediate demand compared to final demand in the gross output of steel forgings sector.¹² With the growth of all 66 sectors, especially many engineering industries, there is a likely tendency that the total output requirements of steel forgings get multiplied. Many of the industries like Aerospace, petrochemicals, oil refineries, motor cycles etc. may place their requirements as in advanced countries like America.¹³ It is also to be mentioned here that the requirements of railways for wheel sets and sleepers are not included in the table.

There are 19 G.I.P.E. sectors out of 66 sectors (see Table 5), requiring the first stage indirect requirements of "45 Residual Iron and Steel excluding basic Iron and Steel and Steel forgings". Again, the proportion of first stage indirect requirements is relatively high in the total indirect requirements (84.24%) of the intermediate products of 45-residual Iron and Steel sector.

5.3.3 An illustration of disaggregation of a sector and inverse elements

The relative advantages of disaggregation of "45-Iron and

¹¹ Similar observations are made in the study of United Kingdom economy by Ghosh, A., Experiments with Input Output Models, Chapter 3, op.cit.

¹² See the Appendix to Chapter III.

Steel industries excluding basic Iron and Steel" in the technical coefficients matrix A (65 x 65) into (i) " 66 - Steel forgings sector" and (ii) " 45-residual Iron and Steel" in A (66 x 66) are of special mention here. As far as first stage indirect requirements of " 45 - Iron and Steel" are concerned, it is a sum of the first stage indirect requirements of (i) 66 - Steel forgings sector and of (ii) 45 - residual Iron and steel sector. But, the total direct and indirect requirements of 45 - combined Iron and Steel sector are not exactly equal to the sum of the total direct and indirect requirements of (i) 66 - Steel forgings sector and of (ii) 45 - residual sector in the respective $(I-A)^{-1}$ matrices. Thus, the inverse elements of disaggregated sectors are likely to be divergent, more from the inverse elements of the aggregated sector. The disaggregation of the sectors enables us to know the distinct direct and indirect requirements of the individual sectors which otherwise would not be possible to distinguish them. The sum of the total requirements of (i) 45 - residual Iron and Steel sector and of (ii) 66 - Steel forgings sector, excluding those to sustain rupee worth final use of 66 - Steel forgings sector is equal to 1.57704554. The total requirements of 45 - combined sector is 1.52632725 in $(I-A)^{-1}$ (65 x 65). The difference 0.05071829 is the additional requirements explained in the inverse elements of disaggregated sectors excluding those of steel forgings sector while the latter is as high as 1.2889066. This also explains the need for distinguishing steel forgings sector separately

from the Iron and Steel sectors.

3.4 Summary and Limitations of this Study

The growth of the demand for steel forgings rests with the growth of the using industries and the latter's unit output requirements of steel forgings. The using industries' unit output requirements of forgings, are from the following using industries listed in order:

- (i) Railways,
- (ii) Motor vehicles,
- (iii) Diesel engines and
- (iv) All other non-electrical machinery industries.

The four using industries however are in the reverse order in respect of their growth rates of gross output during 1960-64. The row input coefficients of "Steel forgings" sector and of "Iron and Steel castings and forgings" sector are dissimilar in respect of their major users for the years 1963 and 1964. The column vectors of (i) 66 - Steel forgings sector in A (66 x 66), (ii) 45 - residual Iron and Steel industries sector in A (66 x 66) and (iii) 111 - Iron and steel castings and forgings sector in A (241 x 241) are constructed and presented for comparison of their input coefficients. The column vectors of the latter two combined sectors are dissimilar from those of steel forgings sector, in respect of major inputs like the (i) forging quality steels, (ii) fuel oils, coke oven gas and other fuels, (iii) electric light and power inputs of steel forgings sector. The need for distinguishing steel forgings sector separately in the input output tables is thus stressed

because of its distinct column and row vectors from those of combined sectors.

The captive and/or small scale units' production of steel forgings in India is significantly high (63.46% of the total intermediate demand of steel forgings) compared to large scale units' production and/or to imports (exports are negligible) of steel forgings in India at 1963 producers' prices. The estimate of captive and/or small scale units production is of the order of Rs. 8,73,99,458 which is not accounted in A.S.I. reports or in any of the official and unofficial reports. The first stage indirect requirements of steel forgings out of the total indirect requirements are of very high proportion (86.97%) mostly because they are intermediate products with a very high intermediate demand. The relative advantages of disaggregation of a combined sector "45 - Iron and Steel other than basic" into (i) "66 steel forgings sector" and (ii) "45 - residual Iron and Steel" are examined in respect of their direct and indirect requirements.

5.4.1 Limitations

The stability and reliability of input structures including that of steel forgings in A (66 x 66) sectors matrix depend mostly on the nature and methods of aggregation adopted for the sectors specification, while other adjustments for refinement of them are also assumed to hold good. The sectors specified and their input structures are assumed to depict the actual production structure in the economy.

In this analysis, the capital coefficients matrix¹³ is not incorporated within the model. This static analysis can be improved by introducing the capital coefficients matrix and growth rates of Leontief trajectories of consumption. Such a dynamic analysis will refine the exogenous final demand vector for the exclusion of capital formation vector and provides the total requirements of steel forgings to sustain the different rates of growth of consumption levels.

¹³ The available capital tables are -

(i) Mathur P.N. and others, "An inter industry capital coefficients table for India - First approximation (1960)", the order of which is 30 x 30 sectors in Economic Analysis in Input Output Frame Work, ed. Mathur P.N. and Bharadwaj, R., 1967.

(ii) Koti R.K., "A Note on capital coefficients matrix (32 x 32) for 1963" Artha Vijnana, June 1969, Vol. XI, No. 2, pp. 256-269.

(iii) Koti, R.K. and Somayajulu, V.V.N., "Replacement values of capital employed in the third division manufacturing industries of Maharashtra, 1959 - A disaggregative study", Artha Vijnana, June 1969, Vol. XI, No. 2, pp. 270-87.

(iv) Koti, R.K., "Capital coefficients matrix based on company data (1960) in Economic Analysis of Input Output Frame-work, ed. Mathur, P.N. and Bharadwaj, R., 1967.

Appendix to Chapter V.Description of 66 Sectors Classification of Economic Activity(By G.I.P.E.)

66 Sector classifi- cation No. (G.I.P.E.)	ASIC Code No.	Description of the Industry	241 Sectors classifica- tion No. (G.I.P.E.)
1	2	3	4
1	311.1	Fertilizers	69,70
2	341.1	Iron and Steel	109
3	360.3	Internal Combustion engines	129
4	360.7	Machine Tools	150
5	201	Slaughtering, preparation and preserving of meat	1
6	202	Milk and malted foods (dairy products)	2
7	203	Canning and preserving of fruits and vegetables	3
8	204	Canning and preserving of fish and other sea foods	4
9	205	Manufacture of grain mill products	5, 6, 7
10	206	Manufacture of bakery pro- ducts	8
11	207	Sugar factories and refineries	9,10
12	208	Manufacture of cocoa, choco- late and sugar confectionary	11
13	209	Manufacture of miscellane- ous food preparations	12 to 19
14	211	Distilling, rectifying and blending of spirit (Alcohol)	20
15	212	Wine industries	21
16	213	Breweries and manufacture of malt	22
17	214	Soft drinks and carbonated water industries	23

Continued/..

1	2	3	4
18	220	Tobacco manufactures	24 to 29
19	231	Spinning, weaving and finishing of textiles	30 to 38
20	232	Knitting mills	39
21	233	Cordage, rope and twine industries	40
22	239	Manufacture of textiles not elsewhere classified	41 to 46
23	241	Manufacture of footwear	47
24	243	Manufacture of wearing apparel (except footwear)	48, 49
25	251	Saw mills, planting and other wood mills	50, 51
26	252	Wooden and cane containers and cane small wear	52
27	259	Manufacture of cork and wood products not elsewhere classified	53, 54
28	260	Manufacture of furniture and fixtures	55, 56
29	271	Manufacture of pulp, paper and paper board	57 to 61
30	280	Printing, publishing and allied industries	62, 63
31	291	Tanneries and leather finishing plants	64
32	293	Manufacture of leather products except footwear and other wearing apparel	65
33	300	Manufacture of rubber products	66, 67, 68
34	311	Basic industrial chemicals excluding fertilizers	71 to 77
35	312	Vegetable oils including solvent extracted oils	78
36	313	Manufacture of paints, varnishes and liqueurs	79
37	319	Manufacture of miscellaneous chemical products	80 to 89
38	321	Petroleum refineries	90

Continued/..

1	2	3	4
39	329	Manufacture of miscellaneous products of petroleum and coal	91
40	331	Manufacture of structural clay products	92,93,94
41	332	Manufacture of glass and glass products	95 to 98
42	333	Manufacture of pottery, china and earthenware	99,100,101
43	334	Manufacture of cement (Hydraulic)	102
44	339	Manufacture of non-metallic mineral products not elsewhere classified	103 to 108
45	341	Iron and steel industries - residual	110 to 113
46	342	Non-ferrous basic metal industries	114
47	350	Manufacture of metal products except machinery and transport equipments	115 to 127
48	360	Manufacture of machinery except electrical machinery	128, 139 to 149 and 151 to 159
49	370	Manufacture of electrical machinery, apparatus appliances and supplies	160 to 171
50	381	Ship building and repairs	172, 173
51	382	Manufacture of rail-road equipment	174, 175
52	383	Manufacture of motor vehicles	176
53	385 and 389	Manufacture of motor-cycles and bicycles and other transport equipments not elsewhere classified	177
54	391	Manufacture of professional and scientific and surgical instruments	178 to 182
55	392	Manufacture of photographic and optical goods	183
56	393	Manufacture of watches and clocks	184

Continued/..

1	2	3	4
57	394	Manufacture of jewellery and related articles	185,186
58	395	Manufacture of musical instruments	187
59	399	Manufacture of industries not elsewhere classified	188 to 199 231 to 236 240, 241
60	511	Electric light and power (generation, transmission and distribution)	200
61	11	Mining-coal	201 to 209
62	01	Agriculture - paddy, wheat, jowar, other cereals	210 to 230
63	71	Railway transport	238
64	72	Road transport	239
65	40	Construction	237
66		Steel forgings	111

CHAPTER VI

**PRODUCT SPECIFICATION IN STEEL FORGINGS
INDUSTRY FOR SECTOR SPECIFICATION IN THE
PROCESS ANALYSIS STUDIES**



6.0 Introduction

A sector in the process analysis is understood as an activity or a process¹ having an unique input output combination or an input output coefficients column vector, producing a single homogeneous unit activity level. It is these independent disaggregative activities that satisfy the ideal definition of a sector. Such a sector may avoid the problems of product mix and process mix² for the stability of interindustry structures in the theoretical input output models and in the linear programming models. However, in the empirical studies of input output analysis, those problems causing instability of input structures become difficult to avoid. The problems of product mix and process mix arise due to the sector specification, based on the usually available industry and/or trade classifications at the national and international levels. The classification schemes are some statistical aggregations of mainly horizontal integration, vertical integration and other principles of aggregation. While every aggregation provides some practical conveniences of handling the data, there is an inevitable loss of information, because of both direct and indirect repercussions of the inputs and outputs in the analysis. What should be the level of aggregation or of dis-

¹ Process and activity terms are synonymously used here, though the distinction of them can be maintained as in some literature.

² Product mix and process mix problems have been extensively discussed in Chapter IV.

aggregation is a matter of trial and error for the stability of direct and indirect repercussions, without much loss of information.

In addition to these main problems in respect of specification of a sector, there are also problems of product multidimensionality, both on technical and economic grounds. "The technical fact is that the process by which the multidimensional product is made is such that it will generate a wide range of all products' dimensions and that the different values of the dimensions affect the costs of production differentially. The economic fact is that a particular establishment does not confine itself to producing an output embodying the fixed combination of possible values of output dimensions."³

Product multidimensionality problem is thus termed as that there may be very many dimensions by which a product of a sector may be identified or defined and that the variations in the physical quantities of these dimensions are likely to influence the input structures of the firms in the industry. This problem will be amplified if those product dimensions are continuous variables, making the product specification more difficult. The illimitable list

³ Mathilda Holzman, Problems of classification and Aggregation, in Studies in the structure of American Economy - theoretical and empirical explorations in Input output analysis, ed. Leontief and others, pp. 344. Oxford University Press, New York, 1953.

⁴ Ibid. p. 359.

of the products of a process, characterized by various continuous dimensions, violates the discreteness of a sector with unique input output combination. But, for any inter-industry analytical uses, the process must be a discrete concept.

In general, the input structures for a multidimensional product must be obtained from engineering production functions for the product.⁴ For this purpose resort to direct technological information is warranted even within the framework of the orthodox statistical method of estimating coefficients.⁵ In this connection, Leontief⁶ observes, "As soon as economist abandons grossly aggregative formulations, he will find in engineering data a promising and accessible source of direct empirical information on the input-output structures of individual industries." Similarly, Chenery suggested the derivation of 'economic production functions' from engineering production functions⁷ and in his "process and production functions from engineering data."⁸

⁵Carter, Anne P., The technological structure of the cotton textile industry, in Studies in Structure of American Economy, op.cit., pp. 362-63.

⁶ Leontief, W.W., "Introduction", Chapter I, in Studies in the Structure of American Economy, op.cit., pp. 13 and 14.

⁷ Chenery, H.B., Engineering Production Functions, The Quarterly Journal of Economics, Vol. LXIII, Nov. 1949, No. 4, pp. 507-531.

⁸ Chenery, H.B., Process and Production functions from engineering data, in Studies in the Structure of American Economy, op.cit., pp. 297-325.

In addition, the uses of such economic production functions, derived from engineering relations are suggested,⁹

- (1) as a basis for classification and aggregation for sector specification,
- (2) as a supplement to other methods of calculating input coefficients,
- (3) in testing and modifying assumption of fixed proportions among inputs and outputs.

It is in this context of the utility of engineering variables for sector specification of a jobbing type industry of steel forgings, an attempt has been made here to specify the discrete and distinct product groups with respect to the homogeneity of continuous product dimensions. Such product groups may serve as sectors in the disaggregative commodity wise input output tables and in the linear programming models.

This chapter deals with

- (1) Problems of product specification in forging industry.
- (2) Use of Principal components and scatter diagram method for product specification.
- (3) Selection of product dimensions and number of observations.
- (4) Product groups specification - results and interpretation - (i) steel die forgings, (ii) steel open forgings.

⁹Ibid.

6.1 Problem of Product Specification in Forging Industry

Forging industry is a jobbing type intermediate product industry catering to the requirements of many using industries. The variations in the capital structures, demand potential and nature of products of using industries are likely to cause heterogeneity in forgings. Product specification in the input output context, is a ticklish problem in this industry because the forgings produced by the forging process are not homogeneous both with respect to their characteristics and to uses. Nomenclature of forgings are very many in number which are broadly known by six names¹⁰ representing only the shapes to some extent. The shapes are not amenable for measurement. Neither nomenclature nor shape of forging is homogeneous with respect to product characteristics and to their uses. Each nomenclature of forging is further subdivided into types of forgings and each type is being identified by different physical quantities of its characteristics. Generally customers specify the physical quantities of the characteristics of the forgings to meet their own requirements and producers are to incorporate those specifications in the products. To list the characteristics,¹¹ they are (1) Net weight, (2) Material specification, (3) Mechanical properties of final piece,

¹⁰ The broad nomenclature of forgings : (a) Forgings for gears, (b) Miscellaneous lever forgings, (c) crankshafts, (d) camshafts, (e) shaft forgings and (f) connecting rods. (See the Chart I, Appendix C).

¹¹ The characteristics (4), (5), (6), (7), (8), (9) are not overlapping with the customers specifications (1), (2), (3) and (1) in the sense that the characteristics (3) and (10) are not quantifiable and not be taken care of. It is assumed that the characteristics of the processes or materials in the die shop are likely to take care of (3) and (10).

(4) Gross weight and especially in case of die forgings,
(5) Die block volume,
/ (6) Die life, (7) Presinking hours, (8) Sinking hours, (9)
Postsinking hours, (10) Other specifications and tolerances
with a distinct design and drawing for each type of forg-
ing. The characteristics (1), (2), (3) and (10) are gene-
rally specified by customers, while other characteristics
of the process in the shop are to fulfill customers'
specifications. All these characteristics are also known
as product dimensions. Though, all forgings are produced
by the forging process, apparently there is no limit in
enlisting the numerous forgings because of variations in
the physical quantities of product dimensions. Next,ly,
these product dimensions are continuous variables. Because
of the product dimensionality problem and the problem of
continuous change in product dimensions, while the process
needs to be a discrete concept for interindustry analytical
uses, the variations in the physical quantities of product
dimensions are likely to affect the input structures of
firms differently in the industry. In such cases, discrete
product groups specification is required, so that the
differences in the input structures of firms will be
accounted for the differences in the product groups compo-
sitions in the firms. Such a product groups specification
is also useful for many other economic studies, for example,
optimum production capabilities of the firm with the help
of linear programming method, demand potential and pricing
policies of the specific products in this industry. This

study may provide a methodology for specification of the products in similar jobbing type industry studies.

6.2 Use of Principal Components and Scatter diagram method for Product specification

If there are n product dimensions each forging is represented as a point on n dimensional real space. Graphical representation of the points on a more than 3 dimensional space becomes difficult. Various statistical methods are available to analyse and interpret these geometric multidimensional problems in terms of Multivariate analysis for different purposes.¹² The principal components method for grouping the numerous forgings with respect to the homogeneity of product dimensions of the forgings is chosen for the following reasons : (1) as there is no prior knowledge on the number of product groups that this industry may have, (2) as it is not known which are the dependent variables while others are independent and it is quite likely that there may not be any dependent variable in the sense of regression analysis, (3) as computational procedures are well developed compared to other factor analytical techniques, (4) as it has got certain desirable statistical properties, for example, orthogonality of components, the best indices with minimum error variance and

¹² G. Tintner, Some applications of Multivariate analysis to economic data, Journal of the American Statistical Association, Vol. 41, pp. 482-484. Reproduced in his text book Econometrics, Chapter 6, pp. 93 to 153.
See also Holzinger K.J. and Harman, H.H., Factor Analysis, Chicago, 1941.

maximum sum of squares of correlation coefficients of each variate with the component values and approximating to maximum likelihood estimates if the variables are normally distributed.¹³ When a large number of measurements are available, it is natural to enquire whether they could be replaced by a fewer number of measurements or of their functions, without much loss of information, for convenience in the analysis and in the interpretation of data. Principal components, which are independent linear functions of the measurements are suggested for this.¹⁴ It is therefore relevant to examine in what sense Principal Components provide a grouping scheme for a large number of forgings (say N), each being specified by n measurements.

The method of Principal Components attempts⁶ to analyse the intercorrelations among a group of product dimensions or variables into a set of orthogonal principal components, also called as Factors. These factors are linear functions of the standardized variables, with weights known as factor loadings. These factor loadings are the net correlations between the factors and standardized variables. Squares of

¹³ M.A. Grishick, Principal Components, Journal of American Statistical Association, Vol. 31 (1936), pp. 519 ff.

¹⁴ C.R. Rao, The use and interpretation of principal components analysis in Applied Research, Sankhya, Series A, Vol. 26, 1964, page 337.

See also H. Hotelling, Simplified calculation of Principal components, Psychometrika, Vol. I (1936), p. 27. Hagood, M.J. and Bennett, E.H., Component indexes as a basis for satisfying a sample, Journal of American Statistical Association, Vol. 40 (1945), pp. 330.

these factor loadings are the maximum contribution of the concerned factor to the unit variances of the variables. It means that the first factor contributes maximum to the variances of all the variables, the second factor contributes maximum to the residual variances of all the variables and so on. Thus, this is equivalent to choosing a set of factors in decreasing order of their contribution to the 'total communality'.¹⁵ Thus, the analysis proceeds in constructing the linear functions one after the other till the 'total communality' is explained fully, by a method of iterative procedure, for any correlation matrix of the variables. It may so happen, in many of the applications of Principal Components method, that the first two factors themselves may contribute a very good proportion to the total communality. Then those two factors' values of each die forging can be utilised as orthogonal axes to plot the points representing the forgings on a two coordinate system. The scatter of such points can be visualised for their proximity to form distinct or discrete product groups of forgings, satisfying the criterion of homogeneity with respect to their continuous product characteristics for a grouping scheme.

¹⁵ 'Total Communality' is a term used to specify the variances explained by all common factors. It is net of error variance caused by unique factor out of the total variation of all the variables. For further details, please refer to Harman, Modern Factor Analysis, Chapter 7 : Factor Analysis Model.

6.3 Selection of product dimensions and number of forgings for Product Specification

6.3.1 Adequacy of the Survey

Based on a pilot study from a firm, a preliminary exercise is carried out with a few variables or product dimensions, to bring out a few tentative hypotheses in respect of selection of variables, demonstrating the use of Principal Components and scatter diagram method for grouping purposes. It was followed by a field investigation of 19 firms in the industry. Only ten firms covering six die forging firms and four open forging firms, have provided the details on two important variables, for a total of 398 to 400 types of die forgings and 197 open or free forgings. Adequacy of the survey for the purpose of forming product groups in this industry cannot be judged, because we do not have prior knowledge either on the number of product groups that this industry may have or on the nature of products that are not included in the survey. However, it is felt that these 597 types of forgings would be a relatively adequate proportion of the industry's products and may provide a good sample of types of forgings required to form product groups.

All the ten firms provided data on (1) net weight, (2) material specification and (3) gross weight. Only three die forging firms provided partial data on (4) die block volume and (5) die life. Only one die forging firm provided data on the duration of various die preparation activities,

broadly grouped as (6) presinking hours, (7) sinking hours and (8) postsinking hours. The rest of the variables are nonquantifiable and that cannot be taken into account for the purpose. Omission of a firm for the study means the omission of certain distinct products which cannot be sacrificed for the purpose of forming product groups.

6.3.2 A Pilot Study

The number of die forging considered are 72 and variables are six. The six variables are the following :

- X_1 - Die block volume, X_2 - Die life (estimates),
 X_3 - Presinking hours, X_4 - Sinking hours,
 X_5 - Postsinking hours, X_6 - Net weight

Table I - The Correlation Matrix of Six Variables

	X_1	X_2	X_3	X_4	X_5	X_6
X_1	1.00000	-.31004	.64725	.60262	.16469	.87244
X_2		1.00000	-.40717	.00974	.18232	-.33185
X_3			1.00000	.70163	.33398	.49285
X_4				1.00000	.63610	.42629
X_5					1.0000	.05018
X_6						1.00000

Table 2. Principal Factor pattern for the first three factors *of his Variables*

Variable	Common factors loadings		Communa- lities	Third fac- tor load- ings	Communa- lities
	F ₁	F ₂	R ₁ ²	F ₃	h ₂ ²
X ₁	.89519	-.21431	.84729	.30956	.94312
X ₂	-.37373	.68569	.60984	.57826	.94422
X ₃	.85572	.00510	.73228	-.32161	.83571
X ₄	.81413	.47517	.88860	-.02629	.88929
X ₅	.43006	.78287	.79783	-.21575	.84438
X ₆	.79022	-.35417	.74988	.41557	.92258
Percentage contribution of factor to total com- munality	52.43%	24.67%	77.10%	12.56%	89.66%

Results and interpretation of tables I and ~~II~~ together are as follows :

(1) Looking at all factors' loading together, their values in decreasing order are interpreted as follows : The first factor explains to the maximum $(.995)^2$ variation in die block volume, $(.856)^2$ variation in presinking hours, $(.814)^2$ variation in sinking hours, $(.790)^2$ variation in net weight, representing the first factor's dominance on the heaviness and intricacies of the jobs. The intricacies of the jobs are assumed to get reflected in presinking and sinking hours,

because the hours for sinking the impressions as a replica of the requisite die forging will be more, the more the intricacies of the job. The net weight, die block volume, presinking and sinking hours are highly correlated (See Table I). The second factor explains the remaining two variables to the maximum $(.783)^2$ variation in post sinking hours and $(.686)^2$ variation in die life, observed in the same decreasing order.

(2) 'Communalities' under columns h_1^2 , and h_2^2 are the sum of squares of the first two and first three factors' loadings respectively, against each variable. These are usually termed with a standard symbol ' h^2 '. The third factor is incorporated in the table 2 only to show its relative insignificance compared to first two factors. The first two factors together explain above 60% variation in each variable and above 73% variation in each except in die life. The first three factors explain above 83% variation in each variable.

(3) The last row provides the percentage contribution of each factor, in decreasing order, to the 'total communality' or the total variation of all variables. The first two factors together are contributing 77.10% to total communality of all variables, the first three 89.66%, the first four 95.82%, the first five 98.40% and first all six 100%. Thus, the first two factors may be adequate for the purpose as they cover each variable's variation to a considerable extent. With these first two factors' transformed values

as orthogonal axes, a scatter of points of 72 die forgings has been formed (See Chart II Appendix C). From this scatter diagram, it is observed that nearly 57 points are clustered together on F_1 axis (positive side) with a few to both sides of F_2 within this cluster. It means that this cluster can be formed with F_1 itself. This group includes a considerable proportion (nearly 80%) of the total number (72) of die forgings. It includes (a) all forgings for gears (24), (b) all miscellaneous lever forgings (27), a few (6) of (c) crankshafts, (d) camshafts, (e) shaft forgings and (f) connecting rods. These six broad names of die forgings, representing their shapes to some extent, have no significant relevance to the formation of product groups. It is also observed that (a) and (b) are small and less intricate jobs whereas (c) to (f) are slightly big and more intricate jobs. The remaining 15 die forgings are big die forgings widely scattered all over but only towards the positive side of F_1 . From these results, we only infer that we have got only one group of less intricate small die forgings because of only 72 observations in this exercise.

6.3.3 Quantitative and Qualitative features of forgings

Looking at this industry's technology, also from users' point of view, broadly speaking, more fundamental variables are termed as (a) quantitative and (b) qualitative features of forgings. (1) Net weight, (2) Gross weight, (3) Die block volume and (4) Die life are quantitative features and (5) Material specification, (6) Mechanical properties

of final forging piece, (7) Presinking hours, (8) Sinking hours and (9) Post sinking hours are qualitative features of forgings. Both these two types of features are to be represented in the final selection of variables.

(a) Quantitative variables

Net weight is the final piece weight of forging. Gross weight is the steel material weight of a piece of forging. The variation in gross weight is expected to be explained more or less fully by the variable, net weight as they are highly correlated (0.993562 is the value of correlation coefficient based 398 observations or forgings). It is also seen from pilot study of a die forging firm that net weight has high positive correlations with die block volume, pre-sinking hours and sinking hours (See Table 1 - Correlation matrix). All these four variables have their highest factor loadings in the first component itself (See Table 2). Thus, net weight can be taken to represent the three quantitative variables (including itself) and two qualitative variables. The two qualitative variables represent the intricacies of the jobs. Net weight is a very important variable explaining the heaviness and intricacies of the jobs. It is also important because it is the weight of final piece that a firm can produce to fulfil customer's requirements.

Die life is the number of pieces that can be turned out with a single die impression. There is uncertainty in the realization of the estimated values of die life because of frequent breakage of the die blocks. Post sinking hours

include hours of only a few unimportant miscellaneous activities, like lead casting and some incalculable hours as to account for the customer's approval of the die impressions. The data on these two variables are unreliable and also partial in availability. Because of these difficulties also, die life and post sinking hours are neglected in the following analysis which may not cause a significant effect for the purpose of this study.

(b) Qualitative Variables

Mechanical properties of the piece are the qualitative features, which may be approximated to the variable, material specification, or to the tensile strength of material as detailed below. Material specification is the same as specification of the grade of steel used as raw material for forging piece. There are some hundreds of forging quality steels for forging purposes with their code numbers and symbols which cannot be quantifiable. Each type of steel has its chemical composition and a set of mechanical properties. Generally, the customers specify the types of steel to be used as material. Their chemical composition is automatically fixed up without any choice left to the producer. The mechanical properties of steel are also fixed up for the given chemical composition of steel, if those mechanical properties are not improved by the heat treatment facilities of forging unit. Many customers generally insist on improving the mechanical properties of the forging piece by the heat treatment facilities for which they are to pay. The

mechanical properties of final forging piece are more meaningful and significant for the purpose than the chemical composition of the steel. But no data were available on the mechanical properties of final forging piece from any firm, as they do not have any such records. Alternatively mechanical properties of steel are an approximation to that of final piece. It may be justified because the more the mechanical properties of steel, the more the final piece can absorb the heat treatment facilities to improve their physical values. All these mechanical properties especially, tensile strength in tons per square inch, hardness in brinell numbers etc., are related technologically in fixed proportions with their conversion measures. Variation in any of these variables, say tensile strength, will explain more or less all mechanical properties. The tensile strength of the steel material, as an approximation to that of final forging piece, will represent the qualitative features of forgings. Thus, finally, only two very important variables (1) net weight of final forging piece and (2) tensile strength of the material are chosen. These two together represent both the quantitative and qualitative features of forgings, for the purpose of forming product groups. We could collect data from all ten firms on these two variables for about 597 forgings.

6.4 Product groups specification - Results and interpretation of two methods

6.4.1 Die forgings

There are two methods available : (1) use of scatter

diagram with the two variables as axes on a two coordinate system, and (2) use of scatter diagram with two orthogonal factors, which are linear functions of the variables, as axes. By adopting the first method, the scatter has been widely spread over, with respect to both the axes. As these two variables are continuous, an attempt has been made, with six continuous class intervals on net weight and thirteen continuous class intervals on tensile strength, to form a two way frequency table (Table 3 given on next page), each cell being represented as a group. The number of groups, ($6 \times 13 = 78$), is too large to make any significant analysis for the purpose.

From Table 3, we observe that most of the die forgings are within the net weight range 0-5 Kg. with the original values of variables for 400 die forgings, the following are the statistics obtained :

$$\bar{X} = \text{Mean value of net weight} = 13.45 \text{ Kg.}$$

$$\sigma_X = \text{Standard deviation of net weight} = 50.52 \text{ Kg.}$$

$$\bar{Y} = \text{Mean value of tensile strength} = 44.45 \text{ tons per sq. inch.}$$

$$\sigma_Y = \text{Standard deviation of tensile strength} = 22.30 \text{ tons per sq. inch.}$$

$$r_{xy} = \text{Correlation coefficient between these two variables} = 0.050912$$

$$n = \text{Number of observations} = 400.$$

Table 3. Frequency distribution of die forgings by their net weights and tensile strengths of material

Tensile strength in tons per sq. inch(Y)	Net weight in Kg (X)						Total
	0-5	5-10	10-30	30-100	100-250	250-520	
10-25	42	5	5	3	-	-	55
25-30	46	8	11	-	-	-	65
30-35	13	-	1	1	-	-	15
35-40	47	5	1	2	2	2	59
40-45	14	10	14	2	1	-	41
45-50	15	3	-	-	-	-	18
50-55	11	4	2	3	2	2	24
55-60	47	2	4	1	1	-	55
60-65	13	1	-	-	-	-	14
65-70	11	5	4	1	-	-	21
70-75	6	6	-	-	-	-	12
75-105	-	-	2	-	-	-	2
105-135	11	3	3	-	2	-	19
Total	276	52	47	13	8	4	400

Having identified each die forging (a point on the scatter diagram) by a code number assigned, those code numbers have been arranged in all 78 groups to read back the original die forgings. A number of trials have been made to aggregate these 78 groups to form a smaller number

of groups, by adjusting them to many possible ways of aggregating the class intervals of the two variables. Each of such possible sets of groups seems to be an arbitrary trial as we are not assured of the relative reliability of those sets of groups.

Visualization and fixing up of the number of groups on the scatter diagram with the original variables as axes, became difficult because of the following reasons :

(1) We do not know how many product groups that this industry may have, (2) the differences in the means of the two variables and differences in the standard deviations of the two variables will have their impact on the scatter of the points, because the axes are not independent of origin and scale. The different units of measurement of the two variables will also have their impact on the scatter and grouping becomes more arbitrary because of the continuity of the variables' physical values with different measurements. (3) Correlation effects of the original variables also have their impact on the scatter of the observations.

Following the second method, the Principal Components, as independent linear functions of the two standardized variables, will be independent of origin, scale or units of measurement. As these two factors are orthogonal, their correlation coefficient is zero and they are independent of correlation effects.¹⁶ With two variables, we can form

¹⁶ It is verified with the transformed values of F_1 and F_2 that the mean values of F_1 and F_2 are zero and the correlation coefficient between F_1 and F_2 is also zero.

only two factors together explaining 100% variation of the two original variables. When we plot the points of die forgings with these two factors as orthogonal axes, we are able to visualize better the proximity of the points, for all the above reasons, and will be able to form product groups with a better judgement. The following are results and interpretation.

Table 4. The correlation matrix of two variables

	X	Y
X	1.000000	0.050912
Y	0.050912	1.000000

Table 5. The Principal Factor Pattern of two factors for two variables

Variable	Common Factors' Loadings		Communality h^2
	F_1	F_2	
X	0.724890	0.688865	1.000000
Y	0.724890	-0.688865	1.000000
Percentage contribution of Factor to 'Total Communality'	52.5465%	47.4535%	100%

From Table 5, we observe that each factor is contributing equally to the variations of net weight and tensile strength. The first factor explains 52.5465% of variation of each of X and Y respectively. The rest of the variation

of each variable is being explained by second factor. With these two factors' transformed values as variables on the two orthogonal axes, a scatter of points of die forgings has been obtained (See Chart III Appendix C). This scatter makes easier the visualization of the proximity of points. Thus, we could form six product groups of 398 die forgings while the scatter of the observations with the original variables could not provide distinct product groups. Only two points are not taken into account for the analysis as they do not fall into any of these six product groups. The product dimensions of these two observations could not be combined as a group or with any other group. It is assumed that the two points may not cause any significant influence for the purpose of the study. All the points are assigned certain code numbers to read back the corresponding die forgings under the distinct product groups. Proximity of the points within the group and divergence between the groups as far as possible are the criteria kept in mind while visualizing and fixing up the product groups. These six product groups can be broadly termed as :

- I. Small die forgings with inferior quality.
- II. Small die forgings with medium quality.
- III. Small die forgings with superior quality.
- IV. Small die forgings with very superior quality.
- V. Big die forgings having on an average medium quality.
- VI. Very big die forgings having on an average medium quality.

Small, big and very big refer to piece weight ranges representing quantitative features of die forgings. Inferior, medium, superior and very superior refer to tensile strength ranges representing the qualitative features of die forgings. Mean values and range values of net weight and tensile strength, number of types of die forgings grouped for each product group and those of product groups shown against each firm are given in Table 6. Standard errors of the means of net weight and tensile strength in the six groups are also given in Table 6. As the correlation coefficient between the two variates is not significant, univariate normal distributions are assumed and a few tests of significance for the homogeneity of means and that of variances of net weight and tensile strength between the product groups are carried out. The results are interpreted as follows :

(1) Between the product groups I and II : The means and variances of tensile strength are significantly different both at 5% and 1% levels of significance. The means of net weight are statistically not significantly different, whereas, the variances of net weight are significantly different both at 5% and 1% levels of significance. Thus, groups I and II are justified more on the basis of significant differences in the means of tensile strength of the groups.

(2) Between groups II and III : The means and variances of tensile strength are significantly different both at 5% and 1% levels of significance, whereas the means and variances of net weight are statistically not significantly different.

It is preferred to take more number of observations for the purpose of forming product groups and the first two important variables. However, the results of the two sets are as follows :

Set I : n_1 = number of observations = 136.

\bar{X}_1 = Mean value of net weight = 69.80 kg.

σ_{X_1} = Standard deviation of net weight = 210.68 kg.

\bar{Y}_1 = Mean value of tensile strength = 43.044 Tons per sq.inch.

σ_{Y_1} = Standard deviation of tensile strength = 6.01 tons per sq.inch.

\bar{Z}_1 = Mean value of gross weight = 93.053 Kg.

σ_{Z_1} = Standard deviation of gross weight = 236.96 Kg.

Table 7. Correlation Matrix of three variables

Variables	X_1	Y_1	Z_1
X_1	1.000000	0.481095	0.968432
Y_1		1.000000	0.147905
Z_1			1.000000

The gross weight is highly correlated with the net weight. By neglecting the gross weight, it may not cause significant loss of information as net weight explains $(.968432)^2$ variation of gross weight.

Set II. n_2 = No. of observations = 197

\bar{X}_2 = Mean value of net weight = 51.11 Kg.

σ_{X_2} = Standard deviation of net weight = 177.63 Kg.

\bar{Y}_2 = Mean value of tensile strength = 42.62 tons per sq.inch.

$\sqrt{Y_2}$ = Standard deviation of tensile strength = 6.60 tons
per sq.-inch.

$r_{x_2y_2}$ = Correlation coefficient of net weight and tensile
strength = 0.432412.

Comparing the two sets, the mean values of net weight are reduced from 69.80 to 51.11 Kg. and the standard deviations of net weight also are reduced from 210.68 to 177.63 kg., while there are not significant changes in other statistics of two samples (Set I and Set II). This suggests to get the principal components or factors of the two variables alone, with all 197 open forgings, as in the case of die forgings.

Table 8. Principal Factor pattern of two factors for two variables

Variable	Common factor loadings		Communality h^2
	F_1	F_2	
X_2	0.846290	0.532723	1.000000
Y_2	0.846290	-0.532723	1.000000
Percentage contribution of a factor to total communality	71.62%	28.33%	100%

Based on two factors' transformed values as variables on the two orthogonal axes, a scatter of points of 197 open forgings, could form four product groups, broadly termed as :

- (1) Small open forgings of medium quality.
- (2) Small open forgings of superior quality.

- (3) Big open forgings of medium quality.
- (4) Very big open forgings of medium quality.

Mean values and range values of net weight and tensile strength, number of types of open forgings grouped for each product group and those of product groups shown against each firm are presented in Table 9. (See also Chart IV, Appendix C).

6.5 Summary

Product specification is the basic information for many economic studies of an industry and it is a problem in a few industries of jobbing type nature, like forgings industry, because of their product multidimensionality and continuous variability. An attempt is made to solve the continuous product multidimensionality problem by grouping numerous forgings with respect to continuous product dimensions. A pilot study has been conducted to know the intercorrelations of product dimensions, demonstrating a scheme for grouping a number of die forgings with the help of principal components and scatter diagram method. For technological reasons and due to limitations of data availability on variables, only two very important variables have been selected for grouping 398 die forgings and 197 open forgings. The tentative results of the pilot study are also found helpful in the selection of the variables. Six product groups are formed in die forgings industry and 4 product groups in open forgings industry are similarly formed, with the help of principal components and scatter diagram method. Reliability of these six product groups, so specified

for die forging industry, have been discussed with the help of statistical tests for significance of the equality of means of two product dimensions between the product groups. Thus, this study may provide a methodology for product specification of similar industry studies.

Table 6. Product groups specification of die forgings in different firms and their characteristics

Product groups characteristics	Firms															
	D		C		B		A		F		E		Total			
	X	Y	X	Y	X	Y	X	Y	X	Y	X	Y	X	Y		
I	M	4.056	21.90	4.092	26.77	3.577	28.33	6.135	6.135					4.264	24.77	
	S.E.													.5062	.4635	
	R	(0.04 to 33.73)	(13 to 20)	(0.4 to 15.0)	(25 to 35)	(.12 to 21.60)	(19 to 35)	(.27 to 27.67)	(29)					(0.04 to 33.73)	(13 to 35)	
	n	71		26		21		18						136		
II	M	6.779	40.15	1.470	40.33	1.550	38.67	6.237	42.00					4.384	40.31	
	S.E.													.4919	.2706	
	R	(0.09 to 21.89)	(36 to 45)	(.22 to 12.25)	(38 to 47)	(.25 to 3.40)	(38 to 42)	(2.26 to 14.52)	(42)					(.09 to 21.89)	(36 to 47)	
	n	48		40		6		10						104		
III	M	4.985	55.40	2.534	61.46	2.765	60.89							3.626	58.76	
	S.E.													.4150	.6162	
	R	(.15 to 20.28)	(50 to 87)	(.33 to 9.00)	(50 to 73)	(.09 to 19.0)	(50 to 73)							(.09 to 20.28)	(50 to 73)	
	n	50		48		18								116		
IV	M	9.829	112.91	3.806	118.00									7.289	115.05	
	S.E.													1.7616	3.2934	
	R	(1.54 to 27.80)	(75 to 129)	(.6 to 10.5)	(86 to 132)									(.6 to 27.80)	(75 to 132)	
	n	11		8										19		
V	M	48.80	42.55					34.47	42	77.60	30			49.913	41.54	
	S.E.													5.75	3.65	
	R	(26.84 to 77.22)	(15 to 67)											(26.84 to 77.60)	(15 to 67)	
	n	11						1		1				12		
VI	M	151.60	55					117.03	42			324.75	45.50	286.663	46.10	
	S.E.													42.32	2.3431	
	R											(160 to 480)	(38 to 53)	(117.03 to 480)	(38 to 55)	
	n	1						1		1		8		10		
Total	M	8.641	41.756	2.601	50.847	2.982	42.73	10.81	34.20	77.60	30	324.75	45.50	12.84	44.129	
	S.E.															
	R	(.04 to 151.60)	(13 to 129)	(.04 to 15.0)	(125 to 132)	(.09 to 21.60)	(19 to 73)	(.27 to 117.03)	(29 to 42)			(160 to 480)	(38 to 53)	(.04 to 480)	(13 to 132)	
	n	192		122		45		30		1		8		398		

Note. (1) A,B,C,D,E,F are firms and I,II,III,IV,V,VI are product groups. (2) X : Net weight in kg, Y : Tensile strength in tons per sq.inch. n - number of types of die forgings. (3) M : Mean value, S.E. : Standard error of the mean, R : Range values of the group.

Table 9. Product specification of open or free forgings in different firms and their characteristics

Product groups characteristics	Firms										Total	
	K		L		J		N				X	Y
	X	Y	X	Y	X	Y	X	Y	X	Y	X	Y
(1) M	12.92	40.44	10.69	38.00			15.69	38.27	12.30	39.24		
R	(.035 to 55.00)	(29 to 42)	(0.47 to 40,70)	(29 to 42)			(0.80 to 32.40)	(35 to 42)	(0.35 to 55.00)	(29 to 42)		
n	52		52				15		119			
(2) M	16.99	49.65	-	-	2.96	52.06			12.80	50.37		
R	(1.90 to 41.80)	(48 to 50)	-	-	(0.06 to 26.27)	(45 to 60)			(0.06 to 41.80)	(45 to 60)		
n	40				17				57			
(3) M	85.63	37.00	133.60	29.			123.48	39.20	109.35	39.10		
R	(65 to 102)	(29 to 42)					(66.40 to 151.00)	(35 to 42)	(65 to 151)	(29 to 42)		
n	4		1				5		10			
(4) M	437.00	42	323.00	46			921.00	39.20	615.55	40.71		
R	(359 to 515)	42	(270 to 372)	(35 to 65)			(475 to 1910)	(35 to 42)	(270 to 1910)	(35 to 65)		
n	2		4				5		11			
To- tal	26.20	44.27	34.76	38.42	2.96	52.06	218.31	38.64	51.05	42.54		
R	(0.35 to 515.00)	(29 to 60)	(0.47 to 372)	(29 to 65)	(0.06 to 26.27)	(45 to 60)	(0.80 to 1910.00)	(35 to 42)	(0.35 to 1910.00)	(29 to 65)		
n	98		57		17		25		197			

Note. X : Net weight in Kg., Y : Tensile strength in tons per square inch. n : number of types of open forgings
M : Mean value, R : Range values of the variable.

CHAPTER VII

**AVERAGE PRICES AND INPUT STRUCTURES OF THE
AGGREGATED PRODUCT GROUPS AND THEIR RELEVANCE
IN THE INTER INDUSTRY FRAME WORK AND IN THE
PROJECT COST ESTIMATES OF ENTREPRENEURS**



7.0 Introduction

In the light of distinct product groups specified in steel forgings industry in the earlier Chapter VI, here, it is attempted to derive the distinct average prices of aggregated product groups. It is also attempted to derive the input structures of those distinct aggregated product groups under two different and a mix technologies assumptions. The derived discrete processes with unique input output combination to produce the unit output levels of the aggregated product groups may serve as sectors in the disaggregative commoditywise input-output tables. Thus, this chapter deals with (a) Need for commoditywise input output tables, (b) Problem of finding average prices for the product groups - two methods and their assumptions, (c) Average prices of the product groups of the die forgings and of open forgings, (d) A brief review of the United Nations' methods of deriving the commoditywise input output tables, (e) problem setting and a method for product groups' input structures under two technologies' assumptions, (f) Input structures of the product groups of die forgings and open forgings - results and interpretation, followed by summary and concluding remarks.

7.1 Need for commoditywise input-output tables vis-a-vis industrywise input output tables

In the construction of input-output tables, with a few exceptions like those of Japan, the usual practice is to treat an industry or a group of industries as a sector, for the requisite dimensions of the table. These sectors are based on industry classification schemes for which the unit

of analysis is generally the establishments. But, variations in the product mix of different establishments in the same industry and/or of the same establishment over time are likely to affect the input-structures of the industry. Thus, the stability of column input structures of the sectors in the industrywise table cannot be ensured.

Secondly, the final uses, being exogeneously determined, are generally expressed in terms of commodity outputs rather than in terms of industry outputs. As the industry output is a composition of commodity outputs, the fluctuations in the individual commodity outputs will make variations in the product composition of final demand of industry. Thus, the stability in the final demand of industrywise sectors in the table cannot be ensured.

Thirdly, the intermediate uses, being endogeneously determined, are generally expressed in terms of commodity outputs rather than in terms of industry outputs. Following the above similar reasoning, the stability of the industrywise row sector input coefficients cannot be ensured in the table.

Fourthly, prices are generally expressed for commodity outputs rather than for industry outputs. If the price structures of industries are derived in a centralized economy through input output analysis, it becomes more difficult to derive the price structures of the individual commodities. The derived prices of industries' outputs do not serve as much purpose to the general public or to the industrialists, as the prices of the commodity outputs. Here again, following

similar reasoning as above, the stability of the price structures of the industrywise sectors cannot be ensured in the table.

It is the commodity output of a single process that approximates to the definition of a disaggregative sector of unique input output combination to produce the unit level of output. The industry output of multiple processes and products does not approximate to such a disaggregative sector. If a single technological process like the forging process provides a wide variety of continuous changes in product dimensions, then the variations in the physical quantities of those product dimensions may not ensure the stability of the input structure of the technological forging process. Once the discrete product groups specification of the technological process is attained, the problem of getting distinct average prices of the discrete product groups and the input structures of those distinct product groups remains. This problem is pursued, in the following study, with the result that the derived dissimilar input structures of the aggregated product groups may serve as sectors in the disaggregative commoditywise input output tables or in the linear programming models, and as guide lines to the project cost estimates of production units.

7.2.1 Problem of finding average prices for product groups

It is seen from tables 6 and 9 in previous Chapter VI that six firms and their six product groups of die forgings and 4 firms and their 4 product groups of open forgings have different range values and mean values of net weight and tensile

strength, the two important characteristics of the product groups. Because of these differences, average prices of the product groups, the values of production and their breakdown under product groups of the firms may also differ. To arrive at such a composition of value of production of product groups in firms, it is necessary to have data on the value of production, accounted for each type of forging in each firm. But no firm has provided such a detailed information as they do not have such detailed records. However, data on the tonnage produced against each type of forging are collected from their monthly progress records. These data enabled to compile the composition of tonnage production of product groups in ten firms, separately for die forgings and for open forgings. But composition of value of production of the product groups in the firms may not be in the same proportion as that of tonnage production because of different prices charged for each forging sold to the customer. A collection of such prices would be useful to find the average prices of the product groups irrespective of the firms. Only a rough knowledge of the range of the prices of forgings is gathered from the discussions with the officials of the firms, that the prices may lie between Rs. 3000 and Rs. 21000 per ton with a few exceptions, depending upon the quantitative and qualitative features of forgings.

7.2.2 Data availability and a method to determine average prices of product groups of die forgings

Only two firms have provided the prices of their die forgings, called as wheel sets and sleepers, which are being

specialized by them with no other production. These two types of die forgings, wheel sets and sleepers, are a different category with respect to prices and input structures though they are part of the product groups V and VI, with respect to product dimensions, net weight and tensile strength. They are distinctly different from each other and possibly from any other firms' die forgings. Their prices (Rs. 1792.50 per ton for wheel sets and Rs. 830.00 per ton for sleepers in 1966-67) are also distinctly different from each other and they are far lower than even minimum prices (around Rs. 3000 per ton) of other die forgings produced in other firms. Their input structures are distinct from all other die forgings' firms, as the nature of the products mass production, specialization and organisational structure of these two firms are distinct from others. Monopoly exists in India for these two products, while imperfect competition prevails in the industry. These two firms and the two types of die forgings are necessarily to be treated separately from the product groups V and VI in the following analysis as their prices and input structures are likely to distort the average prices and input structures of product groups produced by other firms. Thus, only 4 firms' die forgings are considered for the purpose of finding average prices of the six product groups. From one of these four firms, a few (35) actual prices charged for 35 types of die forgings are collected, whereas the same firm is having 192 types of die forgings. Out of these 35 types, 3 are big forgings and 32 are small forgings. Out of 32 small forgings, 27 are

inferior quality, one medium quality and 4 are superior quality.

A regression function of price on net weight and tensile strength based on these 35 types of die forgings, is envisaged for predicting the average prices of the six product groups. It implies a bold assumption that the product groups composition, both of value of production and of tonnage production, will hold good for the rest of die forgings in the same firm and/or in other firms under this heroic assumption. The regression function of price on net weight and tensile strength, so fitted is :

$$P = 3536.24 + 75.93 X + 35.23 Y$$

(17.93) (25.61)

where P - Price per ton, X - Net weight in Kg, Y = Tensile strength in tons per square inch. $R^2 = .38169$. Multiple Correlation coefficient. This R^2 value, which is the variation explained by X and Y in P with the above 35 types of die forgings as observations out of the unit variance in P, is too low to predict reliable average prices.¹ The multiple

¹ By introducing the mean values of net weight in Kg and of tensile strength in tons per square inch of the product groups of different firms in this equation, one will arrive at the average prices of the product groups not being distinctly different from one another over firms. By introducing the mean values of the net weight and of tensile strength of the product groups irrespective of the firms, the average prices of the product groups will be as follows:

<u>Description of the product groups</u>	<u>Average prices per ton</u>
Poor quality small die forgings	I Rs. 4732.73
Medium quality small die forgings	II Rs. 5289.32
Superior quality - do -	III Rs. 5881.74
Very superior quality - do -	IV Rs. 8143.05
Big die forgings of medium quality	V Rs. 8649.32
Very big die forgings - do -	VI Rs.15446.12

Continued/..

regression function is statistically significant both at 5% and 1% levels of significance. This function may not provide average prices of the product groups of open forgings as the 35 types of die forgings or observations do not include all the forgings. For limitations of data availability of this nature, it becomes difficult to ascertain what exactly the average prices of the product groups are.

7.2.3 An alternative method for determining average prices of product groups

Let T be a square matrix of tonnage production of dimensions, product groups \times firms, (say $n \times n$), P be a row vector of prices of the same product groups of order $(1 \times n)$, then V will be the row vector of value of production in the same firms of order $(1 \times n)$, given by the relationship, $V_{(1 \times n)} = P_{(1 \times n)} T_{(n \times n)}$. This relationship states that the value of production in a firm is the sum of values of production of its product groups (a product of price and quantity is the value of production of the concerned product group) in that firm. By post-multiplying both sides by T^{-1} we derive the price vector $P_{(1 \times n)} = V_{(1 \times n)} T_{(n \times n)}^{-1} \dots (I)$ for a given tonnage production matrix and a Vector of value of production in the firms.

These prices are altogether different from the average prices of wheel sets : Rs. 1792.50 per ton and of sleepers : Rs. 830.00 per ton in 1966-67. The average prices based on the above regression function are seemed to be higher estimates for the first 3 product groups, which are necessarily to be deflated to correspond to value of production in the firms with their given tonnage distribution.

Two precautions are required to make use of this linear transformation : (1) To ensure the conformability of product (multiplication) matrices, stated above, it is necessary that there are as many product groups as there are firms, implying squareness of T matrix. As we have got six product groups and four firms, a suitable aggregation of them may provide a square matrix of tonnage production of the same number of new set of product groups and firms. (2) To ensure the distinct features of the product groups and that of firms, and also for the existence of inverse matrix (T^{-1}) it is necessary either that the product groups' composition in each firm is linearly independent of the other or each product group's distribution over firms is linearly independent of the other. It suggests the specialization of the product groups by the respective firms. The product groups distinct from one another are likely to have distinct average prices and may also have distinct input structures. This method is adopted for the die forgings and open forgings separately in what follows.

7.3.1 Average Prices for the product groups of die forgings

To derive the average prices of the product groups in the range, approximately between Rs. 3000 per ton and Rs.21000 per ton, a number of trials of suitable aggregations of the 6 product groups and 4 firms, keeping in view the proximity of the product groups plotted on the scatter diagram of all die forgings, have been attempted. Out of 24 sets of such trials, making use of above transformation (I) for different

combinations of product groups and firms, only two sets have given meaningful average prices falling within the range of Rs. 3000 per ton to Rs. 21000 per ton. We may describe these two sets of product groups as follows :

Set I

<u>Product group Code Name newly formed</u>	<u>Product groups Code No. ear- lier formed</u>	<u>Description of the product</u>
A	I and II	Small die forgings of inferior and medium quality
B	III	Small die forgings of superior quality
C	IV	Small die forgings of very superior quality
D	V and VI	Big and very big die forgings having on an average medium quality

Set II

α	I to IV	All small die forgings
β	V and VI	All big and very big die forgings

The first Set I distinguishes the qualitative variations among small die forgings whereas the Set II does not. The average prices for the respective product groups are obtained from the linear transformation (I) as follows.

<u>Set I</u>		<u>Set II</u>	
<u>Product group</u>	<u>Average price (P_{1x4}) in Rs. per M. ton</u>	<u>Product group</u>	<u>Average price (P_{1x2}) in Rs. per M. ton</u>
A (I and II)	3537.13	α (I to IV)	4255.51
B (III)	5048.94		
C (IV)	9304.22		
D (V and VI)	20531.35	β (V to VI)	15732.06

Comparing Set I average prices and Set II prices, one observes the significant contribution of quality variations in distinguishing the product groups and their prices. The same but less significant distinction is observed by comparing with the earlier set of 6 product groups' prices based on the regression function. The differences in the average prices of product group D in Set I and of product group β in Set II are because of the nature of aggregations of T matrix in $P = VT^{-1}$. The distinct set of aggregated product groups and firms are examined in the light of their value of production matrices, $V = PT$ with the given P vectors in the two sets. (Tables 1 and 2 on next page).

From these two sets of value of production matrices, it is observed that the diagonal elements are relatively more dominant in Set I compared to those in Set II, observing also their proportions both rowwise and columnwise.² It represents the specialization of the product groups by the respective firms. For the reasons of more detailed classification of the product groups distinguishing the quality variations in the small forgings, as observed from their price vectors and value of production matrices, one prefers Set I Product groups for distinguishing their input structures compared to Set II aggregate groups. The latter set may serve as an additional information in this study.

² See below the tables 4, 5, 6, 7, 8, 9 as defined in 7.4.3 section.

Table 1. Value of production matrix (all in Rupees) - V (4 x 4) *of die folgende*

Set I

Product Groups	Firms				Total
	A	B	C	D	
A (I and II)	63,76,268.17	16,74,309.05	24,85,885.59	98,62,650.97	2,03,99,113.78
B (III)	-	66,98,078.95	26,13,257.40	26,83,878.40	1,19,95,214.75
C (IV)	-	-	12,05,715.01	11,73,747.43	23,79,462.44
D (V and VI)	96,905.83	-	-	40,39,032.44	41,35,938.27
Total	64,73,174.00	83,72,388.00	63,04,858.00	1,77,59,309.24	3,89,09,729.24

Table 2. Value of production matrix (all in Rupees) - V (2 x 2) *of die folgende*

Set II

Product Groups	Firms		Total
	A, B and C	D	
α (I to IV)	2,10,76,164.56	1,46,64,418.85	3,57,40,583.41
β (V and VI)	74,255.44	30,94,890.39	31,69,145.83
Total	2,11,50,420.00	1,77,59,309.24	3,89,09,729.24

7.3.2 Average prices of product groups of open forgings

Here, the second alternative method is the only recourse to derive the average prices of the product groups of open forgings. In the case of open forgings' firms, we could arrive at 3 firms' input structures (see in Chapter IV), independent of each other, as the fourth firm supplied a partial information for two months only. It is observed from Table 9 (product specification of open forgings) of Chapter VI and tables 3, 7, 8, 9 in this chapter (value of production matrix and of their proportion matrices²), that the product groups II and IV are being specialized more by two firms respectively. By aggregating the product groups (I) and (3), the tonnage distribution of the 3 new set of firms over the newly formed 3 product groups provides the dominance of diagonal elements, which is necessary in getting the distinct average prices of the 3 product groups. The 3 product groups along with their average prices and value of production matrix, are described as follows.

Product group newly formed	Description of Product group ³	Average price in Rs. per ton (P ₁ x 3)
K (I) and (3)	Small and big open forgings of medium quality	5932.23
J (2)	Small open forgings of superior quality	6382.72
N (4)	Very big open forgings of medium quality (mostly repairs and maintenance parts)	1147.94

³The ranges and mean values of small, big or very big and of inferior, medium, superior or very superior in case of open forgings are not the same as those of die forgings as these code names are merely for indicative purposes.

Table 3. Value of production matrix of open forgings'
product groups - V (3 x 3)

Product groups	Firms			
	K and L	J	N	Total
K (I and 3)	10341186.16	-	407407.72	10748593.88
J (2)	132377.61	13167543.00	-	13299920.61
N (4)	75837.23	-	2921939.28	2997776.51
Total	10549401.00	13167543.00	3329347.00	27046291.00

7.4 A method for deriving input structures of the product groups

7.4.1 A brief review

The United Nations⁴ have evolved a set of methods for presenting commodity x commodity input tables and industry x industry input output tables in place of the usually available commodity x industry input output data tables of an economy under each of the assumptions of commodity technology, industry technology and a combination of the two. The commodity technology assumption is that every commodity may have its own input structure irrespective of the industry from which it is made. The industry technology is that every industry may have its own input structure irrespective of its product mix are transformed into commodity x commodity or industry x industry tables because of (i) subsidiary

⁴ United Nations, A System of National Accounts, Studies in Methods, Series F, No. 2 Rev. 3, Chapter III. The system as a basis for input output analysis, pp. 35-52. Department of Economic and Social Affairs, Statistical Office of the United Nations, New York, 1968.

production of different commodities in each industry, (ii) allocation of proper input structure to such subsidiary production and (iii) the final demands being expressed generally in commodity outputs rather than in industry outputs. If there is no subsidiary production in the economy, the commodity outputs would be the same as industry outputs, so their input structures, final demands etc., without the necessity of any assumption, either of commodity technology or of industry technology. However, it cannot be expected that either of these particular assumptions will hold good in all circumstances, and it is difficult to give general rules for choosing between them. In favour of the assumption of a commodity technology it can be said that specific commodities (with the exception of by-products) probably do have somewhat similar cost structures wherever they are made, but against this assumption it can be said that it is usually necessary to group commodities and that subsidiary production is often not very typical of its characteristic group. This last point may be in favour of the assumption of industry technology.

These assumptions will, in general, give slightly different results and each will contain some more or less obvious small errors. These errors arise because subsidiary production is not typical either of its commodity group or of the characteristic production of the industry in which it is made. These errors are the inevitable price of insufficient knowledge of allocation of the inputs to the

differing outputs of subsidiary products.

To deal with the same problem, Richard Stone also earlier suggested a method on similar lines in his "Input output and National Accounts".⁵ These methods deal with aggregative industry groups or the sectors of the economy. Because of the different levels of aggregation possible for the sectors, these methods cannot distinguish the two types of product mix; one arising because of by-products and joint products and the second because of the different compositions of the main products in the industry group or a sector.

In making use of these methods to an industry study analysis, a few more findings and limitations of the utility of the general methods are demonstrated in the following study of deriving the input structures of the product groups in steel forging industry, because the input structures of the firms are also likely to be affected by product multi-dimensionality or of the different product groups composition.

7.4.2 Problem setting

Input consumption in a firm is the sum result of its consumption for the production of its product groups. As such, the input structures of the firms are the result of producing their product groups in different compositions,

⁵ Richard Stone, Input output and National Accounts, published by the Organization for European Economic Co-operation, June, 1961.

while each product group may have its own input structure.

Given a product groups composition matrix of the firms, and the input structures matrix of the firms, input structures of the product groups may be obtained as a solution to a system of simultaneous linear equations of the firms, under each of the following two assumptions. Firstly, we may make the assumption of commodity or product group technology that a product group requires a structure of inputs per unit of outputs independently of the firm in which it is made. Secondly, we may make the assumption of industry technology or firm technology that an industry or a set of homogeneous firms or a single firm (as the case may be) requires a structure of inputs per unit of output independently of its product groups composition.

A set of linear transformations, bringing out the implications of the two assumptions are to be expressed (as given in the following section 7.4.3) to derive the input structures of the product groups. But it may so happen, either because of the assumption being not valid or because of dominance of some negative elements of the inverse matrix in the linear transformation, that some coefficients may turn out to be negative, while some others may be spurious. Such coefficients are not meaningful in the input output analysis. Only after examining all input structures of those product groups under the two assumptions, one may arrive at a few important findings which were not being spelt out by the previous studies.

Some inputs like steel inputs, fuel oils and electricity etc. may be more specific to the commodity technology while some overhead items like stationery, printing, telephone charges, etc. are more specific to the firm or industry technology. Some product groups may be more specific to either of the technologies for all its inputs while for some product groups, some coefficients based on firm technology and others based on commodity technology may be thought of. A distinction of those inputs and of product groups following two types of technologies differently in their degree and meaningfulness, is essential for all practical applications of the input output analysis. This exercise may also throw light on the methodology for deriving the product groupwise input structures in tackling the product multidimensionality problems of similar industry studies.

7.4.3 Method for product group's input structures under two assumptions

Let B be a matrix of m input coefficients in n firms of dimensions, inputs \times firms, expressed in the form of a relationship $U_{(m \times n)} = B_{(m \times n)} \hat{g}_{(n \times n)} \dots\dots$ (2) where U is a matrix of m inputs absorbed in n firms and \hat{g} is a diagonal matrix with diagonal elements as the outputs of n firms. Let $V'_{(n \times n)} = C_{(n \times n)} \hat{g}_{(n \times n)} \dots\dots$ (3) where V' is a matrix of outputs of n product groups produced in n firms, of dimensions, product groups \times firms, and C is a matrix of proportions of the same dimensions. This relationship states that each firm makes product groups in its own fixed proportions and the output of each firm is the

sum of the outputs of its different products. As such the column elements in C matrix sum to unity. Following commodity technology assumption, while each product group has its own input structure, each firm's input consumption and/or its coefficient value becomes a linear inner product of its consumption requirements in producing different product groups in different proportions. If A is a matrix of input coefficients of the product groups, of dimensions, inputs x product groups (m x n) and C is a matrix of product groups composition of the firms as defined under (3), then $B_{(mxn)} = A_{(mxn)} C_{(nxn)}$ is the matrix of input structures of the firms. By post multiplying both sides by C^{-1} , we get $A_{(mxn)} = B_{(mxn)} C_{(nxn)}^{-1}$. (4) input structures of the product groups for the given B (firms' input structures matrix) and C (product groups composition matrix).

Similarly, following industry or firm technology assumption, we derive the product groupwise input structures from the following relationships.

$$V = D \hat{q} \dots (5) \text{ and } E = B D \dots (6)$$

where D is a matrix of proportions of dimensions, firms x product groups, V is a matrix of outputs of dimensions, Firms x Product groups, and \hat{q} is a diagonal matrix with diagonal elements as the total outputs of product groups, each being produced by all or some firms. These relationships state that product groups come in their own fixed proportions and the total output of each product group is the sum of its outputs produced by all firms. As such the column elements

in D matrix sum to unity. Here a product group's coefficient value becomes the linear inner product of its consumption requirements over firms in different proportions while each firm or a set of firms may have its own input structure. Thus, we derive the input structures of the product groups following industry or firm technology assumption from $E = B D$ relationship for the given B and D matrices defined above. One advantage with this latter linear transformation $E = B D$ is that the first assumption of the number of product groups being equal to number of firms or the squareness of D matrix is not essential. What all required is the conformability of the product matrix B D in respect of their dimensions. Still we could not distinguish 10 product groups' input structures as we could have only 7 aggregated product groups with distinct average prices.

We can derive the product groupwise input structures, which will be in the form of a commodity x commodity input output coefficients vectors under each of two assumptions but we cannot derive a similar industry x industry input output coefficients vectors (as suggested by United Nations) in this analysis as the product matrices of the linear transformations under the technology assumptions will not be conformable in respect of their dimensions.

A comparison of the relationships (3) through (6) shows that the differences in C, C^{-1} and D matrices and so in A and E matrices are entirely due to subsidiary production other than specialization of the product groups by firms. If there is no such subsidiary production as an extreme case of

perfect specialization of the product groups by the firms, then V would be a diagonal matrix, the firms' outputs being the same as product groups' outputs. Then, $C = C^{-1} = D = I$ and $A = B C^{-1} = B D = E = B$ which implies that the input structures of the firms are the same as the input structures of product groups.

The diagonal elements' dominance compared to off diagonal elements, provide an idea of the degree of specialization of the product groups by the firms. What is expected, in an ideal case of perfect specialization of the product groups by firms is that $C = I = C^{-1} = D$. Then, $A = B C^{-1} = B D = E$. It means that the more C^{-1} tend to identity matrix, the closer the approximation of A and B matrices, or that the more D tend to identity matrix, the closer the approximation of E and B matrices. It implies the relative suitability of the linear transformations under the two technologies assumptions. A comparison of the input structures of the product groups in A and E matrices, with those of firms in B matrix, will provide an idea of relative suitability of assumptions of the technologies for individual product groups, because of degree of specialization of the product groups by the firms.

7.5 Input structures of product groups + results and interpretation

7.5.1 Classification of the inputs

Input structures of the firms, after carrying out the requisite adjustments for their refinement, have been brought out at producers' prices of latest year 1966-67, following G.I.P.E. Sectors, also the ASIC⁶ sectors for reference, as

⁶ G.I.P.E. Sectors mean Gokhale Institute of Politics and Economics' 241 sectors, ASIC means Annual Survey of Industries classification.

the basis for classifying some of the overhead items, ASIC sectors are not available while GIPE sectors are available. Based on GIPE sectors classification an input output table of dimensions 241 x 241 sectors of Indian Economy for 1963 is the most disaggregative available (under preparation) for any analytical use. For reasons of non-availability of details of some inputs against each firm, a sort of further grouping of either GIPE sectors or ASIC sectors is required for presentation and analytical use. For example, all types of steels, like that of carbon steels, alloy steels, die and tool steels, indigenous or imported, are clubbed together as a single sector. Scrap is shown as a negative input into this industry as column element and a negative output of a dummy industry (may be known as scrap) as a row element. Scrap as a joint product has no main product and is treated as a dummy industry for analytical purposes. Richard Stone⁷ suggested this way of treating and presenting the joint products and by-products differently in the usual input output analysis and their tables.

All the interindustry inputs of firms' column vectors are deflated from their purchase values to exfactory values and these differences are taken as the distributive margins of the corresponding interindustry inputs purchased by that firm. These margins summed together form a row element of

⁷ Richard Stone, Input-output and National Accounts, published by the Organization for European Economic Cooperation, June 1961, pp. 39-43.

distributive margins sector under each firm and/or product group column vector. In the case of die forging firms, all the gross value added items (Primary Inputs) are clubbed together to present it as a single sector. There are 15 interindustry inputs including one distributive margins sector and one scrap sector. The 16th sector is gross value added. The sum of all 16 coefficients in each firm is unity.

In the case of open forgings firms, the 'wages and salaries' is shown as a 13th separate primary input sector distinguished from all other gross value added items being clubbed as a 14th single sector, as there are only 12 interindustry inputs including one distributive margins and one scrap sectors. Alloy steels and carbon steels are distinguished as two sectors in the case of open forgings while they are taken as a single sector in the case of die forgings. The sum of all 14 coefficients in each firm is unity.

Whenever firms' input structures are to be aggregated, simple averages of them are taken as the input structures of combined set of firms. Thus, we could get B matrices as the input structures of four die forging firms and of three open forging firms (See Tables 10 and 11). Similarly, $C_{(4 \times 4)}$, $C_{(4 \times 4)}^{-1}$ and $D_{(4 \times 4)}$, $C_{(3 \times 3)}$, $C_{(3 \times 3)}^{-1}$ and $D_{(3 \times 3)}$ as defined under the above relationships, are obtained for the Set I of 4 product groups and 4 die forging firms and 3 product groups of open forging firms, (See Tables 4, 5, 6, 7, 8, 9). $A_{(16 \times 4)} = BC^{-1}$ and $E = BD$ matrices of input structures of the 4 product groups of die forgings, under the respective two

Table 4. Matrix C (4,4) of die forgings

Products	Firms			
	A	B	C	D
	1	2	3	4
A (I and II) 1	.98503000	.19998000	.39428100	.55535100
B (III) 2	.00000000	.80002000	.41448300	.15112500
C (IV) 3	.00000000	.00000000	.19123600	.06609200
D (V and VI) 4	.01497000	.00000000	.00000000	.22743200
Total	1.00000000	1.00000000	1.00000000	1.00000000

Table 5. Matrix C Inverse (4,4) of die forgings

	A	B	C	D
A 1	1.04430595	-.26104362	-1.58731355	-1.91528417
B 2	.00067687	1.24979955	-2.71019863	-.04453819
C 3	.02375619	-.00593831	5.19303223	-1.56316387
D 4	-.06873811	.01718238	.10447995	4.52298623
Total	1.00000000	1.00000000	1.00000000	1.00000000

Table 6. Matrix D (4,4) of die forgings

Firms		Products			
		A (I and II) 1	B (III) 2	C (IV) 3	D (V and VI) 4
A	1	.31257600	.00000000	.00000000	.02343000
B	2	.08207800	.55839600	.00000000	.00000000
C	3	.12186200	.21785800	.50671700	.00000000
D	4	.48348400	.22374600	.49328300	.97657000
Total		1.00000000	1.00000000	1.00000000	1.00000000

Table 7. $C(3 \times 3)$ matrix of open forgings

Products		Firms		
		K	J	N
C =	K	0.98026288	-	.12236866
	J	0.01254835	1.00000000	-
	N	0.00718877	-	.87763134

Table 8. $C^{-1}(3 \times 3)$ matrix of open forgings

		Firms		
		K	J	N
C ⁻¹ =	K	1.02117861	-	-.14238342
	J	-.01281413	1.00000000	.00178663
	N	-.00836448	-	1.14059679

Table 9. $D(3 \times 3)$ matrix of open forgings

		Products		
		K	J	N
D =	K	0.96209665	0.00995326	0.02529783
	J	-	0.99004674	-
	N	0.03790335	-	0.97470217

Table 10. Matrix B (16,4) of die forging firms' input structures

Sr. No.	Inputs description		Description	Firms			
	241 GIPSE Sector No.	ASIC Sector No.		A	B	C	D
1	2	3	4	5	6	7	8
1	62	280-1	Printing and Stationery	.000000000	.00016300	.00098000	.00278800
2	90	321	Fuel Oils	.01729000	.01684800	.02348800	.05211700
3	91	329	C.O. gas etc.	.00061400	.00000000	.00000000	.00000000
4	69-77	311	Chemicals	.00089600	.00000000	.00000400	.00000000
5	110	341-2	Steel	.31584900	.34731000	.34451500	.32377400
6	169,170 171	370-2 370-1	Telephone charges	.00000000	.00014000	.00103400	.00324800
7	200	511	Electricity	.00652700	.01425400	.01562400	.00930900
8	200	512	Oxygen Acetylene	.00000000	.00164300	.00000000	.00000000
9	233	-	Consumable stores	.00150600	.00764500	.00879600	.04680700
10	235	-	Repairs and Maintenance	.00123100	.00071600	.03189700	.00692600
11	236	-	Safety equipment	.00000000	.00035200	.00000000	.00315300
12	238- 239	-	Transport	.00000000	.00457800	.00830500	.01683700
13	241	-	Water	.00000000	.00000000	.00056600	.00022500
14			Distributive margins	.07375200	.08426500	.12254300	.14319400
15			Scrap	-.00167600	-.01615900	.00000000	-.01627300
16			Gross value added	.58401100	.53824500	.44217800	.40789500
Total				1.00000000	1.00000000	1.00000000	1.00000000

Table 11. Matrix B (14x3) of open forging firms' input structures

S.No.	241 GIPE Sector No.	ASIC No.	Description	K and L	Firms J	N
1	2	3	4	5	6	7
1	90	321	Fuel Oils	-	0.00117485	-
2	91	329	C.O.Gases etc.	0.16757160	0.02904361	0.13916723
3	110	341-2	Steel carbon	0.23518714	0.00203538	0.33677715
4	110	341-2	Steel alloy	-	0.46788834	-
5	200	511	Electricity	0.03750915	0.01990591	0.00271548
6	200	512	Oxygen Acetylene	0.13576885	-	0.17417439
7	233	-	Consumable stores	0.01564638	-	0.02211395
8	235	-	Repair and Maintenance	0.03729307	0.09136108	0.04408432
9	238 and 239	-	Transport	-	-	0.01628217
10	241	-	Water	-	-	0.00471053
11	240	-	Distributive margins	0.01057950	0.03107842	-
12	-	-	Scrap	-0.00408176	-0.02378310	-0.01378759
13	-	-	Wages and Salaries	0.28902922	0.14680871	0.16052967
14	-	-	Other gross value added	0.07549685	0.23448680	0.11323270
			Total	1.00000000	1.00000000	1.00000000

Table 12. Matrix A (14 x 3) of open forgings ($A = BC^{-1}$)

S.No.	241 GIPE Sector	ASIC No. No.	Description	Product groups		
				K	J	N
1	90	321	Fuel Oils	-.00001505	0.00117485	0.00000210
2	91	329	C.O. Gases etc.	.16958437	0.02904361	0.13492599
3	110	341-2	Steel carbon	.23732498	0.00203538	0.35064368
4	110	341-2	Steel alloy	-.00599351	0.46788834	0.00083593
5	200	511	Electricity	.03802561	0.01990591	-.00220780
6	200	512	Oxygen and Acetylene	.13718752	-	.17933203
7	233	-	Consumable Stores	.01579280	-	.02299532
8	235	-	Repairs and Maintenance	.03654345	0.09136108	.04513575
9	238 and 239	-	Transport	-.00013619	-	.01857120
10	241	-	Water	-.00003940	-	.00537281
11	240	-	Distributive margins	.01040532	0.03107842	-.00095108
12	-	-	Scrap	-.00374838	-.02378310	-.01568772
13	Wages and	-	Wages and Salaries	.29192635	0.14680871	.14220936
14	-	-	Other gross value added	.07314413	0.23448680	.11882243
			Total	1.00000000	1.00000000	1.00000000

Table 13. Matrix E (14x3) = B D of open forgings

S.No.	241 GIPE Sector No.	ASIC No.	Description	Product groups		
				K 5	J 6	N 7
1	2	3	4			
1	90	321	Fuel Oils	-	.00116317	-
2	91	329	C.O.Gases etc.	.16649504	.03042240	.13988561
3	110	341-2	Steel carbon	.23903763	.00435563	.33420700
4	110	341-2	Steel alloy	-	.46323097	-
5	200	511	Electricity	.03619021	.02008111	.00359570
6	200	500	Oxygen and Acetylene	.13722469	.00135131	.17320309
7	233	-	Consumable Stores	.01589155	.00015573	.02195039
8	235	-	Repairs and Maintenance	.03755040	.09082284	.04391220
9	238 and 239	-	Transport	.00061714	-	.01587029
10	241	-	Water	.00017852	-	.00459133
11	240	-	Distributive margins	.01017850	.03087437	.00026764
12	-	-	Scrap	-.00444935	-.02358623	-.01354204
13	-	-	Wages and salaries	.28415840	.14822431	.16378074
14	-	-	Other gross value added	.07692727	.23290439	.11227805
			Total	1.00000000	1.00000000	1.00000000

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Table 14. Matrix A = B C Inverse = A (16,4) of die forgings

S.No.	241 GIPE Sec. No.	ASIC Sec. No.	Description	Product groups			
				A (I and II)	B (III)	C (IV)	D(V and VI)
1	2	3	4	5	6	7	8
1	62	280-1	Printing and Stationery	-.00016825	.00024580	.00493870	.01107093
2	90	321	Fuel Oils	.01504300	.01729919	.05431304	.16514324
3	91	329	C.O. Gas etc.	.00064120	-.00016028	.00097461	-.00117598
4	69- 77	311	Chemicals	.0093746	-.00023433	-.00103795	-.00183177
5	110	341-2	Steel	.31600654	.35513489	.38027491	.30548279
6	169	370-2	Telephone charges	-.00019860	.00022464	.00532952	.01306811
7	170	370-1	Electricity	.00655711	.01617798	.03311697	.00454570
7	200						
8	200	512	Oxygen and Acetylene	.00000111	.00205342	.00445286	.00007318
9	233	-	Consumable Stores	-.00143057	.00991361	.02745834	.09473291
10	235	-	Repairs and Maintenance	.00156770	.00050310	.16247129	.02092363
11	236	-	Safety Equipment	-.00021649	.00049411	-.00062456	.01424530
12	238 and 239	-	Transport	-.00095695	.00596156	.03247997	.06296755
13	241	-	Water	.00000202	.00000050	.00296278	.00013292
14	-	-	Distributive margins	.07014489	.08779459	.30588821	.31110065
15	24	-	Scrap	-.00064262	-.02003761	.04475423	-.06967285
16	-	-	Gross value added	.59271649	.52462883	-.04689796	.01118731
Total				1.00000000	1.00000000	1.00000000	1.00000000

Table 15. Matrix E (16,4) = B D of die forgings

S.No.	248 GIPE Sector No.	ASIC Sec. No.	Description	Product groups			
				A (I and II)	B (III)	C (IV)	D (V and VI)
1	820-1	280-1	Printing and Stationery	.00148076	.00092832	.00187186	.00272268
2	90	321	Fuel Oils	.03484732	.02618587	.03761020	.05130100
3	91	329	C.O. Gas etc.	.00019192	.00000000	.00000000	.00001439
4	69-77	311	Chemicals	.00028909	.00001612	.00003750	.00002099
5	110	341-2	Steel	.32575616	.34143500	.33428382	.32358832
6	169, 170, 171	370-2	Telephone charges	.00170785	.00103017	.00212613	.00317190
7	200	511	Electricity	.00961485	.01344604	.01250892	.00924382
8	200	512	Oxygen and Acetylene	.00013485	.00091744	.00000000	.00000000
9	233	-	Consumable stores	.02480056	.01665810	.02754618	.04574560
10	235	-	Repairs and maintenance	.00747919	.00889849	.01957923	.00689257
11	236	-	Safety equipment	.00155332	.00090203	.00155532	.00307913
12	238 and 239	-	Transport charges	.00952824	.00813286	.01251369	.01644251
13	241	-	Water	.00017776	.00017365	.00039799	.00021973
14	-	-	Distributive margins	.11413475	.10578930	.13272979	.14156697
15	-	-	Scrap	-.00971792	-.01266413	-.00802721	-.01593101
16	-	-	Gross value added	.47782130	.48815074	.42526678	.41202140
Total				1.00000000	1.00000000	1.00000000	1.00000000

technologies assumptions, and those of 3 product groups of open forgings are obtained and presented in Tables 12, 13, 14 and 15.

7.5.2 Input structures of 4 product-groups of die forgings under commodity technology assumption

It is obvious from $C_{(4 \times 4)}$ matrix of proportions, that Product group A (I & II) is being specialized more by firm A, product group B (III) being specialised more by firm B, product group C (IV) is more by firm C, and product group D (V and VI) is more by firm D as the diagonal elements are stronger than off diagonal elements. It is also the case in C^{-1} matrix with some negative off diagonal elements being compensated by positive diagonal elements so that sum of each column elements is unity.

In $A_{(16 \times 4)}$ matrix, there are six negative input coefficients excluding that of scrap for product group A (I and II). The six inputs are (1) Printing and Stationery, (2) Postage, telegraph and telephone charges, (3) consumable stores and packing materials (4) Uniform safety equipment, (5) Inward and outward transport charges and (6) water. For all these items, except for consumable stores and packing materials, zero values are given under the input structures of Firm A. The rest of the positive input coefficients of product group A (I and II) are approximating to those of firm A. The zero values against some inputs of firms may be because of non-availability of data and/or of no consumption against such overhead items. These items' input requirements, where their

values are given in other firms' input vectors, are relatively insignificant.

Similarly, there are two negative input coefficients of the product group B (III) against the inputs for which zero values are given under the input structure of firm B, while the rest of the positive coefficients are approximating to each other. These two inputs are (1) Coke, Cokeoven gas, Blast furnace gas and crude tar (2) Chemicals and auxiliary materials. These are also a sort of overhead items relatively insignificant even in other firms' input structures. There are five negative coefficients of product group C (IV), while there are three zero valued inputs under the input structure of firm C. There are 4 negative input coefficients of product group D (V and VI), while there are 3 zero valued inputs under the input structure of firm D. The other coefficients of product group C (IV) and D (V and VI) are not approximating to those of firms C and D respectively.

The gross value added coefficients among the firms range between .407895 to .584011 and the distributive margins coefficients range between .073752 to .143194. But the negative coefficient (-.0468976) for gross value added, very high distributive margins coefficient (.30588821) and a positive scrap coefficient (.04475423) under the input coefficients vector of product group C (IV) are spurious. Similarly, the very low gross value added coefficient (.0111873), very high distributive margins coefficient (.3110065) and a high negative scrap coefficient (-0.6967285)

under the input coefficients vector of product group D (V and VI) are also spurious. However, the input structures under each product group with their negative and positive elements taken together sum to unity in A matrix. From these observations in A matrix, it may be inferred that the linear transformation under commodity technology assumption is not suitable for product group D (V and VI) and nextly to product group C (IV), as it is suited to at least some direct inputs like steel, fuels and electricity of product groups A and B.

7.5.3 Input structures of 4 product groups of die forgings under industry or firm technology assumption

It is obvious from $D_{(4 \times 4)}$ matrix of proportions, that the diagonal elements are stronger than the off diagonal elements. In this D matrix, however, only the 4th column diagonal element is stronger than other diagonal elements, whereas the 3rd column diagonal element is nearly as strong as its fourth diagonal element. These latter observations of D matrix are in contrast to those of C matrix.

It is observed from E matrix, that the input structures of the product groups D (V and VI) and C (IV) are approximating to those of Firms D and C respectively, and they may necessarily be preferred in comparison to those of product groups D and C in A matrix, under commodity technology assumption for all their input coefficients. The input structures of product groups A (I and II) and B (III) are higher estimates, with the single exception of low gross value added

coefficients, compared to those of Firms A and B respectively in E matrix under Firm technology assumption. All input coefficients except that of scrap are positive and they sum to unity under each product group in E matrix. This positiveness for all coefficients in $E = BD$ matrix is because of all positive proportions in D matrix, whereas some negative coefficients in $A = BC^{-1}$ matrix are because of the dominance of some negative elements in C^{-1} matrix. From these observations on E matrix it may be inferred that the linear transformation under firm or industry technology assumption is more suitable to product groups D (V and VI) and nextly to C (IV) compared to product groups A (I and II) and B (III).

7.5.4 Input structures of 4 product groups of die forgings under a mix of the two technologies assumptions

It is seen above that neither assumption is suitable to get a complete set of meaningful input structures for all the four product groups simultaneously, as some product groups are also more specific to a particular technology. A proper choice of the product group's input structures is the only recourse, having examined them under both the linear transformations simultaneously and making necessary adjustments, for their meaningfulness (nonnegativity) and consistency. As it is clear from E matrix that the input structures of the product group D (V and VI) are the best of all for all their inputs, they can be retained as they are, without the necessity of any adjustments. As the input structures of product groups A (I and II) and B (III) are better suitable, at least, for

some direct inputs under commodity technology assumption in A matrix compared to those in E matrix of firm technology assumption, the following adjustments, one after the other, are made on A matrix improving the input structures of the product groups for refinement at each stage of adjustment.

(1) Firstly, it is felt to replace the negative coefficients by zero values as we find zero values in the corresponding cells of firms' input structures and deduct the differences (i.e., the sum of negative coefficients) from the gross value added coefficients in the case of product groups A and B and from the distributive margins coefficients in the case of product groups C and D so that sum of input structures of each product group is unity. But, it has not improved the input structures of the product groups C and D as the same previous comments on them still hold good. Input structures of product groups A and B are slightly better if the assumption of zero coefficients for those inputs is justified for the above reason (See Table 16).

(2) Secondly, it is felt to replace the negative/or zero coefficients by the positive coefficients available from the corresponding cells of E matrix. It means that we are borrowing the firm technology input coefficients whenever we cannot have meaningful coefficients under commodity technology assumption as the former coefficients may hold good for the respective cells. The sum of residues of these positive input coefficient values, thus incorporated, over earlier values, have been deducted from the gross value added coefficients in the case of product groups A and B and from the

distributive margins coefficients in the case of product groups C and D, so that sum of input structures under each product group is unity. Here, again, this adjustment improved the input structures of the product groups A and B, whereas, it could not improve the input structures of the product groups C and D, as some spurious results are observed on gross value added and distributive margins etc. (See Table 17).

(3) Thirdly, it is observed that there are three inputs, namely, steel inputs, fuel oils and electricity which show meaningful pattern of their coefficients all through the 4 product groups in A matrix under commodity technology assumption, while all other inputs are represented by their negative coefficients and/or spurious values in at least one of the 4 product groups inputs' structures. It is felt that these three inputs should retain their values in A matrix as they are more specific to commodity technology assumption, while all other input coefficients should be replaced by the corresponding coefficients available from E matrix. The latter set of inputs seems to be more specific to firm technology. The gross value added coefficients are adjusted accordingly. Here, all the product groups' input structures are meaningful except for a few input coefficients of the product groups C and D. The gross value added coefficients for product groups C and D are as low as .34196480 and .32098281, whereas, they are .42526678 and .41202140 respectively in E matrix under firm technology. These differences are because of the higher estimates of fuel oil, steel and electricity coefficients taken together. However, these

results are better than earlier results obtained under the first two adjustments. (See Table 18).

(4) Fourthly, it is felt to retain the input structures of the product groups C and D for all their inputs as they are in E matrix of firm technology, also to retain the steel, fuel oil and electricity coefficients in A matrix of commodity technology for product groups A and B, while other inputs' coefficients are borrowed from E matrix of firm technology for product groups A and B. Necessary adjustments for the gross value added coefficients of products groups A and B, are carried out, so that sum of input structures under each product group is unity. (See Table 19).

Finally, it is observed that the steel and electricity coefficients of product group C (IV) are lower than those of product group B (III) in E matrix, following firm technology and they are too high in A matrix, following commodity technology. As such the choice between the adjustments (3) and (4) especially with regard to the input structures of product group C (IV) becomes difficult. This may be decided with some prior knowledge of the coefficients of inputs concerned or of the gross value added coefficients of the product groups. As all small forgings' direct inputs are likely to follow commodity technology assumption, one prefers the steel coefficients of product (C), given in Adjustment (3).

7.5.5 Input structures of 3 product groups of open forgings under commodity technology assumption

It is obvious from $C_{3 \times 3}$ matrix of proportions, that product group K [(I) and (3)] is being specialized more by

Table 16. Adjustment (1). Input structures of the product groups of die forgings, based on commodity technology assumption, replacing the negative coefficients by Zero values in the respective cells of $A = BC^{-1}$ matrix

S. No.	241 GIPE Sector No.	ASIC Sector No.	Description	Product groups			
				A (I and II)	B (III)	C (IV)	D(V and VI)
1	62	280-1	Printing and Stationery	-	0.00024580	0.00493870	0.01107093
2	90	321	Food oils	0.01504300	0.01729919	0.05431304	0.16514324
3	91	329	C.O. Gas etc.	0.00064120	-	-	-
4	69 to 77	311	Chemicals	0.00093746	-	-	-
5	110	341-2	Steel	0.31600654	0.35513489	0.38027491	0.30548279
6	169, 170, 171	370-2,3	Telephone charges	-	0.00022464	0.00532952	0.01306811
7	200	511	Electricity	0.00655711	0.01617798	0.03311697	0.00454570
8	200	512	Oxygen and Acetylene	0.00000111	0.00205342	-	-
9	233	-	Consumable Stores	-	0.00991361	0.02745834	0.19473291
10	235	-	Repairs and maintenance	0.00156770	0.00050310	0.16247129	-
11	236	-	Safety equipment	-	0.00049411	-	0.01424530
12	238-239	-	Transport charges	-	0.00596156	0.03247997	0.06296755
13	241	-	Water	-	0.00000050	0.00296276	0.00013292
14	-	-	Distributive margins	0.07014489	0.08779459	0.30588821	0.31110065
15	-	-	Scrap	-0.00064262	-0.02003761	-	-0.06967285
16	-	-	Gross value added	0.59271649	0.52462883	-	0.01118731
			Total	1.00297288	1.00039461	1.00923371	1.02400456
			Revised Gross Value added	0.58974361	0.52423422	-	0.01118731
			Revised distributive margins	0.07014489	0.08779459	0.29665450	0.28709609
			Revised Total	1.00000000	1.00000000	1.00000000	1.00000000

Table 17. Adjustment (2). Input structures of the product groups of die forgings based on commodity technology assumption for all positive input coefficients and replacing the zero and negative coefficients in $A=BC^{-1}$ matrix by corresponding cells' positive coefficients in $E = BD$ matrix

S. No.	241 GIPE Sector No.	ASIC Sector No.	Description	Product groups			
				A (I and II)	B (III)	C(IV)	D(V and VI)
1	62	280-1	Printing and Stationery	0.00148076	0.00024580	0.00493870	0.01107093
2	90	321	Fuel Oils	0.01504300	0.01729919	0.054313094	0.16514324
3	91	329	C.O. Gas etc.	0.00064120	0.00000000	0.00000000	0.00001439
4	69-77	311	Chemicals	0.00093746	0.00001612	0.00003750	0.00002099
5	110	341-2	Steel	0.31600654	0.35513489	0.38027491	0.30548279
6	169, 170, 171	370-2	Telephone charges	0.00170785	0.00022464	0.00532952	0.01306811
7	200	511	Electricity	0.00655711	0.01617798	0.03311697	0.00454570
8	200	512	Oxygen and Acetylene	0.00000111	0.00205342	-	-
9	233	-	Consumable stores	0.02480056	0.00991361	0.02745834	0.19473291
10	235	-	Repairs and maintenance	0.00156770	0.00050310	0.16247129	0.00679257
11	236	-	Safety equipment	0.00155332	0.00049411	0.00155532	0.01424530
12	238-239	-	Transport charges	0.00952824	0.00596156	0.03247997	0.06296755
13	241	-	Water	0.00017776	0.00000050	0.00296276	0.00013292
14	-	-	Distributive margins	0.07014489	0.08779459	0.30588821	0.31110065
15	-	-	Scrap	-0.00064262	-0.02003761	-0.00802721	-0.06967285
16	-	-	Gross value added	0.59271649	0.52462883	0.42526678	0.01118731
			Total	1.04222137	1.00041073	1.42806610	1.03083251
			Revised Gross value added	0.55049512	0.52421810	.42526678	.01118731
			Revised distributive margins	0.07014489	0.08779459	-.12217789	.28026841
			Revised Total	1.00000000	1.00000000	1.00000000	1.00000000

Table 18. Adjustment (3). Input structures with commodity technology applicable to steel, fuels and electricity and firm technology applicable to the rest of the input coefficients of all product groups of die forgings

S. No.	241 GIPE Sector No.	ASIC Sector No.	Description	Product groups			
				A (I and II)	B (III)	C (IV)	D (V and VI)
1	62	280-1	Printing and Stationery	0.00148076	0.00092832	0.00187186	0.00272268
2	90	321	Fuel Oils	0.01504300	0.01729919	0.05431304	0.16514324
3	91	329	C.O. Gas etc.	0.00019192	-	-	0.00001439
4	69-77	311	Chemicals	0.00028909	0.00001612	0.00003750	0.00002099
5	110	341-2	Steel	0.31600654	0.35313489	0.38027491	0.30548279
6	169, 170, 171	370-2,3	Telephone	0.00170785	0.00103017	0.00212613	0.00317190
7	200	511	Electricity	0.00655711	0.01617798	0.03311697	0.00454570
8	200	512	Oxygen and Acetylene	0.00013485	0.00091744	-	-
9	233	-	Consumable stores	0.02480056	0.01665810	0.02754618	0.04574560
10	235	-	Repairs and Maintenance	0.00767919	0.00889849	0.01957923	0.00679257
11	236	-	Safety equipment	0.00153332	0.00090203	0.00155532	0.00307913
12	238-239	-	Transport charges	0.00952824	0.00813286	0.01251369	0.01644251
13	241	-	Water	0.00017776	0.00017365	0.00039779	0.00021973
14	-	-	Distributive margins	0.11413475	0.10578930	0.13272979	0.14156697
15	-	-	Scrap	-0.00971792	-0.01266413	-0.00802721	-0.01593101
16	-	-	Gross value added	0.47782130	0.48815074	0.42526678	0.41202140
			Revised Gross Value	0.51043298	0.48060559	0.34196480	0.32098281
			Revised Total	1.00000000	1.00000000	1.00000000	1.00000000

Table 19. Adjustment (4). Input structures with firm technology applicable to product group D for all its inputs and commodity technology to the direct inputs and industry technology to the rest of the inputs of product groups (A), (B) and (C) of die forgings

S. No.	241 GIPE Sector No.	ASIC Sector No.	Description	Product groups			
				A(I and II)	B (III)	C(IV)	D(V and VI)
1	62	280-1	Printing and Stationery	0.00148076	0.00092832	0.00187186	0.00272268
2	90	321	Oils Fuel	0.01504300	0.01729919	0.03761020	0.05130100
3	91	329	C.O. Gas etc.	0.00019192	-	-	0.00001439
4	69-77	311	Chemicals	0.00028909	0.00001612	0.00003750	0.00002099
5	110	341-2	Steel	0.31600654	0.35513489	0.33428382	0.32358832
6	169,170,171	370-2,3	Telephone	0.00170785	0.00103017	0.00212613	0.00317190
7	200	511	Electricity	0.00655711	0.01617798	0.01250892	0.00924382
8	200	512	Oxygen and Acetylene	0.00013485	0.00091744	-	-
9	233	-	Consumable stores	0.02480056	0.01665810	0.02754618	0.04574560
10	235	-	Repairs and maintenance	0.00767919	0.00889849	0.01957923	0.00679257
11	236	-	Safety equipment	0.00155332	0.00090203	0.00155532	0.00307913
12	238-239	-	Transport charges	0.00952824	0.00813286	0.01251369	0.01644251
13	241	-	Water	0.00017776	0.00017365	0.00039779	0.00021973
14	-	-	Distributive margins	0.11413475	0.10578930	0.13272979	0.14156697
15	-	-	Scrap	-0.00971792	-0.01266413	-0.00802721	-0.01593101
16	-	-	Gross value added	0.51043298	0.48060559	0.42526678	0.41202140
			Total	1.00000000	1.00000000	1.00000000	1.00000000

by firm (K and L) on average, product group J (2) is being specialized by firm J and product group N (4) is being specialized more by firm N as their diagonal elements are stronger than off diagonal elements. In $C_{3 \times 3}^{-1}$ matrix, some negative off diagonal elements are being compensated by positive diagonal elements so that sum of each column elements is unity.

In $A_{14 \times 3}$ matrix, there are 4 negative coefficients, excluding that of scrap for product group K [(1) and (3)]. These four inputs are (i) Fuel oils, (ii) alloy steels, (iii) transport charges and (iv) water. For these 4 inputs, zero values are given under the input structures of firm (K and L). The zero values against these inputs are partly due to non-requirement (especially in case of (i) and (iii)) and partly due to nonavailability of data (especially in case of (iii), and (iv)) as the firm is a captive unit. The rest of the positive input coefficients of product group K are approximating to those of firm (K and L). The input structure of product group J is exactly the same as that of firm J. There are 2 negative coefficients of product group N. These are (i) Electricity for which there is positive coefficient in the input structures of firm N, and (ii) Distributive margins for which there is zero value in the input structure of firm N. These two coefficients' values seem to be spurious, while the steel coefficients seem to be very high for product group N in comparison to those of firm N. However, the input structures of each product group, with their negative and positive coefficients taken together, sum to unity in

A matrix. From these observations in A matrix, it may be inferred that the linear transformation under commodity technology assumption is not suitable to product groups N and K at least for some inputs, while it is suitable to product group J for all its inputs.

7.5.6 Input structures of 3 product groups of open forgings under industry or firm technology assumption

It is obvious from $D_{3 \times 3}$ matrix of proportions, that the diagonal elements are stronger than off diagonal elements.

In the E matrix, all the 3 product groups input structures are approximating to 3 firms input structures respectively, mostly in respect of product group N; secondly, in respect of product group K and lastly in respect of product group J. In fact, the input coefficients of each product group under the two technologies assumptions are approximating to those of firms from either of the opposite directions, as far as the positive coefficients are concerned. The merits of E matrix are that (i) all the coefficients in it except those of scrap are positive and (ii) it consists of some positive values of five coefficients for which zero values are assigned in the respective cells of B matrix, mostly due to non-availability of data. All the input structures in E matrix also sum to unity.

7.5.7 Choice of technologies for product groups and inputs of open forgings

Based on these relative merits of the two sets of input structures of the products, it is preferred to have the input

structures of 3 product groups in E matrix under firm technology as there is not much improvement by making adjustments on negative coefficients of product group K in A matrix. It is as well true that input structure of product group J in A matrix of commodity technology assumption also serves a good purpose. The choice becomes difficult as it is not sure whether product groups K and J do really require the positive coefficients of the respective inputs, for which zero values are assigned in B matrix. Thus, it is the knowledge of actual technologies of the product groups and their requisite inputs that determines this choice more appropriately.

7.6 Summary and Concluding remarks

In this study of deriving the input structures of the product groups in steel forging industry, having the problems of product multidimensionality, a number of important findings are thrown up which may be summarised as follows:

(1) It is found that the product group D (big and very big die forgings) is particularly more specific to the firm or industry technology assumption in respect of their meaningful input structures. Hence, the input structure of the product group D derived under the linear transformation $E = BD$ are taken as they are.

(2) It is also found that some direct inputs like steel, fuel oils and electricity are more specific to the commodity technology assumption, while all other overhead items of inter-industry inputs are more specific to firm technology for the product groups A (small die forgings of inferior

and medium quality), B (small die forgings of superior quality) and C (small die forgings of very superior quality).

(3) In the case of open forgings, both the technologies assumptions are providing approximately similar input structures of 3 product groups, so far as positive input coefficients of the firms are concerned. The proper choice of the suitable technologies' assumptions depends on the prior knowledge of the requisite inputs of the product groups and/or of firms especially with regard to zero and/or negative valued coefficients of the firms and/or of product groups.

(4) While the United Nations have evolved a general method of getting commodity x commodity input output tables and industry x industry input output tables with the help of the linear transformations under the technologies assumptions, for aggregative sectors of the economy, this study stresses the implications and the limitations of such general methods in deriving the input structures of the product groups of steel forgings industry. It is not always true that we can derive the commodity x commodity table and industry x industry table with either of the technologies or mixed assumptions for all their inputs without any distinction. It is quite likely that some product groups or commodities are more specific to a particular technology for all their inputs, while for some other commodities, a few inputs are more specific to the industry technology. This finding observed in this industry study analysis has not been spelt out while suggesting very general methods in the previous studies.

(5) Similar or very different findings may be thrown up in the other individual industry studies which need to be given a proper consideration for a priori knowledge before we make use of generalized methods even for aggregative sectors of the economy. Such of these industry studies help in the refinement of the input structures of the commodities and/or industries. They take into account their concerned technologies and serve as an additional information or part of the disaggregative studies.

(6) This study also examined the input structures of the two broad product groups known as small die forgings and big die forgings, under these two technologies assumptions. This analysis supports our findings to the extent that small die forgings are more specific to the commodity technology assumption, while big die forgings are more specific to the industry technology assumption (See Appendix I to this Chapter VII). Similarly, it examined the input structures of the three aggregated product groups, known as - (1) small die forgings of inferior and medium quality, (2) small die forgings of superior and very superior quality and (3) all big die forgings having an average medium quality. The results in this analysis also are similar to those of four products groups study (See Appendix II to this Chapter VII). Thus, all these exercises may serve as an additional information supporting the main findings of this study.

(7) The utility of this study of arriving at the average

prices and the input structures for the different ranges of the product dimensions, as defined in the corresponding product groups, is quite obvious in financial projections or project cost estimates of the entrepreneurs. The distinct prices of the products/product groups throw light on the standardization and the specialization of the products/product groups by the firms, when the demands of the users are also specific to particular products/product groups. Mostly because of this specialization and the demand of only Railways for wheel sets and sleepers, the cost structures of the products are distinctly low. Similar is the case with product group N.

The traditional practice of providing the financial project cost details for a given tonnage capacity of the plant by the prospective entrepreneurs is too aggregative to be of any help in actual practice. Market surveys based on this traditional practice are practically of no use in the actual manufacturing process as the demand pattern is guided by many product dimensions specified by the customers at each stage of production. Even the capital structures of the firms under a given technology are likely to be different for different ranges of product dimensions. For example, an open forging unit does not require a die shop at all, whereas a die forging unit needs die shop facilities, well balanced to the forge shop capacities. Similarly, some product groups of die forgings may not require heat treatment and other facilities or may require to a lesser degree com-

pared to other product groups. The proper choice of the current and capital expenditures of the entrepreneurs ultimately depends upon the proper identification of the ranges of the product dimensions or of the corresponding product groups.

(8) The utility of the input structures of these product groups specified for a multidimensional product of a technological process like steel forgings process as a part of the commoditywise input output tables, cannot be questioned, so far as all other technological processes are also disaggregated to arrive at independent input structures of their multidimensional product groups. But in practice, even the problems of process mix and product mix emanating from the aggregated input output tables could not be resolved for all practical reasons of nonavailability of detailed data on the outputs and the corresponding inputs. However, this study may provide a similar methodology to resolve the latter two problems also. In India, the Annual Survey of Industries reported data are useful, at best to take into account the problems of product mix and process mix on some sectors to some extent, to bring out the most disaggregative input output tables. An illustration of the use of a disaggregative input output table is attempted in Chapter V. For any further refinement of multidimensional products' problems of technological processes, the individual industry studies are the only alternative.

APPENDICES TO CHAPTER VIIInput structures of more aggregative product groups of die forgingsAppendix I

Here, we examine the input structures of two broad product groups, namely (1) All small die forgings α and (2) All big die forgings β whose average prices and values of production matrices are given as set II in this Chapter VII. $C_{(2 \times 2)}$, $C_{(2 \times 2)}^{-1}$, $D_{(2 \times 2)}$, $B_{(16 \times 2)}$, $A_{(16 \times 2)} = BC^{-1}$ and $E_{(16 \times 2)} = BD$ are presented. (in Tables 20 to 28, Appendix B). It is obvious from $C_{(2 \times 2)}$, $C_{(2 \times 2)}^{-1}$ and $D_{(2 \times 2)}$ matrices that small die forgings α (I to IV) are being specialized more by the combined set of firms A, B, C and big forgings β (V and VI) by Firm D.

In A Matrix, there are no negative coefficients, except for scrap as desired, under the input structures of Product group α (I to IV). All the input structures of Product group α (I to IV) are approximating to those of firm (A, B, C), which has no zero valued coefficients. There are six negative coefficients excluding that of scrap under the product groups β (V and VI), while there are three zero valued coefficients under the input structures of Firm D. Negative gross value added coefficient (-.141357), high distributive margins coefficient (.383397) and high negative scrap coefficient (-.066216) and the rest of the coefficients being very high estimates for the input structures of product group β (V and VI) compared to those of Firm D are spurious.

The input structures of each of the product groups α and β in A matrix sum to unity. From these observations in A matrix, one may infer that the linear transformation under commodity technology assumption is suitable only for small die forgings (α) but not for big die forgings (β).

From E matrix, the immediate inference is that the input structures of Product group β (V and VI) are closely approximating to those of Firm D and the input structures of the product group α (I to IV) are very high estimates, with the exception of low gross value added coefficient, compared to those of firm (A, B and C). The sum of input structures of each of product groups α and β is unity. Thus, the linear transformation under Firm or Industry technology assumption is more suitable for Big die forgings (V and VI) than for small die forgings (I to IV). After carrying out the 4 subsequent adjustments, listed in this Chapter for 4 product groups case, for improving the input structures of Product groups in A matrix, it is inferred that the input structures of small die forgings α (I to IV) at the fourth stage of adjustment are improved, while the input structures of big die forgings β (V and VI) in E matrix under Firm technology assumption are required to be retained without any adjustment. These results serve as an additional information whenever the die forgings are distinguished only by their piece weight and they also support the main findings of 4 product groups which distinguish the quality variations in small die forgings.

$A_{(16 \times 3)} = BC^{-1}$, $E_{(16 \times 3)} = BD$ matrices have been obtained (See Tables 29 to 38, Appendix B). It is obvious from C and D matrices that Product group a (I and II) is being specialized more by firm A, product group b (III and IV) by Firm B and C, Product group c (V and VI) by Firm D as their positive diagonal elements are stronger than off diagonal elements.

In A matrix, there are 4 negative coefficients excluding that of scrap for Product group c (V and VI), while there are three zero valued inputs under the input structures of Firm D. The negative coefficients for gross value added (-.041967), high negative scrap coefficient (-.05513) and very high distributive margins coefficients (.328987) of Product group c (V and VI) in A matrix are spurious, while all other coefficients are not at all approximating to those of Firm D.

In A matrix, the comments applicable to Product groups A (I and II), and B (III) in Set I are also true to the Product groups a (I and II) and b (III and IV) in this set III respectively. The input structures of each product group sum to unity. From these observations in A matrix, one may infer that the linear transformation under commodity technology assumption is not suitable to Product group c (V and VI) as it is suitable, at least for some direct inputs, of the product groups a (I and II) and b (III and IV).

In E matrix, all the input structures are positive, with the exception of scrap negative coefficients as desired,

The input structures of each of product groups sum to unity. It is observed in E matrix that the input structures of Product groups b (III and IV) and c (V and VI) are approximating to those of firms (B and C) and D respectively. The input structures of Product group a (I and II) are higher estimates, with the exception of gross value added coefficients being very low, compared to those of Firm A. From these observations in E matrix, one infers that the linear transformation under firm or industry technology assumption is the best suited to product group c (V and VI) and better suited to product group b (III and IV) compared to Product group a (I and II). Thus, product group b input structures in A and E matrices, following both the commodity technology and industry technology assumptions, are approximating to those of Firm (B and C). It is only at the fourth stage of the earlier mentioned adjustments, we could improve the input structures of the 3 aggregative product groups, for their meaningfulness (nonnegativity) and consistency, supporting the main findings of 4 product groups' study. Similar features are observed in the next best set IV of 3 product groups of the same definitions. The set IV results also support the main findings (See tables 39 to 44, Appendix B). These also serve as an additional information, whenever the forgings are required to be defined into these three aggregative product groups.

CHAPTER VIII

SUMMARY AND FINDINGS OF THE STUDY

(1) The study of 'Process analysis of steel forgings industry with special reference to the problems of continuity and product multidimensionality for sector specification in the interindustry framework' is oriented to a two fold problem.

(i) To study the economic features of steel forgings industry in India and the structural role of this jobbing type industry in the interindustry system, especially as a separate sector in the available input output table of Indian economy for 1963;

(ii) To resolve the problems of continuity and product multidimensionality of steel forgings with the help of data on engineering variables and of statistical methods, and to bring out discrete processes or product groups' dissimilar input structures, for analytical uses in the disaggregative commoditywise input output tables or in the linear programming models.

(2) The economic features of the industry are studied with reference to the structure, supply, demand pattern and development problems of the industry. The structure of firms according to plant capacity ranges is summarily presented by the modal type size of the plant capacities. The modal type size of the plant capacities rose from 334 tons in 1963-64, to 396 tons in 1964-65 and to 1551 tons by the end of December 1966. The production/capacity of the industry in private sector reached peak levels from 1960-61 to 1965-66, followed by a sudden trough during 1966-67 and a slight recovery during 1967-68. The demand pattern is dominated by

(i) railways, (ii) motor vehicles, (iii) earth moving equipment, (iv) diesel engines, and (v) all other non-electrical machinery. Imports are high and exports of steel forgings are negligible. The percentage of indigenous production to the total available supply, excluding those of captive and/or small scale units, for internal demand rose from 4.78% in 1960 to 36.84% in 1964.

(3) The development problems of this industry throw light on the necessity of requisite detailed data on the economic variables and on the nature of the products with respect to product dimensions of steel forgings. In this industry, price discriminations and other market imperfections are prevalent. As the nature of the industry demands complete specifications of the various product dimensions by every customer at each stage of any single order, it is necessary to have a rough knowledge of the distinct prices and dissimilar input structures of product groups with discrete ranges of the product dimensions for the interindustry analytical uses at the economy level as well as for financial planning at the firm level. The nature of the published statistics of the estimates of demand, capacity, production, imports and exports are too aggregative to be of any use either for the prospective entrepreneurs or for the analytical researchers. They demand a more detailed techno-economic data on the nature of the products with respect to product dimensions and to users of steel forgings in India. All other development problems also stress this lacuna.

(4) All these broad and general economic features of the industry are required to be studied in the light of a detailed investigation of the processes, products and materials of this industry. In the field investigation, it is observed that a wide range of products and materials are possible for production to meet the requirements of customers. The flexibility in the use of available equipments of the firms enables to meet the continuous change in the specifications of product-dimensions, which identify the numerous products. This is the problem of continuity for discrete sector specification in the inter industry framework. Secondly, the variations in the physical values of the multiple product-dimensions are likely to affect the input structures of the firms and of the industry. This is the problem of product multidimensionality for stable sector specification in the inter industry framework.

(5) To study these problems, initially, the firms in the industry are broadly classified as (i) Die forging firms, (ii) open forging firms and (iii) repairs and maintenance type forge units, which may be open or die forging units, but most of them are open forging units. This distinction of the firms is based on the nature of the products, processes and materials, which are likely to provide distinct product dimensions ranges.

(6) Next, the refined input and capital structures of the open and die forging firms are evaluated as technological parameters of the economic production functions of the units.

In this connection, a discussion is attempted on

(i) the different analytical approaches (traditional and modern) to explain the production theories of the units,

(ii) the nature, uses and limitations of Leontief input output analysis, as an instantaneous production function approach, to a firm or an industry,

(iii) conceptual and empirical problems in the evaluation of the input and capital structures of firms and processes in this industry in particular and in the preparation of input output tables of an economy in general,

(iv) Analysis of the input and capital structures of the firms. The adjustments carried out, for sub-contracting jobs, on the input structures of the firms and the role of sub-contracting jobs for sector specification, signify the importance of the industry studies in refining the structural coefficients of the economy.

(7) While the similarity of some inputs coefficients between firms and over years is partly due to the levels of aggregation and evaluation methods adopted, the discrepancies in the nature of inputs distinctly different from others are mainly due to the nature of products of the individual firms. This feature is very much observed regarding steel inputs, because hundreds of steel grade specifications are being used in the industry and some firms specialize in some products requiring particular sets of specifications of steel. Thus, the availability of materials and processes gets reflected in the nature of products of the firms. Because of the dis-

tinct nature of the products and their influence on the input structures, sleepers are distinguished from wheel sets, these two are distinguished from all remaining die forgings and the latter are distinguished from open forgings. Within each of the latter two, the problems of product multidimensionality still persist. These are the analytical results of the derived input and capital structures of the production units in this industry.

(8) Given the input structures of the firms in steel forgings industry and the aggregative nature of the available input output tables in India, it is intended to examine the direct and indirect repercussions of incorporating this jobbing type steel forgings industry, as an approximate discrete sector, distinguished from combined sectors, in the available disaggregative input output table of Indian economy at purchasers prices of 1963. Steel forgings as intermediate products place mainly intermediate demand within the inter industry structure and the growth of this intermediate demand rests with the growth of using industries' products and the latter's unit output requirements of steel forgings. Thus, (i) Railways, (ii) Motor vehicles, (iii) Diesel engines and (iv) all other non-electrical machinery industries take the major shares of the intermediate demand of steel forgings. The row input coefficients of 'Steel forgings' sector and of 'Iron and steel castings and forgings' sector are dissimilar in respect of their major users for the years 1963 and 1964. This stresses the need for distinguishing the

'Steel forgings' as a separate sector, when the users requirements and their growth rates are dissimilar from those of a combined sector 'Iron and Steel castings^{and} forgings'.

(9) The column vectors of (i) '66 - Steel forgings' sector in A (66 x 66), (ii) '45 - residual of Iron and steel exclusive of basic Iron and Steel and Steel forgings' sector in A (66 x 66), and (iii) '111 - Iron and Steel castings and forgings' Sector in A (241 x 241) are constructed and presented for comparison of their input coefficients. The column vectors of the latter two combined sectors are dissimilar from those of steel forgings sector, in respect of major inputs like the (i) forging quality steel, (ii) fuel oils, coke oven gas and other fuels, (iii) electric light and power inputs of steel forgings sector. The need for separate 'Steel forgings' sector in the input output tables of Indian economy is thus stressed because of its distinct column and row vectors from those of combined sectors.

(10) Incorporating the '66 - Steel forgings' as a separate sector in the (66 x 66) sectors input output table of Indian economy at purchasers prices of 1963, the following results are obtained : The estimated captive and/or small scale units' production of steel forgings in India are significantly high (65.46% of the total intermediate demand of steel forgings) compared to large scale units production and/or to imports (exports are negligible) of steel forgings in India at 1963 producers prices. The estimate of captive and/or small scale units' production is of the order of Rs. 8,73,99,458

which is not accounted for in any of the official and unofficial reports.

(11) The first stage indirect requirements of steel forgings, given in 66th row of A matrix, out of the total indirect requirements, given in the 66th row of $[A^2 + A^3 + \dots]$ are of very high proportion (86.97%), mostly because they are intermediate products with a very high intermediate demand. The relative advantages of disaggregation of a combined '45 - Iron and steel other than basic' into (i) '66 - Steel forgings' and (ii) '45- residual of Iron and steel exclusive of basic iron and steel and steel forgings' are also examined in respect of their total direct and indirect requirements.

(12) The second problem posed in paras (1) and (4) of this Chapter VIII, of product multidimensionality and of continuous change in product dimensions, especially in respect of a jobbing type industry like steel forgings, is taken up, here, to specify the discrete and distinct product groups in the industry. Such a discrete product groups specification is essential for many economic studies, especially in respect of interindustry analysis, as the illimitable products violate the discrete nature of a process. In the above study of the first problem, described in paras 5 to 11 of this Chapter VIII, the implicit assumption is that the technological forging process, described as a sector in the input output table, is an approximate discrete sector for the purpose of analysis. This implicit assumption is not required, if the product groups specified in the following study, have discrete processes with dissimilar input structures. Incidentally,

they may serve as the activities of linear programming models and as sectors in the disaggregative commoditywise input output tables. Their relevance to the project cost estimates of the forge units are also examined.

(13) Specification of the distinct product groups in this industry is made with respect to the homogeneity of the two very important engineering variables or characteristics or product dimensions. To arrive at the discrete and distinct product groups, the principal components analysis and scatter diagrams are adopted in this study. Six product groups (I to VI) of die forgings and four product groups (I to IV) of open forgings are formed with distinct and discrete ranges and means of the product dimensions. Statistical tests of significance for the homogeneity of means and of variances of the product groups are carried out.

(14) Average prices of a set of 4 (A to D) aggregated product groups (I to VI) of die forgings and of a set of 3 (K, J, N) aggregated product groups [(1) to (4)] of open forgings are derived by the method of linear transformations, $P = VT^{-1}$, where P is price vector of product groups, V is value of production vector of firms and T is tonnage distribution matrix of firms over product groups. The prices of wheel sets and sleepers are given in 'Statistics for Iron and Steel' published by the Hindustan Steel Limited, Ranchi. Thus, the average prices per ton of the products during 1966-67, presented in the Table I, are distinctly different from each other. Similarly, average prices of (i) all small die forgings

and (ii) all big die forgings as one set and of (i) small die forgings of inferior and medium quality, (ii) small die forgings of superior and very superior quality and (iii) Big and very big die forgings of medium quality as another set are also distinct (Not presented here).

Table I. Average prices of the product groups in steel forgings industry

S.No.	Product groups	Description	Average price in Rs.per M.Ton
<u>Die forgings</u>			
1	A (I and II)	Small die forgings of inferior and medium quality	3537.13
2	B (III)	Small die forgings of superior quality	5048.94
3	C (IV)	Small die forgings of very superior quality	9304.22
4	D (V and VI)	Big and very big die forgings of medium quality	20531.35
5		Wheel sets	1792.50
6		Sleepers	830.00
<u>Open forgings</u>			
7	K (I and III)	Small and big open forgings of medium quality	5932.23
8	J (II)	Small open forgings of superior quality	6382.72
9	N (IV)	Very big open forgings of medium quality	1147.94
		(Mostly repairs and maintenance type parts)	

The distinct prices of the products/product groups throw light on the standardization and specialization of the pro-

ducts/product groups by the firms, when the demands of the users are also specific to particular products/product groups. Mostly because of this specialization and the demand of only Railways for wheel sets and sleepers, the cost structures of the products are distinctly low. Similar is the case with product group N. The qualitative and quantitative features of the steel forgings are represented in the distinct prices of the product groups specified in Table I.

(15) To derive the dissimilar input structures of the product groups A, B, C, D, K, J and N (input structures of wheel sets and sleepers are given by the respective production units), the United Nation's (U.N.) general methods of linear transformations are adopted in the analysis. Two distinct assumptions and mixed assumptions of the two, specified below, are made and correspondingly linear transformations describing the technology matrices are derived by them. The assumptions are :

(i) commodity technology assumption is that each commodity will have its own input structure irrespective of the industry in which it is produced;

(ii) industry technology assumption is that every industry will have its own input structure irrespective of its productmix. These assumptions are correspondingly redefined as to (i) product group technology assumption and (ii) firm technology assumption and their respective linear transformations, for the purpose of the problem setting, in this industry study. The need for commoditywise input output tables is often

stressed with respect to the stability of inter industry structures, of final demands, of the commodities and of the price structures of the commodities in comparison to those of industries or industry groups as sectors.

(16) While the United Nations have evolved general methods of preparing commodity x commodity and industry x industry input output tables from the available commodity x industries data tables, with the help of the linear transformations under either of the two or mixed technologies assumptions, for aggregative sectors of the economy, this industry study, while bringing out the product groupwise input structures, stresses the implications and limitations of such general methods.

It is not always true that we can derive the feasible (commodity x commodity and industry x industry) input structures of each sector, with either of the technology assumptions, without any distinction between the different inputs of each sector. This difficulty arises because of the restrictive condition of square matrix and the inverse matrix elements of the linear transformation under commodity technology assumption and because of the conformability conditions of the product matrices of the linear transformations. As such it implies the precautions : (i) the number of commodities is equal to the number of industries, (ii) the derived input coefficients are non-negative and are not spurious. Findings of this industry study, especially the different technologies assumptions for different inputs of the sectors, are not spelt out by U.N., while suggesting the very general methods.

(17) The product group D (big and very big die forgings) is particularly more specific to the firm technology assumption in respect of all inputs. In the case of other product groups of die forgings, some direct inputs like steel, fuels and electricity are more specific commodity technology, while all other overhead items of inputs are more specific to firm technology for the product groups A (Small die forgings of inferior and medium quality), B (small die forgings of superior quality) and C (small die forgings of very superior quality). In the case of open forgings, both the technologies assumptions are being followed by 3 product groups corresponding to all positive coefficients of the firms. The proper choice of the suitable technologies assumptions depends on the prior knowledge of the requisite inputs of the product groups and/or of firms, especially with regard to zero and/or negative input coefficients and gross value added coefficients of the firms and/or of product groups.

(18) It is also seen that all small die forgings are more specific to commodity technology and all big die forgings are more specific to the firm technology assumption. Similar results are obtained on the 3 product groups (see para 14) of die forgings analysis. Very different findings may be thrown up in the other individual industry studies. Such findings of the individual industry studies are to be taken into consideration, before one makes use of generalized methods even for aggregative sectors of the economy. Such of these industry studies help in the refinement of the input structures of the commodities and/or of the industries, taking into

account their concerned technologies. They serve as part of the disaggregative studies, so far as all other technological processes are also disaggregated to arrive at the independent input structures of their multidimensional product groups. Any analytical use of such of the most disaggregative tables requires that the final bill of goods demand also needs to be distinguished by the same ranges of the product groups of the multidimensional products. But in practice, even the problems of productmix and process mix emanating from the aggregated input output tables could not be resolved for all practical reasons of nonavailability of detailed data on outputs and corresponding inputs.

(19) The utility of this study of arriving at the average prices and the input structures of the product groups of multidimensional products is quite obvious in financial projections every year or project cost estimates of the prospective entrepreneurs. The traditional practice of providing the project cost details for a given tonnage capacity of the plant is too aggregative to be of any use, as the demand pattern is guided by many product dimensions specified by customers at each stage of production. Even the capital structures of the firms under a given technology are likely to be different for different ranges of product dimensions. The proper choice of the current and capital expenditures of the entrepreneurs ultimately depends upon the proper identification of the ranges of the product dimensions or of their product groups.

(20) The two-fold problem of this study is thus oriented to provide a methodology for similar jobbing type industries studies, with their problems of continuity and multidimensionality for sector specification in the interindustry framework. The available Annual Survey of Industries' reported data which are the main source to bring out the most disaggregate input output tables may at best take into account the problems of productmix and processmix to some extent at least on some sectors for the stability of the interindustry structures. For any further refinement of the multidimensional products' problems on stability of interindustry structures, resort to the individual industry studies is the only alternative.

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Table A.4 : Input Structures of Die Forging Firms at Producers Prices of years 1960-61 to 1967 after making all Requisite Refinements.

S.No.	Nature of Input	241 S.I. P.E. Sector No.	ASIC No.	Firm C (1963-64 ending March)	Firm E (1963-64 March ending)	Firm F (1963- 64 March ending)	Firm F (1962- 63 ending March)	Firm F (1961-62 March ending)	Firm F (1960-61 March ending)
1.	Printing and Stationery	62	280-1	0.001822					
2.(a)	Light Diesel Oil	90	321						
2.(b)	High speed Diesel Oil	90	321						
2.(c)	Furnace Oil	90	321	0.029874					
2.(d)	Lubricants	90	321	0.001744					
2.(e)	Motor car running expenses	90	321	0.002723					
2.	TOTAL oils	90	321	<u>0.034341</u>					
3.(a)	C o k e	91	329						
3.(b)	2Coke Oven gas	91	329		0.010233	0.005466	0.007506	0.005275	0.001665
3.(c)	Elast Furnace Gas	91	329		0.001429	0.000766	0.001327	0.002644	0.032019
3.(d)	Crude Tar	91	329						
3.	TOTAL Coke Products	91	329		<u>0.011662</u>	<u>0.006232</u>	<u>0.008833</u>	<u>0.007919</u>	<u>0.033684</u>
4.	Refractories	93	331-2		0.002147	0.000607	0.000661	0.000279	
5.	Chemicals - Auxiliaries	69 to 77	311	0.000212					
6.(a)	Carbon steel - Imported	110	341-2						
6.(b)	" " Indigenous	110	341-2						
6.(c)	TOTAL Carbon Steel	110	341-2						
7.(a)	Alloy Steel Imported	110	341-2						
7.(b)	" " Indigenous	110	341-2						
7.	TOTAL Alloy Steel	110	341-2						
8.(a)	Die Block Steel Imported	110	341-2						
8.(b)	" Tool " "	110	341-2						
8.	TOTAL Die Steel	110	341-2						
9.	TOTAL Steel	110	341-2	<u>0.340531</u>					
10-	Postage, Telephone charges	169,170	370-2 &	0.000679					
11.	Electricity.....	171	370-3						
		200	511	0.030213	0.013387	0.002273	0.003483	0.003524	0.015659
12.	Oxygen & Acetylene	200	512		0.000577	0.000166	0.000300	0.000113	
13.	Consumable Stores and Packing Materials	233	-	0.019697	0.013544	0.001349	0.001993	0.004267	0.009389
14.	Repairs and Maintenance	235	-	0.026873	0.026637	0.006160	0.007504	0.005107	0.028242
15.	Uniform Safety Equipment	236	-						
16.	Transport	238 & 239	-	0.021188	0.005039	0.000120	0.001080	0.000063	0.002936
17.	Water	241	-	0.000384	0.006750	0.000311	0.000271	0.000422	0.001947
18.	Distributive Margins	240	-		0.068807	0.069231	0.066085	0.091966	
19.	Scrap				-0.192260	-0.006068	-0.010651	-0.024598	-0.035094
20	Ingots & Blooms	109	341-1		0.507830	0.426035	0.585341	0.623072	0.886235
21.	Gross value added			0.524000	0.535880	0.493584	0.334900	0.287866	0.057002
	T O T A L			1.000000	1.000000	1.000000	1.000000	1.000000	1.000000

Note : Free or Open Forging Firms' input structures are the same as given in Table 1 of Chapter IV with no further details

Table A.5. Fixed capital coefficients of die forging firms other than those given in Table 2.

Nature of Fixed Capital	Firm G(1965-1966)	Firm Y (1965-66)	Firm X (1964-1965)
1. Plant and Machinery	0.506149	0.793667	0.669741
2. Electrical installation	0.030190	0.066646	0.043275
3. Transport equipment	0.010562 (a)	0.010562	0.010562
4. Engineering instruments	0.005336	0.005336	0.005336 (b)
5. Buildings	0.075740	0.186737	0.096681
6. Factory equipment	0.018842	0.018842	0.018842 (c)
7. Land	0.020199	0.043540	0.020186
8. Office equipment	0.005874	0.008827	0.008827 (d)
9. Furniture and fittings	0.013418	0.008704	0.004855
10. Motor cars and Commercial vehicles	-	0.036236	0.031753
11. Railway Road sliding	-	-	0.004754
12. Other fixed assets	-	0.016912	-
Total	0.686310	1.196009	0.914812

Note

The Fixed capital coefficients of open Forging Firms are not available.

(a) This coefficient of Firm G is assumed to be the same for other firms Y and X also.

(b) This coefficient of Firm X is assumed to be the same for other firms G and Y also.

(c) This coefficient of Firm X is assumed to be the same for other firms G and Y also.

(d) This coefficient of Firm X is assumed to be the same for Firm Y also.

Table A.6. Inventories of working capital coefficients of steel forging firms during 1965-1967

Nature of Inventories	Die forging firms			Open Forging Firms				
	Firm D (1966-1967 Imported)	(1966-1967 Indigenious)	June ending Total)	Firm G (1967)	Firm G (1966)	Firm G (1965)	Firm J (1966-67)	Firm N (1966-67)
1.1 Fuels								
(a) Furnace oil	-	0.002421	0.002421	0.004690	0.004167	0.005059	-	-
(b) Light diesel oil	-	0.000619	0.000619	-	-	-	-	-
(c) High speed diesel oil	-	0.000056	0.000056	-	-	-	-	-
1.2 Lubricants	-	0.003604	0.003604	0.001313	0.001535	0.001012	-	-
1.3 Power	-	-	-	0.001876	0.002193	0.001686	-	-
1.4 Water	-	-	-	0.000563	0.000658	0.000675	-	-
I Total fuels etc.	-	<u>0.006700</u>	<u>0.006700</u>	<u>0.008442</u>	<u>0.008553</u>	<u>0.008432</u>	<u>0.003797</u>	-
II Materials - basic								
(a) Carbon steel	0.053269	0.121685	0.174954	-	-	-	0.007810	-
(b) Alloy steel	0.223267	-	0.223267	-	-	-	0.312380	-
(c) Die block steel	0.059632	-	0.059632	-	-	-	0.000337	-
(d) Die and Tool steel	0.045723	-	0.045723	-	-	-	0.107432	-
II Total Material steel	<u>0.381891</u>	<u>0.121685</u>	<u>0.503576</u>	<u>0.066604</u>	<u>0.073465</u>	<u>0.129848</u>	<u>0.427959</u>	-
III Semi-finished goods and in process								
(a) Forge shop	-	0.082324	0.082324	-	-	-	-	-
(b) Heat Treatment shop	-	0.116279	0.116279	-	-	-	-	-
(c) Die shop	0.086862	0.059238	0.146100	-	-	-	-	-
III Total semi-finished goods in process	<u>0.086862</u>	<u>0.257841</u>	<u>0.344703</u>	<u>0.018762</u>	<u>0.010965</u>	<u>0.038786</u>	<u>0.156307</u>	-
IV Products and by products								
(a) Finished forgings	-	0.061659	0.061659	0.028143	0.010965	0.025295	0.047010	0.039121
Total	<u>0.468753</u>	<u>0.447885</u>	<u>0.916638</u>	<u>0.121951</u>	<u>0.103948</u>	<u>0.202361</u>	<u>0.635073</u>	-

Table A.6 (a). Inventories of Working capital coefficients of Firm E

	1963-64	1964-65	1965-66	1966-67
1. Wheel ingots (tons)	0.006940	0.015085	0.002162	0.010662
2. Axle Blooms (tons)	0.000848	0.001897	0.010256	0.010142
3. Wheel sets (Nov)	0.021000	0.057809	0.034331	0.066583
4. Others	0.494412	0.205369	0.148761	0.178111
Total	0.523200	0.280160	0.195510	0.265498

Table A.6 (b). Inventories of Working capital coefficients of Firm F

	1961-62	1962-63	1963-64	1964-65	1965-66	1966-67
1. Sleeper bars	0.055829	0.008581	0.07519	0.025825	0.027102	0.029989
2. Sleepers	0.121666	0.185510	0.010648	0.019375	0.101473	0.135816
	0.177495	0.194091	0.018167	0.045200	0.128575	0.165805

Table A.7. Personnel coefficients per rupee worth
output of a steel die forging unit

1. Managerial	0.044617
2. Supervisory and Technical	0.010267
3. Supervisory and Non-technical	0.002365
4. Trainee Engineers	0.007831
5. Job Trainees	0.002470
6. Foreign Technicians	0.039858
7. Labour	0.050623
8. Clerical	0.014523
Total	0.172554

Table A.8(a). Input structures of the intermediate technological processes of Firm E (wheel sets unit) during 1963-64

Nature of Inputs	241 GIPE Sec. No.	ASIC No.	Process I Ingot breaking	Process II Heating, Pressing for wheels	Process III Wheel machining	Process IV Cutting, Heating Forging Axle Bloom	Process V Axle Machining	Process VI Assembly of wheel sets
1. Ingots	109	341-1	0.980439					
2. Blocks	109	341-1		0.756190				
3. Forged wheel	111	341-3			0.938867			
4. Blooms	109	341-1				0.711016		
5. Forged Axle	111	341-3					0.868048	
6. Machined wheel	111	341-3						0.731296
7. Machine Axle	111	341-3						0.237005
8. Wheel sets (6 and 7)	111	341-3						0.968301
9. Wages and Salaries	-	-	0.011506	0.053936	0.030977	0.049422	0.076257	0.012552
10. Productive supplies	233	-	0.004230	0.007739	0.009514	0.022037	0.012205	0.010099
11. (a) Raw water	241	-		0.004381	0.000976	0.005913	0.001556	0.000368
(b) Processed water	241	-	-	0.002638	0.001217	0.002707	0.002976	-
(c) Electricity	200	511	0.000097	0.011291	0.006795	0.026062	0.013803	0.002637
(d) Coke oven gas	91	329		0.017492		0.014083		
(e) Blast furnace gas	91	329		0.002438		0.001979		
(f) Int. Rail transport	238	-		0.005023		0.006734		
(g) Int. Road transport	239	-		0.002231		0.002991		
(h) Refractories	93	331-2	0.	0.004176		0.005599		
(i) Oxygen	200	512		0.000831		0.001113		
11. Total services	-	-	<u>0.000097</u>	<u>0.050501</u>	<u>0.008988</u>	<u>0.067181</u>	<u>0.018335</u>	<u>0.003005</u>
12. Repairs and maintenance	235	-	-	0.081850	-	0.095252	-	-
13. Overheads	-	-	0.003728	0.049784	0.011654	0.055092	0.025155	0.006043
14. Total cost of production (1 to 14)	-	-	<u>1.000000</u>	<u>1.000000</u>	<u>1.000000</u>	<u>1.000000</u>	<u>1.000000</u>	<u>1.000000</u>
15. Scrap and Scale	-	-	-0.096783	-0.004856	-0.038758	-0.120416	-0.209403	-
16. Value in Rs. total cost of production			12058919	13713985	14858689	6683099	6077320	17126661
17. Tonnage production			32118	27124	18970	15569	9846	24953

Table A.8(b). Input structures of the intermediate technological processes of Firm E (wheel sets unit) during 1964-65

Nature of Input	241 GIPE Sector No.	ASIC No.	Process I Ingot breaking	Process II Heating, Processing for wheels	Process III wheel machining	Process IV Cutting, Heating, Forging Axle Bloom	Process V Axle machining	Process VI Assembly of wheel sets
1. Ingots	109	341-1	0.970601					
2. Blocks	109	341-1		0.724370				
3. Forged wheel	111	341-3			0.918136			
4. Blooms	109	341-1				0.735064		
5. Forged Axle	111	341-3					0.882067	
6. Machined wheel	111	341-3						0.669818
7. Machined axle	111	341-3						0.296274
8. Wheel set (6 + 7)	111	341-3						<u>0.966092</u>
9. Productive supplies	233	-	0.005374	0.018579	0.009894	0.019694	0.009833	0.007424
10. Wages and Salaries	-	-	0.014782	0.053682	0.037805	0.037824	0.059102	0.012851
11. Services (a) Raw water	241	-		0.002993	0.000625	0.003694	0.000721	0.000198
(b) Processed water	241	-		0.002229	0.001011	0.002127	0.001675	-
(c) Electricity	200	511	0.000094	0.010324	0.007051	0.021569	0.009898	0.002881
(d) Coke oven gas	91	329		0.015404		0.010488		
(e) Blast furnace gas	91	329		0.002586		0.001763		
(f) Int. railway transport	238	-		0.005428		0.005733		
(g) Int. road transport	239	-		0.002270		0.002398		
(h) Refractories	93	331-2		0.003598		0.003800		
(i) Oxygen	200	512		0.001286		0.001358		
11. Total services	-	-	<u>0.000094</u>	<u>0.046118</u>	<u>0.008687</u>	<u>0.052930</u>	<u>0.012294</u>	<u>0.003079</u>
12. Repairs and Maintenance	235	-	-	0.071467	-	0.072033	-	-
13. Overheads	e.		0.009149	0.085784	0.025478	0.082455	0.036704	0.010554
14. Total cost of production (1 to 14)			<u>1.000000</u>	<u>1.000000</u>	<u>1.000000</u>	<u>1.000000</u>	<u>1.000000</u>	<u>1.000000</u>
15. Scrap and Scale			- .145386	- .010457	- .033185	- .000264	- .210185	-
16. Value in Rs. total cost of production			13148756	16630643	16911223	9098047	10197019	25304524
17. Tonnage Production			31993	30887	21981	17706	10182	32514

Table A.8 (c). Input structures of the intermediate technological processes of Firm E (wheel sets unit) during 1965-66

Nature of Input	241 GIPE Sector No.	ASIC No.	Process I Ingot breaking	Process II Heating, Processing for wheels	Process III wheel machining	Process IV Cutting, Heating Forging Axle Bloom	Process V Axle machining	Process VI Assembly of wheel sets
1. Ingots	109	341-1	0.978451					
2. Blocks	109	341-1		0.758266				
3. Forged wheel	111	341-3			0.916401			
4. Blooms	109	341-1				0.738745		
5. Forged axle	111	341-3					0.837658	
6. Machined wheel	111	341-3						0.672703
7. Machined axle	111	341-3						0.305639
8. Total (6 + 7)	111	341-3						<u>0.978342</u>
9. Wages and salaries			0.013459	0.048778	0.035279	0.041708	0.066332	0.012960
10. Productive supplies	233	-	0.002210	0.021641	0.022009	0.019389	0.048321	0.001330
11. Services (a) Raw water	241	-		0.002020	0.000580	0.002840	0.000266	0.000062
(b) Processed water	241	-		0.001233	0.000524	0.001815	0.000971	-
(c) Electricity	200	511	0.000089	0.010168	0.005696	0.023862	0.008769	0.002641
(d) Coke oven gas	91	329		0.015592		0.012117		
(e) Blast Furnace gas	91	329		0.002620		0.002076		
(f) Int. Rail transport	238	-		0.005128		0.005629		
(g) Int. Road transport	239	-		0.002784		0.003056		
(h) Refractories	93	331-2		0.005514		0.005951		
(i) Oxygen	200	512		0.001442		0.001590		
11. Total services			<u>0.000089</u>	<u>0.046501</u>	<u>0.006800</u>	<u>0.058936</u>	<u>0.010006</u>	<u>0.002703</u>
12. Repairs and maintenance	235	-	-	0.062218	-	0.066668	-	-
13. Overheads			0.005791	0.062596	0.019511	0.074554	0.037683	0.004665
14. Total cost of production (1 to 14)			<u>1.000000</u>	<u>1.000000</u>	<u>1.000000</u>	<u>1.000000</u>	<u>1.000000</u>	<u>1.000000</u>
15. Scrap and Scale			-0.080486	-0.013873	-0.024520	-0.017417	-0.078116	-
16. Value in Rs. total cost of production			16354434	19953019	21749238	9050259	10821995	30285160
17. Tonnage Production			36823	32463	22917	16038	10390	31859

Table A.8(d). Input structures of the intermediate technological processes of Firm E (wheel sets unit) during 1966-67

Nature of Input	241 GIPE Sector No.	ASIC No.	Process I Ingot breaking	Process II Heating, Processing for wheels	Process III wheel machining	Process IV Cutting, Heating Forging Axle Bloom	Process V Axle machining	Process VI Assembly of wheel sets
1. Ingots	109	341-1	0.972848					
2. Blocks	109	341-1		0.689738				
3. Forged wheel	111	341-3			0.894104			
4. Blooms	109	341-1				0.699884		
5. Forged Axle	111	341-3					0.842442	
6. Machined wheel	111	341-3						0.639248
7. Machined axle	111	341-3						0.324781
8. Wheel set (6 + 7)	111	341-3						<u>0.964029</u>
9. Total wages and salaries			0.017982	0.054986	0.048994	0.037261	0.067320	0.016429
10. Productive supplies	233	-	0.001472	0.018185	0.020025	0.023396	0.038583	0.005973
11. Services (a) Raw water	241	-		0.002541	0.000711	0.002687	0.000277	0.000086
(b) Water Processed	241	-		0.002173	0.000567	0.001955	0.000852	-
(c) Electricity	200	511	0.000085	0.013231	0.007761	0.025130	0.008922	0.003397
(d) Coke oven gas	91	329		0.023174		0.014843		
(e) Blast Furnace gas	91	329		0.003578		0.002312		
(f) Int. Rail Transport	238	-		0.005987		0.006210		
(g) Int. Road transport	239	-		0.005621		0.005830		
(h) Refractories	93	331-2		0.005781		0.002626		
(i) Oxygen	200	512		0.001494		0.001550		
11. Total services			<u>0.000085</u>	<u>0.063580</u>	<u>0.009039</u>	<u>0.063143</u>	<u>0.010051</u>	<u>0.003483</u>
12. Repairs and maintenance	235	-		0.087840	-	0.093316		
13. Overheads			0.007613	0.085671	0.027838	0.082992		0.010086
14. Total cost (1 to 14)			<u>1.000000</u>	<u>1.000000</u>	<u>1.000000</u>	<u>1.000000</u>	<u>1.000000</u>	<u>1.000000</u>
15. Scrap and Scale			-.126184	-.018996	-.024520	-.012072	-.078116	-
16. Value in Rs. total cost of production			11813294	14803587	15108064	8364119	10881487	23046397
17. Tonnage production			25061	20901	15019	12059	7586	21305

Table A.9. Fixed capital coefficients of Plant and Machinery per rupee worth capacity of die forging firms - shopwise

	Firm D	Firm A	Firm C	Firm G
1. Forge shop	0.785880	0.401864	0.372812	0.343559
2. Heat Treating shop	0.088005	0.052917	0.078005	0.032029
3. Saw and shear	0.085731	0.042894	0.040263	0.006986
4. Die Shop	0.156079	0.030725	0.080176	0.101550
5. Finishing Deptt.	0.080592	0.009821	0.028744	0.025007

Total	1.196287	0.538221	0.600000	0.509131

Note.

The detailed machinerywise coefficients are given in Table 10 only for firm D as incremental capital coefficients of the new plant.

Table A.10. Incremental Fixed capital coefficients of a new plant per rupee worth capacity

Nature of Fixed capital goods	Fixed capital coefficients	
	Imported	Indigenous
<u>I. Forge shop equipment</u>		
1. 25000 lbs. drop Hammer with all its regular equipment	0.112452	-
2. 600 ton press with all its electrical equipment	0.024707	-
3. 16000 lbs drop hammer	0.094653	-
4. 545 ton trimmer mill with all its " "	0.023395	-
5. 12000 lbs. drop hammer	0.069425	-
6. 7 1/2" Forging Machine (upsetter)	0.470665	-
7. 500 ton trimming press	0.023395	-
8. 4" Forging Machine (upsetter)	0.046296	-
9. 6000 lbs. Drop hammer	0.041154	-
10. 200 Ton Trimming Press	0.014263	-
11. 4000 lbs drop hammer	0.029590	-
12. 200 Ton Press	0.012167	-
13. 3000 lbs drop hammer	0.052204	-
14. 100 Ton Presses	0.017578	-
15. 2000 lbs drop hammer	0.036110	-
16. 100 Ton Presses	0.017578	-
17. 4000 lbs drop forging hammer	0.022889	-
18. 1000 ton Hydraulic Press	0.036745	-
19. 200 ton bulldozer	0.010584	-
20. Oil Fired Heating Furnaces (12' x 4'-6")	0.013574	-
21. " (8' x 3'-6")	0.004263	-
22. " (8" x 2'-6")	0.004531	-
23. " (5'-3" x 4'-0")	0.002842	-
24. " (8' x 3'-6")	0.001322	-
25. " (8' x 3'-6")	0.001133	-
26. 100 Ton Presses	0.017578	-
27. 75 ton presses crank single	0.008386	-
Total forge shop	<u>0.785880</u>	-
<u>II. Heat Treating Equipments</u>		
28. Oilfired hardening, tempering furnaces and quenching tanks	0.067711	-
29. " " "	0.013573	-
30. Heat Treating Furnaces	0.006721	-
Total Heat Treatment	<u>0.088005</u>	-
<u>III. Saw and Shear</u>		
31. Bar billet shear 900 ton press	0.044493	-
32. " 500 "	0.016252	-
33. Abrasive cutting machine 400 ton bars press	0.007850	-
34. Grinder saws with all electrical equipment	0.017136	-
Total saw and shears	<u>0.085731</u>	-

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Continued/..

Table A.10 - continued

Nature of Fixed capital goods	Fixed capital coefficients	
	Imported	Indigenous
<u>IV. Die Shop</u>		
35. Vertical hydro Diesinking M/c with elec.equipment	0.025069	-
36. " "	0.042214	-
37. " "	0.061552	-
38. Surface grinder incl. elec. equipment	0.025652	-
39. Band Saw 28"	0.001592	-
Total Die Shop	<u>0.156079</u>	-
<u>V. Finishing Dept.</u>		
40. Shot blasting machine with ancillaries	0.019526	-
41. Crank Press with electrical equipment	0.016735	-
42. Straightening Press	0.011596	-
43. Countering Machine	<u>0.032735</u>	-
Total Finishing dept.	<u>0.080592</u>	-
<u>VI. Materials handling equipment</u>		
44. Hydraulic crane	0.011731	-
45. Electric lift platform trucks	0.025221	-
46. Forklift Trucks	0.007359	-
47. Forklift hydraulic platform trucks	0.002549	-
Total Materials handling equipment	<u>0.046860</u>	-
<u>VII. Maintenance equipment</u>		
48. Surface grinder (high powered precision)	0.019068	-
49. 600 Ampere Motor generator Arc Welder	0.000424	-
50. Steam cleaner, oil fired electric	<u>0.000461</u>	-
Total Maintenance equipment	<u>0.019953</u>	-
<u>VIII. Inspection and Laboratory equipment</u>		
51. 60,000 lbs. Universal Testing M/c. with elec. equipment	0.009093	-
52. Import testing M/c.	0.001622	-
53. Hardness Testing M/c. with 16" capacity "	0.000447	-
54. Balphot Metallograph	0.003815	-
55. Spectrograph	0.002124	-
56. Magnaflux equipment	0.005484	-
57. Direct reading Brinell Hardness Tester	0.003913	-
58. Brinell Microscoper	0.000650	-
59. Minneapolis Thermocouple Test set	<u>0.000216</u>	-
Total Inspection and Laboratory Equipment	<u>0.027364</u>	-
<u>IX. Tool Room Equipment</u>		
60. Automatic saw sharpening M/c. with elec. equipment	0.002564	-
61. Universal cutter, grinder - do -	<u>0.002352</u>	-
Total Tool room equipment	<u>0.004916</u>	-
<u>X. Miscellaneous Equipment</u>		
62. Combustion control instruments for automatic /forge temperature control of 14/heating furnaces	0.008702	-
63. Weighing balance 10 M. Tons with 12" dia.	0.000474	-
64. Grinders complete with elec. equipment	0.002152	-
65. Marvel Hack Saw - do -	0.002209	-

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Continued/..

Table A.10 - concluded

Name of Fixed capital goods	Fixed capital coefficients	
	Imported	Indigenous
66. Vibration absorbing material for hammer use	0.018238	-
67. Rectifier of Power supply	0.002515	-
68. Electric Hoists and Trolleys	0.010061	-
69. Pipes, Valves fittings, traps, insulating materials	0.021596	-
70. Two steam generators	0.036020	-
71. Mechanical and electrical components for cranes	0.035506	-
72. Spares parts for hammer	<u>0.036050</u>	-
Total Miscellaneous equipment	<u>0.173523</u>	-
<u>XI. Crankshaft Facility</u>		
73. Hydraulic copying lathe	0.028296	-
74. Hydraulic grinding machines	0.037037	-
75. Crankshaft drilling machine	0.012261	-
76. Carbide tool grinder with motor	0.000948	-
77. Drill grinder	0.000960	-
78. Tapping machine, balancing and keyway sealing m/c.	0.015741	-
79. Shimoga lathe 9 1/4" x 8'10"	-	0.006241
80. Herbert Turret Lathe	-	0.010216
81. Bombay Lathe 12 1/2" x 12'	-	0.017519
82. 24 high speed shaping m/c.	-	0.008519
83. Radial drilling m/c. 52" x 15	-	0.004184
84. Universal Milling m/c.	-	0.008148
85. Universal Cutter and Tool Grinder	-	0.002370
Total crankshaft facility	<u>0.095243</u>	<u>0.057197</u>
Total	1.564146	0.057197

Table A.11. Ratios Producers' to Purchasers' Prices of inputs/outputs

Nature of inputs/outputs	241 GIPE Sector No.	ASIC Sector No.	<u>Producers Prices</u> <u>Purchasers Price</u>
1. All Fuel oils	90	321	0.542824
2. Electricity	200	511	0.780000
3. Oxygen and Acetylene	200	512	1.000000
4. Coke, Coke oven gas, Blast furnace gas	91	329	1.000000
5. Carbon steel	110	341-2	0.748785
6. Alloy steel	110	341-2	0.950294
7. Die steel	110	341-2	0.950294
8. Lubricants	90	321	0.542824
9. Water	241	-	1.000000
10. Refractories	93	331-2	0.740000
11. Chemicals and Auxiliary Materials	69-77	311	0.617238
12. Consumable stores and Packing Materials	233	-	0.637952
13. Transport	238-239	-	1.000000
14. Motor car running expenses	90	321	0.542824
15. Crude tar	91	329	1.000000
16. Printing and Stationery	62	280-1	0.500000
17. Postage, telephone charges	169,170,171, 370-2,3		0.760000
18. Conveying expenses	238-239	-	1.000000
19. Repairs and Maintenance	235	-	1.000000
20. Uniform safety equipment	236	-	1.000000
21. Distributive Margins	240	-	1.000000
22. Scrap	-	-	1.000000
23. Ingots and Blooms	109	341-1	1.000000
24. Sleeper bars	109	341-1	1.000000
25. Steel Forgings	111	341-3	0.730000

Appendix B. Appendix Tables to Chapter VII
(Tables B.20 to B.44)



Set IITable B.20. $C(2 \times 2)$ matrix of die forgings

Firms \rightarrow	A, B, C	D
Product groups \downarrow		
α	.996489	.825731
β	.003511	.174269

Table B.21. $C^{-1}(2 \times 2)$ Matrix of die forgings

	1.020561	-4.835680
	.020561	5.835680

Table B.22. $D(2 \times 2)$ matrix of die forgings

Product groups \rightarrow	α	β
Firms \downarrow		
A, B, C	.589698	.023431
D	.410302	.976569

Set IITable B.23. Matrix B (16x2) - Input structures of die forgings firms

Sr. No.	241 GIPE Sector	ASIC Sector	Description	Firms A, B, C	Firm D
1	62	280-1	Printing and Stationery	0.000381	0.002788
2	90	321	Fuel oils	.019209	.052117
3	91	329	C.O. Gas etc.	.000205	-
4	69-77	311	Chemicals	.000323	-
5	110	341-2	Steel	.335891	.323774
6	169, 170, 171	370-2, 3	Telephone charges	.000391	.003248
7	200	511	Electricity	.012135	.009309
8	200	512	Oxygen and Acetylene	.000548	-
9	233	-	Consumable Stores	.005982	.046807
10	235	-	Repairs and Maintenance	.011281	.006926
11	236	-	Safety equipment	.000117	.003153
12	238- 239	-	Transport	.004294	.016837
13	241	-	Water	.000189	.000225
14	-	-	Scrap	-.005945	-.016273
15	-	-	Distributive margins	.093521	.143194
16	-	-	Gross value added	.521478	.407895
			Total	1.000000	1.000000

Set IITable B.24. Matrix $BC^{-1} = A(16,2)$. Input Structures of die forgings

S. No.	241 GIPE Sector	ASIC Sector	Description	$\alpha(I, II, III, IV)$	$\beta(V, VI)$
1	62	280-1	Printing and Stationery	.000332	0.014428
2	90	321	Fuel oils	.018532	.211249
3	91	329	C.O. gas etc.	.000209	-.000991
4	69-77	311	Chemicals	.000330	-.001562
5	110	341-2	Steel	.336140	.265180
6	169, 170, 171	370-2, 3	Telephone charges	.000332	.017064
7	200	511	Electricity	.012193	-.004357
8	200	512	Oxygen and Acetylene	.000559	-.002650
9	233	-	Consumable Stores	.005143	.244224
10	235	-	Repairs and Maintenance	.011371	-.014133
11	236	-	Safety equipment	.000055	.017834
12	238-239	-	Transport	.004036	.077491
13	241	-	Water	.000188	.000399
14	-	-	Scrap	-.005733	-.066216
15	-	-	Distributive margins	.092500	.383397
16	-	-	Gross value added	.523813	-.141357
			Total	1.000000	1.000000

Set IITable B.25. Matrix ED = E(18,2). Input structures of Product groups of die forgings

S. No.	241 GIPE Sector	ASIC Sector	Description	α (I,II,III,IV)	β (V, VI)
1	62	280-1	Printing and Stationery	0.001369	0.002732
2	90	321	Fuel oils	.032711	.051346
3	91	329	C.O.Gas etc.	.000121	.000005
4	69-77	311	Chemicals	.000190	.000008
5	110	341-2	Steel	.330919	.324058
6	169, 170, 171	370-2,3	Telephone charges	.001563	.003181
7	200	511	Electricity	.010975	.009375
8	200	512	Oxygen and Acetylene	.000323	.000013
9	233	-	Consumable Stores	.022733	.045850
10	233	-	Repairs and Maintenance	.009494	.007028
11	236	-	Safety equipment	.001363	.003082
12	238-239	-	Transport	.009440	.016543
13	241	-	Water	.000204	.000224
14	-	-	Scrap	-.010183	-.016031
15	-	-	Distributive margins	.113902	.142030
16	-	-	Gross value added	.474876	.410556
			Total	1.000000	1.000000

Set II

Table B.26. Adjustment (I). Input structures of product groups of die forgings, based on commodity technology assumption, replacing the negative coefficients by zero values in the respective cells of $A=BC^{-1}$ Matrix

S. No.	241 GIPE Sector	ASIC Sector	Description	$\alpha(I-IV)$	$\beta(V,VI)$
1	62	280-1	Printing and Stationery	0.000332	0.014428
2	90	321	Fuel oils	0.018532	0.211249
3	91	329	C.O. Gas etc.	0.000209	-
4	69-77	311	Chemicals	0.000330	-
5	110	341-2	Steel	0.336140	0.265180
6	169, 170, 171	370-2,3	Telephone charges	0.000332	0.017064
7	200	511	Electricity	0.012193	-
8	200	512	Oxygen and Acetylene	0.000559	-
9	233	-	Consumable Stores	0.005143	0.244224
10	235	-	Repairs and Maintenance	0.011371	-
11	236	-	Safety equipment	0.000055	0.017834
12	238, 239	-	Transport	0.004036	0.077491
13	241	-	Water	0.000188	0.000399
14	-	-	Scrap	-.005733	-.066212
15	-	-	Distributive margins	.092500	.383397
16	-	-	Gross value added	.523813	-
			Total	1.000000	1.000000

Set II

Table B.27. Adjustment (3). Input structures with commodity technology applicable to steel, fuels and electricity and firm technology to the rest of the input coefficients of all product groups of die forgings

S. No.	241 GIPE Sector	ASIC Sector	Description	α (I-IV)	β (V-VI)
1	62	280-1	Printing and Stationery	0.000332	0.014428
2	90	321	Fuel oils	0.018532	0.211249
3	91	329	C.O. Gas etc.	0.000121	0.000005
4	69-77	311	Chemicals	0.000190	0.000008
5	110	341-2	Steel	0.336140	0.265180
6	169, 170, 171	370-2,3	Telephone charges	0.000332	0.017064
7	200	511	Electricity	0.010975	0.009375
8	200	512	Oxygen and Acetylene	0.000323	0.000013
9	233	-	Consumable Stores	0.005143	0.244224
10	235	-	Repairs and maintenance	0.009494	0.007028
11	236	-	Safety equipment	0.000055	0.017834
12	238-239	-	Transport	0.004056	0.077491
13	241	-	Water	0.000188	0.000399
14	-	-	Scrap	-0.010183	-0.016031
15	-	-	Distributive margins	.113902	.142030
16	-	-	Gross value added	.474876	.410556
			Total	1.000000 0.964456	1.000000 1.400853
			Revised Gross Value added	.510420	-

Set II

Table B.28. Adjustment (4). Input structures with firm technology applicable to product group β for all its inputs and commodity technology to the direct inputs and firm technology to the rest of the inputs of product group α of die forgings

S. No.	241 GIPE Sector	ASIC Sector	Description	α (I-IV)	β (V-VI)
1	62	280-1	Printing and Stationery	0.000332	0.002732
2	90	321	Fuel oils	0.018532	0.051346
3	91	329	C.O. Gas etc.	0.000121	0.000005
4	69-77	311	Chemicals	0.000190	0.000008
5	110	341-2	Steel	0.336140	0.324058
6	169, 170, 171	370-2,3	Telephone charges	0.000332	0.003181
7	200	511	Electricity	0.010975	0.009375
8	200	512	Oxygen and Acetylene	0.000323	0.000013
9	233	-	Consumable Stores	0.005143	0.045850
10	235	-	Repairs and maintenance	0.009494	0.007028
11	236	-	Safety equipment	0.000055	0.003082
12	238-239	-	Transport	0.004036	0.016543
13	241	-	Water	0.000188	0.000224
14	-	-	Scrap	-.010183	-.026031
15	-	-	Distributive margins	.113902	.142030
16	-	-	Gross value added	.510420	.410556
			Total	1.000000	1.000000

Set IIITable B.29. C (3 x 3) Matrix of die forgings

Firms → Product groups ↓	A	B, C	D
a (I, II)	.983676	.283058	.554573
b (III, IV)	-	.716942	.197437
c (V, VI)	.016324	-	.247990

Table B.30. C⁻¹ (3 x 3) Matrix of die forgings

	1.050084	-.414590	-2.018209
	.019036	1.387298	-1.147064
	-.069120	.027292	4.165273

Table B.31. D (3 x 3) Matrix of die forgings

Product groups → Firms ↓	a(I, II)	b(III, IV)	c(V, VI)
A	.312579	-	.023431
B, C	.203944	.750066	-
D	.483477	.249934	.976569

Set III

Table B.32. Matrix B(16,3) Input structures of die forgings firms

Sr. No.	241 GIPE Sector	ASIC Sector	Description	Firm A 1966-67 average	Firm B,C 1965-66-67 average	Firm D 1966-67 June ending
1	62	280-1	Printing and Stationery	-	0.000572	0.002788
2	90	321	Fuel oils	0.017290	0.020168	0.052117
3	91	329	C.O. Gas etc.	0.000614	-	-
4	69-77	311	Chemicals	0.000896	0.000037	-
5	110	341-2	Steel	0.315849	0.345913	0.323774
6	169,170,171	370-2,3	Telephone charges	-	0.000587	0.003248
7	200	511	Electricity	0.006527	0.014939	0.009309
8	200	512	Oxygen and Acetylene	-	0.000822	-
9	233	-	Consumable stores	0.001506	0.008221	0.046807
10	235	-	Repairs and maintenance	0.001231	0.016307	0.006926
11	236	-	Safety equipment	-	0.000176	0.003153
12	238-239	-	Transport	-	0.006442	0.016837
13	241	-	Water	-	0.000283	0.000225
14	-	-	Scrap	-0.001676	-0.008080	-0.016273
15	-	-	Distributive margins	0.073752	0.103401	.143194
16	-	-	Gross value added	0.584011	0.490212	.407895
			Total	1.000000	1.000000	1.000000

Set III

Table B.33. Matrix $BC^{-1} = A(16,3)$ Input structures of product groups of die forgings

Sr. No.	241 GIPE Sector	ASIC Sector	Description	a(I,II)	b(III,IV)	c(V,VI)
1	62	280-1	Printing and Stationery	-.000182	.000870	.010957
2	90	321	Fuel oils	.014938	.022233	.159053
3	91	329	C.O. Gas etc.	.000645	-.000255	-.001238
4	69-77	311	Chemicals	.000942	-.000320	-.001850
5	110	341-2	Steel	.315874	.357773	.314374
6	269,170,171	370-2,3	Telephone charges	-.000213	.000903	.012855
7	200	511	Electricity	.006495	.018273	.008466
8	200	512	Oxygen and Acetylene	.000015	.001140	-.000943
9	233	-	Consumable Stores	-.001497	.012058	.182494
10	235	-	Repairs and Maintenance	.001124	.022301	.007659
11	236	-	Safety Equipment	-.000214	.000330	.012931
12	238-239	-	Transport	-.001041	.009396	.062741
13	241	-	Water	-.000010	.000399	.000612
14	-	-	Scrap	-.000792	-.010957	-.055131
15	-	-	Distributive margins	.069517	.116779	.328987
16	-	-	Gross value added	.594399	.449077	-.041967
			Total	1.000000	1.000000	1.000000

Set III

Table B.34. Matrix BD = E(16,3). Input structures of product groups of die forgings

Sr. No.	241 GIPE Sector	ASIC Sector	Description	a (I, II)	b(III, IV)	c (V,VI)
1	62	280-1	Printing and Stationery	.001465	.001126	.002723
2	90	321	Fuel oils	.034715	.028153	.051301
3	91	329	C.O. Gas etc.	.000192	-	.000014
4	69-77	311	Chemicals	.000288	.000028	.000021
5	110	341-2	Steel	.325812	.340380	.323588
6	169,170, 171	370-2,3	Telephone charges	.001690	.001252	.003172
7	200	511	Electricity	.009587	.013532	.009244
8	200	512	Oxygen and Acetylene	.000167	.0000616	-
9	233	-	Consumable Stores	.024777	.017865	.045745
10	235	-	Repairs and maintenance	.007059	.013962	.006792
11	236	-	Safety equipment	.001560	.000920	.003079
12	238-239	-	Transport	.009454	.009040	.016442
13	241	-	Water	.000166	.000268	.000220
14	-	-	Scrap	-.010037	-.010127	-.015930
15	-	-	Distributive margins	.113372	.113347	.141567
16	-	-	Gross value added	.479733	.469638	.412022
			Total	1.000000	1.000000	1.000000

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Set III

Table B.35. Adjustment (I). Input structures of product groups of die forgings, based on commodity technology assumption, replacing the negative coefficients by zero values in the respective cells of $A=BC^{-1}$ Matrix

Sr. No.	241 GIPE Sector	ASIC Sector	Description	a (I, II)	b (III,IV)	c (V, VI)
1	62	280-1	Printing and Stationery	-	0.000870	0.010957
2	90	321	Fuel oils	0.014938	0.022233	0.159053
3	91	329	C.O. Gas etc.	0.000645	-	-
4	69-77	311	Chemicals	0.000942	-	-
5	110	341-2	Steel	0.315874	0.357773	0.314374
6	169,170 171	370-2,3	Telephone charges	-	0.000903	0.012855
7	200	511	Electricity	0.006495	0.018273	0.008466
8	200	512	Oxygen and Acetylene	0.000015	0.001140	-
9	233	-	Consumable Stores	-	0.012058	0.182494
10	235	-	Repairs and Maintenance	0.001124	0.022301	0.007659
11	236	-	Safety Equipment	-	0.000330	0.012931
12	238-239	-	Transport	-	0.009396	0.062741
13	241	-	Water	-	0.000399	0.000612
14	-	-	Scrap	-0.000792	-0.010957	-0.055131
15	-	-	Distributive margins	0.069517	0.116779	.328987
16	-	-	Gross value added	0.594399	0.449077	-
			Total	1.000157	0.894753	1.045998
			Revised Distributive margins	0.069517	0.116779	0.282989
			Revised Gross Value added	0.591242	0.554323	-
			Total	1.000000	1.000000	1.000000

Set III

Table B.36. Adjustment (2). Input structures of the product groups of die forgings based on commodity technology assumption for all positive input coefficients and replacing the zero and negative coefficients in $A = BC^{-1}$ Matrix by corresponding cells' positive coefficients in $E=BD$ Matrix

Sr. No.	241 GIPE Sector	ASIC Sector	Description	a (I, II)	b (III, IV)	c (V, VI)
1	62	280-1	Printing and Stationery	0.001465	0.000870	0.010957
2	90	321	Fuel oils	0.014938	0.022233	0.159053
3	91	329	C.O. Gas etc.	0.000645	-	0.000014
4	69-77	311	Chemicals	0.000942	0.000028	0.000021
5	110	341-2	Steel	0.315874	0.357773	0.314374
6	169,170, 171	370-2,3	Telephone charges	0.001690	0.000930	0.012855
7	200	511	Electricity	0.006495	0.018273	0.008466
8	200	512	Oxygen and Acetylene	0.000015	0.001140	-
9	233	-	Consumable Stores	0.024777	0.012058	0.182494
10	235	-	Repairs and Maintenance	0.001124	0.022301	0.007659
11	236	-	Safety Equipment	0.001560	0.000330	0.012931
12	238-239	-	Transport	0.009454	0.009396	0.062741
13	241	-	Water	0.000166	0.000399	0.000612
14	-	-	Scrap	-0.000792	-0.010957	-0.055131
15	-	-	Distributive margins	0.069517	0.116779	0.328987
16	-	-	Gross value added	0.594399	0.449077	0.412022
			Total	1.042269	1.000603	1.458055
			Revised Distributive margins	0.069517	0.116779	-
			Revised Gross Value added	0.552130	0.448474	-
			Total	1.000000	1.000000	-

Set III

Table B.37. Adjustment (3). Input structures with commodity technology applicable to steel, Fuels and electricity and firm technology to the rest of the input coefficients of all product groups of die forgings

Sr. No.	241 GIPE Sector	ASIC Sector	Description	a (I, II)	b(III,IV)	c(V,VI)
1	62	280-1	Printing and Stationery	0.001465	0.001126	0.002723
2	90	321	Fuel oils	0.014938	0.022233	0.151301
3	91	329	C.O. Gas etc.	0.000192	-	0.000014
4	69-77	311	Chemicals	0.000288	0.000028	0.000021
5	110	341-2	Steel	0.315874	0.357773	0.314374
6	169,170, 171	370-2,3	Telephone charges	0.001690	0.001252	0.003172
7	200	511	Electricity	0.006495	0.018273	0.008466
8	200	512	Oxygen and Acetylene	0.000167	0.000616	-
9	233	-	Consumable Stores	0.024777	0.017865	0.045745
10	235	-	Repairs and Maintenance	0.001124	0.022301	0.007659
11	238-239	-	Safety Equipment	0.001560	0.000920	0.003079
12	238-239	-	Transport	0.009454	0.009040	0.016442
13	241	-	Water	0.000166	0.000268	0.000220
14	-	-	Scrap	-0.000792	-0.010957	-0.055131
15	-	-	Distributive margins	.113372	.113347	.141567
16	-	-	Gross value added	.479733	.469638	.412022
			Total	0.970503	1.023723	1.051674
			Revised Distributive margins	.113372	.113347	.141567
			Revised Gross Value added	.509230	.445915	.360348
			Total	1.000000	1.000000	1.000000

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Set III

Table B.38. Adjustment (4). Input structures with firm technology applicable to product group c for all its inputs and commodity technology to the direct inputs and firm technology to the rest of the inputs of product groups a and b of die forgings

Sr. No.	241 GIPE Sector	ASIC Sector	Description	a (I, II)	b(III,IV)	c(V,VI)
1	62	280-1	Printing and stationery	0.001465	0.001126	0.002723
2	90	321	Fuel oils	0.014938	0.022233	0.051301
3	91	329	C.O. Gas etc.	0.000192	-	0.000014
4	69-77	311	Chemicals	0.000288	0.000028	0.000021
5	110	341-2	Steel	0.315874	0.357773	0.323588
6	169,170,171	370-2,3	Telephone charges	0.001690	0.001252	0.003172
7	200	511	Electricity	0.006495	0.018273	0.009244
8	200	512	Oxygen and Acetylene	0.000167	0.000616	-
9	233	-	Consumable Stores	0.024777	0.017865	0.045745
10	235	-	Repairs and Maintenance	0.001124	0.022301	0.006792
11	236	-	Safety equipment	0.001560	0.000920	0.003079
12	238-239	-	Transport	0.009454	0.009040	0.016442
13	241	-	Water	0.000166	0.000268	0.000220
14	-	-	Scrap	-0.000792	-0.010957	-0.015930
15	-	-	Distributive margins	0.113372	0.113347	0.141567
16	-	-	Gross value added	0.509230	0.445915	0.412022
			Total	1.000000	1.000000	1.000000

Set IVTable B.39. C (3,3) Matrix of die forgings

Firms → Product groups ↓	A	B	C,D
a (I and II)	0.980825	0.199130	0.510955
b (III and IV)	-	0.800870	0.274068
c (V and VI)	0.019175	-	0.214977

Table B.40. Matrix C⁻¹ of die forgings

	1.062332	-0.264138	-2.188188
	.032425	1.240580	-1.658654
	-0.094757	.023558	4.846842

Table B.41. D (3,3) Matrix of die forgings

Product groups → Firms ↓	a (I,II)	b(III,IV)	c(V,VI)
A	.312577	-	.023431
B	.082080	.504134	-
CD	.605343	.495866	.976569

Set IV

Table B.42. Matrix B (16,3). Input structures of die forging firms

Sr. No.	241 GIPE Sector	ASIC Sector	Description	Firm A 1966-67 Average	Firm B 1966-67	Firm C,D, Average 1965-66-67
1	62	280-1	Printing and Stationery	-	0.000163	0.001884
2	90	321	Fuel oils	0.017290	0.016848	0.037803
3	91	329	C.O. Gas etc.	0.000614	-	-
4	69-77	311	Chemicals	0.000896	-	0.000037
5	110	341-2	Steel	0.315849	0.347310	0.334145
6	169,170, 171	370-2,3	Telephone charges	-	0.000140	0.002141
7	200	511	Electricity	0.006527	0.014254	0.012467
8	200	512	Oxygen and Acetylene	-	0.001643	-
9	233	-	Consumable Stores	0.001506	0.007645	0.027802
10	235	-	Repairs and maintenance	0.001231	0.000716	0.019412
11	236	-	Safety equipment	-	0.000352	0.001577
12	238-239	-	Transport	-	0.004578	0.012571
13	241	-	Water	-	-	0.000396
14	-	-	Scrap	-0.001676	-0.016159	-0.008136
15	-	-	Distributive margins	0.073752	0.084265	.132864
16	-	-	Gross value added	0.584011	0.538245	.425037
			Total	1.000000	1.000000	1.000000

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Set IV

Table B.43. Matrix $BC^{-1} = A(1613)$ Input Structures of Product groups of die forgings

Sr. No.	241 GIPE Sector	ASIC Sector	Description	a (I,II)	b(III,IV)	c(V,VI)
1	62	280-1	Printing and stationery	-.000173	.000247	.000861
2	90	321	Fuel oils	.015332	.017225	.117446
3	91	329	C.O. Gases etc.	.000652	-.000162	-.001343
4	69-77	311	Chemicals	.000948	-.000236	-.001781
5	110	341-2	Steel	.315135	.355310	.352344
6	169,170,171	370-2,3	Telephone charges	.000198	.000224	.010145
7	200	511	Electricity	.006215	.016253	.022501
8	200	512	Oxygen and Acetylene	.000053	.002038	-.002725
9	233	-	Consumable Stores	-.000787	.009741	.118776
10	235	-	Repairs and maintenance	-.000509	.001020	.090206
11	236	-	Safety equipment	-.000138	.000474	.007060
12	238-239	-	Transport	-.001043	.005976	.053336
13	241	-	Water	-.000038	.000009	.001919
14	-	-	Scrap	-.001534	-.019796	-.008964
15	-	-	Distributive margins	.068492	.088187	.342821
16	-	-	Gross value added	.597197	.523490	-.110602
			Total	1.000000	1.000000	1.000000

Set IV

Table B.44. Matrix BD = E(16,3). Input structures of product groups of die forgings

Sr. No.	241 GIPE Sector	ASIC Sector	Description	a (I,II)	b (III,IV)	c (V,VI)
1	62	280-1	Printing and stationery	.001154	.001016	.001840
2	90	321	Fuel oils	.029671	.027239	.037322
3	91	329	C.O. Gases etc.	.000192	-	.000014
4	69-77	311	Chemicals	.000302	.000018	.000057
5	110	341-2	Steel	.329507	.340782	.333716
6	169,170,171	370-2,3	Telephone charges	.001307	.001132	.002091
7	200	511	Electricity	.010757	.013368	.012328
8	200	512	Oxygen and Acetylene	.000135	.0000828	-
9	233	-	Consumable Stores	.017928	.017640	.027186
10	235	-	Repairs and maintenance	.012194	.009987	.018986
11	236	-	Safety Equipment	.000984	.000959	.001540
12	238-239	-	Transport	.007985	.008541	.012276
13	241	-	Water	.000240	.000196	.000387
14	-	-	Scrap	-.006775	-.012181	-.007985
15	-	-	Distributive margins	.110398	.108364	.131479
16	-	-	Gross value added	.484021	.482111	.428763
			Total	1.000000	1.000000	1.000000

Appendix C. Appendix Tables and Charts to
Chapter VI (Tables C.10 to C.15
and Charts I to IV)

APPENDIX C.Appendix tables and charts to Chapter VI

The variables (X's) (the corresponding number of observations are given for each table) available for deriving the following correlation matrices (R) and the Principal Factor patterns are :

X_1 - Net weight in Kg,

X_2 - Tensile strength in tons per sq. inches

X_3 - Gross weight in kg,

X_4 - Die block volume in cu. ft,

X_5 - Die life in number of pieces (estimate),

X_6 - Presinking hours in number,

X_7 - Sinking hours in number,

X_8 - Postsinking hours in number.

Table C.10. Correlation matrix R (3 x 3), N = 398

Variable ↓	X ₁	X ₂	X ₃
X ₁	1.000000	0.013637	0.993562
X ₂		1.000000	-0.006464
X ₃		-0.006464	1.000000

Table C.11. Principal Factor Pattern of 3 Factors, N=398

Variable ↓	Factors' Loadings		
	F ₁	F ₂	F ₃
X ₁	0.998374	0.0064412	0.0563276
X ₂	0.007295	0.9999992	-0.0007613
X ₃	0.998236	-0.0071614	-0.0563267
% Contribution to total communality	66.4426%	33.3364%	0.2210%

Table C.12. Correlation Matrix, R (5 x 5), N = 205

Variable → ↓	X ₁	X ₂	X ₃	X ₄	X ₅
X ₁	1.000000	0.055004	0.921545	0.670290	-0.195427
X ₂		1.000000	-0.017231	-0.035187	-0.128154
X ₃			1.000000	0.714570	-0.210982
X ₄				1.000000	-0.143179
X ₅					1.000000

Table C.13. Principal Factor Pattern of 5 Factors, N = 205

Variable → ↓	Factors' Loadings				
	F ₁	F ₂	F ₃	F ₄	F ₅
X ₁	0.9390477	-0.0254604	0.1129572	-0.2671202	-0.1828274
X ₂	0.0287100	0.8285908	0.5573961	0.0417647	-0.0145849
X ₃	0.9549534	-0.0806156	0.0495161	-0.1997392	0.1980271
X ₄	0.8438514	-0.1427179	0.0676544	0.5124508	-0.0190379
X ₅	-0.3169945	-0.6231908	0.7144982	-0.0250756	0.0056046
% Contribution to total communality	52.1428%	22.0489%	16.8197%	7.5245%	1.4649%
Cumulative %	52.14%	74.19%	91.01%	98.54%	100.00%

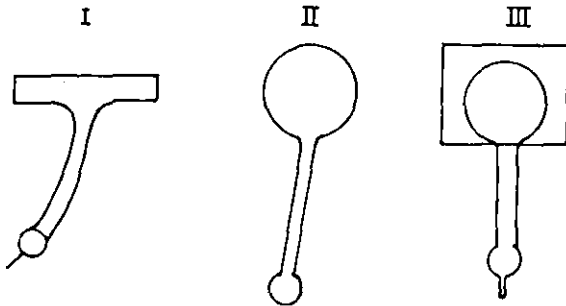
CHART NO. I

BROAD NOMENCLATURE AND GENERAL SHAPES OF STEEL DIE FORGINGS.

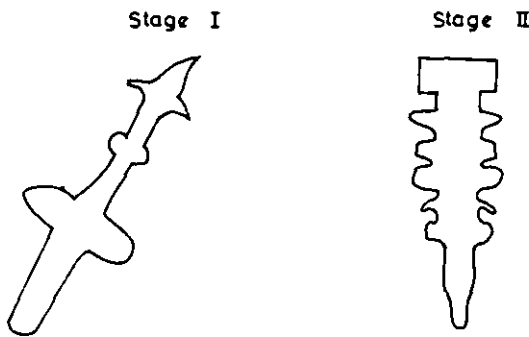
I FORGINGS FOR GEARS: (I)Rear hub (II)Drive gear (III)Gear wheel (IV) Crown wheel (V)Hypoid bevel gear etc.



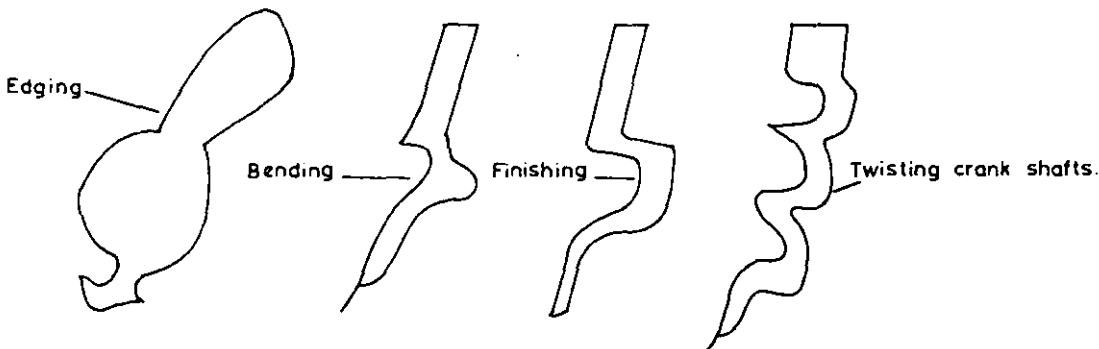
II CONNECTING RODS:
Stage of process



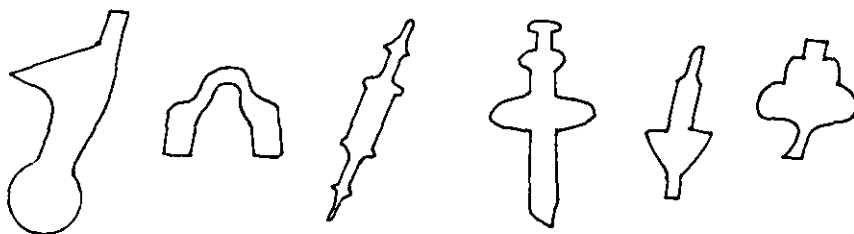
III CAMSHAFTS



IV CRANK SHAFTS



V SHAFT FORGINGS: Stage of process I Edging II Bending III Finishing IV Twisting crank shafts

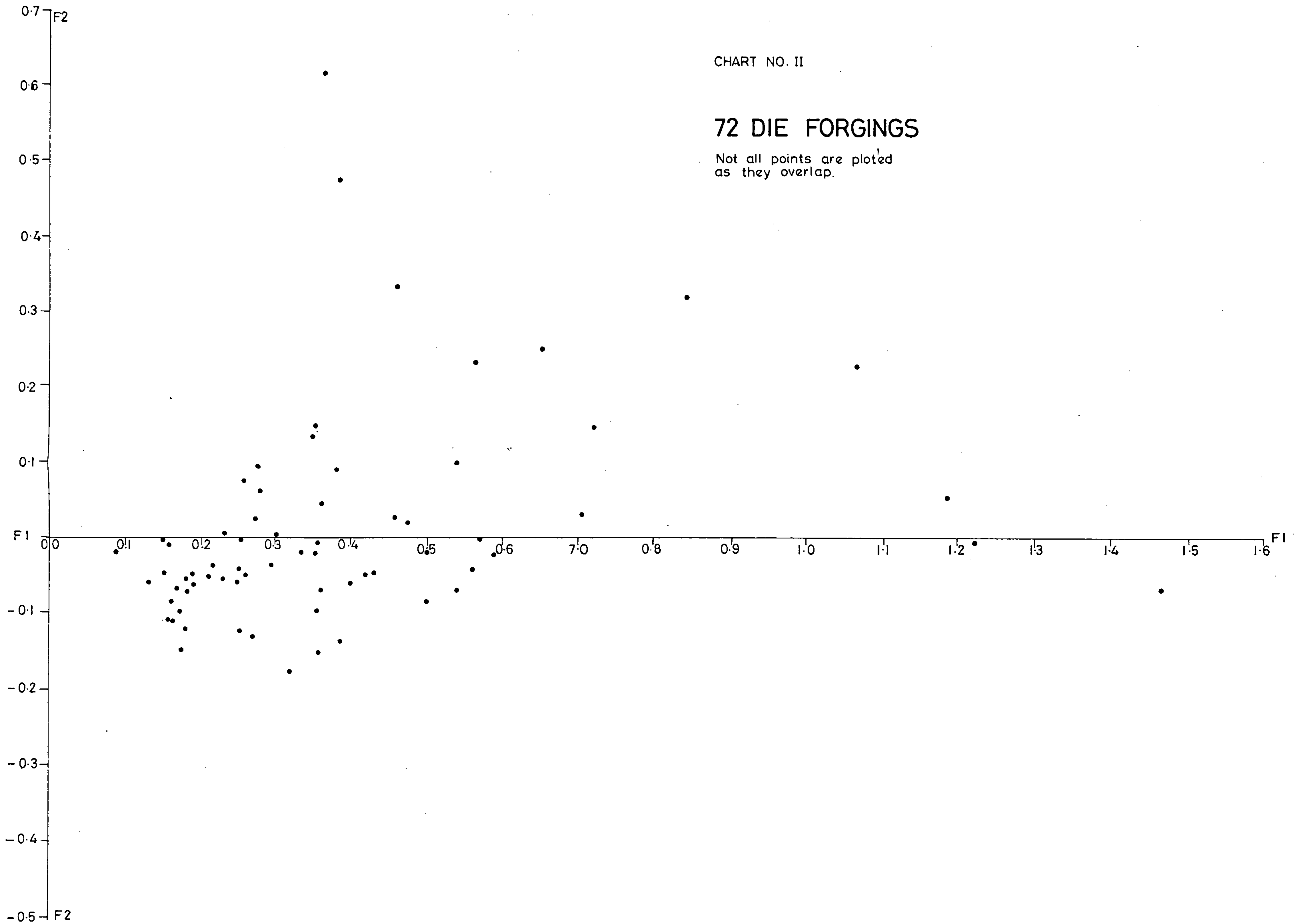


VI LEVER FORGINGS
No shapes can be generalised.

CHART NO. II

72 DIE FORGINGS

Not all points are plotted
as they overlap.



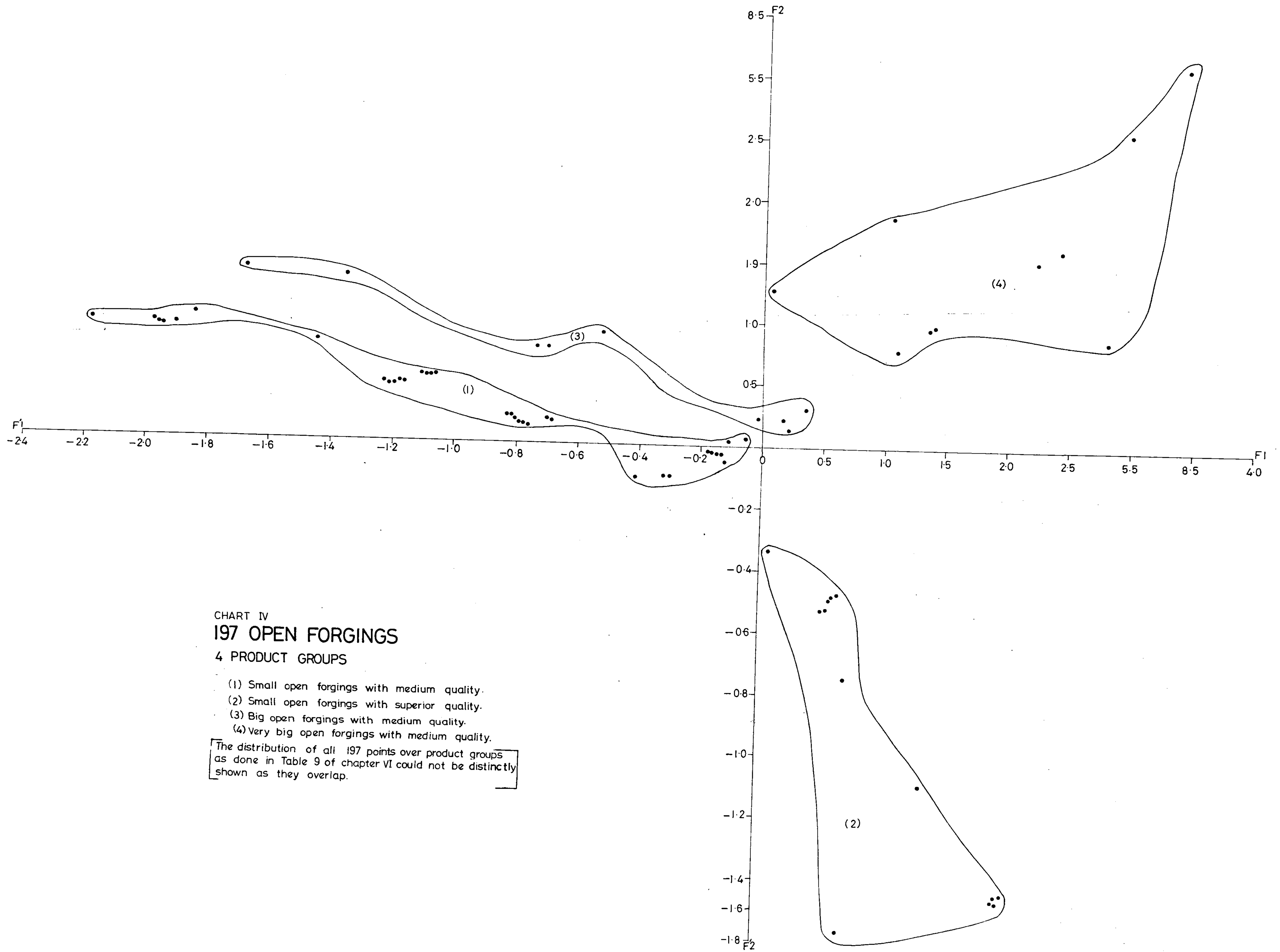


CHART IV
197 OPEN FORGINGS
 4 PRODUCT GROUPS

- (1) Small open forgings with medium quality.
- (2) Small open forgings with superior quality.
- (3) Big open forgings with medium quality.
- (4) Very big open forgings with medium quality.

The distribution of all 197 points over product groups as done in Table 9 of chapter VI could not be distinctly shown as they overlap.