

**A TECHNO-ECONOMIC ^{शुद्धता} STUDY OF THE DYESTUFFS
AND INTERMEDIATES INDUSTRY IN INDIA**

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CHAPTER I

INTRODUCTION

1.1 Importance of Industry Study

In the broadest classification, any economy is divided into two major sectors - agriculture and industry. Reference may be made to the two sector economic models given by a number of economists right from Ricardo. Most of these models treat these two sectors viz. agriculture and industry, as distinctly different.

Confining our attention to the industrial sector, we find that with the development of modern industries and the growing degree of industrialization, a need is being felt to study the individual industries at more and more disaggregative levels. This is because each industry has its own distinct and special features and peculiarities. Each individual industry study throws new light on industry problems and adds to our knowledge and this in turn helps in planning for industrialization.

During the last few years, so many industry studies have come out. Most of these studies could be classified under two broad categories: (i) the studies highlighting the accounting aspect of the industry - cost, price structure, profitability, etc.; and (ii) studies based on the engineering aspects of the industry which are purely technical in nature. The former become outdated with a change in the price structure. Thus they are useful only

at a point of time. The latter are not of much use to understand the inter-relations and the economic aspects of the industry. They only highlight the technology of manufacture.

What happens to the raw material within a plant is not the concern of the economist. He is interested in studying the input requirements of different products, their substitutes and the possible output combinations. His concern is with the differences in raw materials that go through the pipelines and the product-mix that comes out as the output of the industry and the different possible combinations of these.

In a simple economy the production of different finished commodities is largely independent from each other in a structural sense. The various stages of processing the raw materials form a chain in which each stage is dependent on the previous one. But, as a rule, no industry supplies to all other industries, and it is possible to distinguish commodities by the stage they have reached in processing.

Consider, in contrast, a developed economy, with dozens of industries processing for other industries. Moreover, industries are using each others' products on an increasing scale. The chemical industries for instance are consuming coal and petroleum; the coal and petroleum industries need elaborate equipments made of steel and

other metals and the modern techniques of metal-making require the products of the chemical industries. To produce a pack of final goods - say, tooth paste, saucepans and household coal - the outputs of the chemicals, metals and coal industries have to be set at levels which are adequate to provide for the requirements of final consumers and also those of each other for materials and intermediate products.

In the same way, a modern large-scale industrial firm carries out a number of technically distinct activities which are inter-related to produce goods for sale to consumers or to other firms. To produce a given output for sale, at a given time, that firm will have to plan carefully, and to plan well in advance, the quantities of commodities constituting its output, its purchases from other firms and the levels of activity in its different plants or workshops. Moreover, from time to time, it will have to re-examine its whole product programme in relation to both the state of demand and trends in technology. The firm may be able to market more profitably, a different set of commodities, or in different proportions from those actually produced, or it may, with profit, discard the technique of production actually employed and introduce a different one.

The development of synthetic rubber and synthetic fibres, for instance, brought about the growth of a series

of industries producing chemicals which are closely inter-related to such an extent that even an industrial classification of the various plants becomes difficult. All this complexity of technology in which we live today does not, of course, invalidate the formal economic theory; but it does make the numerical solutions of economic problems more intricate.¹

These factors emphasize the need to carefully study the inputs consumed by a firm or industry to produce a given product-mix. Because of this, whether in industry studies or in national planning, input-output analysis is increasingly being used as an important tool of economic analysis.

Each industry uses a number of raw materials and services to produce a given output. Some of the complex industries may have to use literally thousands of inputs in different proportions. The output of each industry, in turn, may go as inputs in a number of different industries in different proportions. Thus we can visualise different degrees of inter-relations between various industries. Industry studies analysing such inter-industry relations

¹ See Tiber Barna, in Introduction to the Structural Interdependence of the Economy, John Wiley & Sons, Inc. New York, Proceedings of an International Conference on Input-Output Analysis, Ed. Tiber Barna.

could be of great use to national planners also, especially in the developing countries in the preparation of the development plans.

In recent years inter-industry studies have thrown new light on inter-dependence and inter-relations between different industries and the input-output relations within an industry.

As an economy develops and the mode of production is transformed from primitive self-sufficient to more elaborate processes leading to specialization and exchange, the need to investigate the intricate and increasing inter-dependence becomes increasingly important.

1.2 Leontief Approach to Sectoral Interdependence

Theoretical explorations in this area began more than two centuries ago with the construction of Tableau Economique (1766) by Francois Quesnay, the famous French economist and culminated in the work of Leon Walras (1874).² In "Tableau Economique" the idea of the compartmentalized treatment of necessarily inter-dependent production activities was first formally advanced. Later, Leon Walras³

² See R. Bharadwaj and P.N. Mathur, "The Input-Output Economics - A Resume," in P.N. Mathur and R. Bharadwaj (ed.). Economic Analysis in Input-Output Framework, Vol. I. Poona: Input-Output Research Association, 1967.

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

employed a similar approach to explain the interdependence among the different sectors of the economy in terms of the competing demands of each industry for the available factors of production and of the substitutability among their outputs in consumption. The main use of his mathematical formulations was to demonstrate the existence of determinate solutions for the quantities and prices in the system under the assumptions of maximizing behaviour. However, the formulations of Walras also remained unmanageable in the practical field, and their use was limited to the theoretical analysis only.

It was W. W. Leontief⁴ who provided a practical tool of analysis in 1930 to derive a set of parameters from a single point observation of each of the inter-industry transactions in the economy. This interdependent multi-sectoral instantaneous production function approach provides at any point of time, the equilibrium production points with a set of fixed coefficients observed in the economy.

Later on, Dantsig and Koopmans⁵ (1951) developed the mathematical technique of activity analysis or linear

4 Leontief, W.W. Structure of the American Economy. Cambridge, Mass.: Harvard University Press, 1939. Second Edn. New York: Oxford University Press, 1951. For the mathematical formulations, see Part II, pp. 33-68 of the Second Edn.

5 Koopmans (ed.). Activity Analysis of Production and Allocation. John Wiley and Sons, 1951; and Koopmans, T.C. Three Essays on the State of Economic Science. New York: McGraw Hill Inc., 1957.

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.

Input-Output Flow Tables

Leontief⁶ imagines an economy in which goods like iron, coal, alcohol, etc. are produced in their respective industries by means of a primary factor such as labour and by means of other inputs such as iron, coal, alcohol, etc. He rejects as unrealistic the Austrian economists' view that you can identify certain industries as being in "earlier" stages of production and certain other industries as being in "later" stages. Thus, Leontief argues against inevitability of finding an industry such as agriculture which sells only to an industry such as manufacturing, buying nothing from it; he denies that you can follow a loaf of bread from the early stages through a one-directional hierarchy of industries with value being added to the bread by virtue of primary factors employed in each of the industries.

Instead Leontief finds that the real world requires you to recognize the "whirlpools" of industrial relationships characteristic of general models of interdependence. For

⁶ See R. Dorfman, P. Samuelson, R. Solow. Linear Programming and Economic Analysis, Chapter 9, p. 205.

the production of coal, iron is required; for the production of iron, coal is required; no man can say whether the coal industry or the iron industry is earlier or later in the hierarchy of production.

The Leontief system can be considered as a multi-industry counterpart of Marshall's short-run partial analysis which 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.⁷

1.3 Innut-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.⁸ From that the production levels, price proportions vectors, employment levels, wages, interest and profit relationships,

⁷ See Mathur, P.N., "Input-Output Framework for Explorations in Theoretical and Empirical Economic Research," Artha Vijnana, Vol. XI, No. 2, June 1969, pp. 13-148.

⁸ (a) Leontief, W.W., "Input Output Analysis," in Leontief (ed.), Input Output Economics. New York: Oxford University Press, 1966.

(b) Bharadwaj, R., and Mathur, P.N. "The Input-Output Economics - A Resume," op.cit., p. 4.

(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.

the effects of foreign trade vectors, etc., and the conditions for international consistency and viability of both closed and open input-output models can easily be derived. 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 homogeneous linear equations,⁹ such as :

$$\begin{aligned} x_{i1} &= a_{11}x_i, \dots, x_{in} \\ &= a_{in}x_i \quad (i = 1, 2, 3, \dots, r) \end{aligned}$$

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 a unit output level of the corresponding activity or a sector.

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

9 Leontief, W. W. The Structure of the American Economy, 1919-1939 - An Empirical Application of Equilibrium Analysis, Part II, The Theoretical Scheme. New York : Oxford University Press, 1951, pp. 33-65.

in producing a unit of a particular sector, one can arrive at the same by constructing the production accounts. But if one unit of the output of an industry is to be delivered to final demand, it becomes necessary to produce:

- (i) the original unit of output,
- (ii) all direct inputs to make this possible, and
- (iii) all the indirect inputs required for the chain relationship of the inputs and outputs of the interdependent industries to fulfil the direct input requirements of the industry concerned.

All these are taken into account by the convergent series of $[I - A]^{-1}$ matrix which is equivalent to $I + A + A^2 + \dots$, usually known as the matrix multiplier. Information of this kind is 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 level estimates. Such information is also useful to a firm for market research. A businessman can compare his company's marketing position with that of the industry, of which it is a part, and find out the possible areas of additional market potential.¹⁰

¹⁰ (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 Projections," in Leontief, W.W. Essays in

(continued)

1.4 Dynamic Analysis of a Firm or an Industry

Every industry requires, apart from the flow requirements of production in the sector, some stocks to carry on the 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 it to increase its necessary stock holdings. In the case of a decreased 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 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, semi-finished goods and finished products will fall, while under the latter category, buildings, plant and

Economics, Theories and Theorizing. New York: Oxford University Press, 1966, pp. 237-47.

(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, Deane, 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 Inter-Industry Relations Data and Methods," in Input Output Analysis—An Appraisal (ed.) NBER, Princeton University Press, 1935, pp. 53-123.

machinery, transport equipment and other fixed assets will be included. When the stock requirements of an industry go down in proportion to the decreased output, the fixed equipments are not diminished proportionately. Instead, the difference between the technically necessary and the actually available stocks results in the appearance of unused capacity or idle capacity. 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 on both fixed capital coefficients and working capital coefficients. These capital structures involving the time dimension, are the parameters of the expanded differential balance equations of the dynamic input-output analysis.¹¹

1.5 Assumptions and Limitations of Input-Output Analysis

The predictive value of input-output analysis for any problem depends on the stability of the technical coefficients during the period between the construction of the table and the application of the model. Computation of the stable technical coefficients of an industry, which are

¹¹ See Mathur, P.N., "A Modified Leontief Dynamic Model and Related Price Systems," Econometric Annual of the Indian Economic Journal, Vol. XIII, 1965.

crucial to depict the structure of the economy in terms of the inter-dependence of the sectors, is of utmost importance for all practical uses and theoretical conveniences.

There are at least seven situations of theoretical interest and of practical importance under which the technical coefficients become unstable.

First, when a plant or an industry is subject to economics of scale.

Second, when substitution between inputs takes place because of relative price changes in the long run. Some economists admit the possibility of alternative techniques of production to produce a product. Under this assumption, the open form of input output analysis turns into linear programming analysis. This is true only if the number of alternative processes for producing a given product are finite.

Third, there are practical problems of product-mix arising out of horizontal integration of identical technological processes or firms producing multiple products 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.

Fourth, there are practical problems of process mix, arising out of vertical integration of separate technological processes in a firm or an industry while the techniques of individual processes are changing. If the different processes are separately identified as sectors, then the input structures of processes or sectors can be corrected in the light of the changes in technique and individual processes. The assumption that the economy will operate always at the currently available best technology, is not always correct because a developing economy operates with an admixture of old and new techniques all through the period of its technological transformation.

Fifth, while the day to day operation of a modern economy is determined primarily by the static input-output models, in the long run it should be approached through the stock-flow relationships of structural time lags and of technological changes. These elements are to be properly identified and taken care of, through suitable dynamic input-output models approximating to reality.

Sixth, the practical problems in respect of different capital intensities, managerial organizations, working

conditions of units and the market imperfections may also cause instability of input structures of an industry.¹²

Seventh, one has to take into account the changes due to the changing price structure. With a change in the price structure, there will be a consequent change in the input coefficients. The changing price structure between categories or sectors can be adjusted through price indices, and such changes should not be confused with the instability of input coefficients. However, changes in price structure of the commodities aggregated within a sector cannot be so adjusted. This, therefore, leads to an operational instability rather than an inherent instability. This can be minimised by sufficient disaggregation.

1.6 Conceptual and Practical Problems in the Empirical Evaluation of Capital and Input Structures of Firms, Processes and Industry

We find that very often for practical conveniences and for marketing purposes, products are grouped together whose manufacturing processes or input structures may be different. In the dyestuff industry, for instance, a number of individual dyes having different shades and concentration

12 V. V. N. Somayajulu, "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 Framework". Ph.D. Thesis, University of Poona, Poona, 1970.

are grouped together under one product-group like Vat or Azo depending upon their chemical base. But there may be remarkable differences in their input requirements. This has been examined in Chapter V in greater details.

In the matter of capital coefficients, their estimation in the chemical industry becomes all the more difficult because of the peculiar nature of the industry apart from the secrecy that is generally maintained by the people in the industry.

Multiplicity of products is one problem. Further problems are introduced by the prevalence of joint products and variability of capital requirements both between alternative processes and within nominally identical processes.

1. Joint Products : Many chemical processes yield more than one product, not uncommonly in variable proportions and, often, optional by-products can be added to a plant's output by means of small additions to equipment.

2. Alternative Processes : Paralleling the prevalence of variability in input proportions is the variability in the capital input structures used to produce a given output. Such capital substitutions take two major forms: existence of alternative processes used to produce a given product, and intra-process variation in equipment and building items. Where information on alternative

processes is available, separate sets of capital coefficients can be presented.

3. Variation in Plant Design : Considerable variation can be found in capital requirements in relation to capacity, not only among different processes, but also among individual plants using the same process, depending on location, plant size and other specific conditions.

In the case of the dyestuff industry, in the course of field investigation and discussion with chemical engineers, it was found that virtually thousands of small and big equipments are used by the large scale dyestuff plants and computing of the capital coefficients becomes an extremely difficult task. Industry people are not willing to extend their co-operation for various reasons which have been enumerated later in this chapter.

It was found, however, that reactions kettles, and other equipments are similar in the manufacture of many products. This suggests a need for aggregating the capital coefficients in order to find a way out in the computation of capital coefficients.

1.7 Uses of Input-Output Analysis in the Chemical Industry

The awareness of the interdependence that exists in a particular industrial sector is an indispensable factor in planning for the growth programme for it. The chemical

industry is one where the interdependence is not only high but a very complex one. Because of this complexity, it is necessary to carry the disaggregation not only down to certain sub-sectors like fertilizers, organic intermediates, synthetic fibres, plastics, etc., but down to certain well defined chemicals like acetylene, ammonia, polyethylene, etc.

While applying the input-output analysis to the chemical industries, the Italian Five Year Plan, for instance, has adopted a special approach where a separate chapter has been devoted to the development of the chemical industry. This approach can be useful in planning for the development of chemical industries.¹³

The first phase of the work consists of drawing up a technological matrix of the sector in very disaggregative terms. This matrix, in addition to being a useful instrument for investigation, also makes it possible to fix the coefficients.

With the technological matrix, the breakdown of value added per product, sub-sector or productive flow can be obtained.

Similarly, by knowing the amount of investment required to build the production plants, the technological

¹³ See Giuseppe Calogero, A Disaggregated Planning Model for the Italian Chemical Industry. Fourth International Conference on Input-Output Techniques, Geneva, January 8-12, 1968.

matrix will give an estimate of the future investment required in the sector to raise the productive capacity of a particular product by a certain figure.

By combining the results of the data for value added and investment, the integral capital-output ratios (ICOR) can be obtained and from these, once the growth rate of a product, sub-sector or the entire sector has been fixed, the investment required to reach that growth rate can be estimated.

Value Added : Of the two possible methods of calculating value added, only the one by difference can be used because the necessary elements for calculating value added by addition may not always be available.

Value added for the whole of the products considered in the technological matrix can be calculated by difference by adding to the value of exports of the products concerned, the value of quantities of such products consumed outside the group of products considered and subtracting the value of imports, feedstocks, which are different from the products themselves, and power consumption.

Capital-Output Ratios

In economics capital-output ratio means the ratio between the existing capital stock and the value added obtained from it. On the other hand, marginal capital-output

ratio is used to express the ratio between the increase in capital stock and the increase in value added. The correct interpretation of these coefficients is essential in formulating either national or sectoral growth programmes. They in fact serve to assess the volume of investment required to achieve certain objectives or to forecast what results may be obtained from a certain volume of investment.

In the case of national planning, these coefficients also serve to check that the various objectives are congruent. In fact if Y equals income produced over a certain period of time, ΔY the increase in income in the following period, C propensity to consume, S saving, I investment and COR marginal capital-output ratio, this gives:

$$I = COR \cdot \Delta Y$$

$$(1 - C) \frac{S}{Y} = \frac{I}{Y}$$

$$\text{Therefore } \frac{\Delta Y}{Y} = \frac{(1 - C)}{COR}$$

Hence if it is desired to achieve a 5 per cent income growth with an 80 per cent propensity to consume, the marginal capital-output ratio for the whole economy should be 4.

Marginal capital-output ratio is equally important for sectoral planning. Once certain objectives have been fixed, the volume of investment required can be estimated.

Capital-output ratio is a broad indicator of the

capital requirement per unit of output. Whereas the aggregate capital-output ratio finds an important place in the theories of growth, the capital-output ratio at the level of individual industries and commodities occupies a central place in discussions about choice of techniques, allocation of investment and pattern of international trade. Relative capital intensity of an industry is reflected in its capital-output ratio. For a capital scarce economy like India, low capital-intensive industries are suggested in preference to high capital-intensive industries, wherever the choice exists - so as to increase the rate of flow of output per unit capital available to the maximum possible extent. Since in all this, an inter-industry comparison is involved, it is necessary to look for a proper concept of capital-output ratio at industry level which would be operationally meaningful.

Two Concepts of Capital-Output Ratios¹⁴

The capital-output ratio for a particular industry can be defined as the value of investment necessary to bring an annual stream of product in relation to that product. In other words, it is the investment divided by the value of annual product it is likely to generate. The value of the

¹⁴ For a detailed and lucid discussion of this see Mathur, P.N., "Two Concepts of Capital-Output Ratios and Their Relevance for Development," Artha Vijnana, Vol. 4, No. 4, December 1962.

product is to be taken in the "value added" sense. It is the value added to the raw materials and intermediate goods by the process which is done with the instrumentality of the capital created by the investment.

If C_1 is the investment necessary to produce one rupee worth of the i^{th} commodity; and a_{ji} worth be the amount of the j^{th} commodity required to be used as input for the production of one rupee worth of the i^{th} commodity, then the value added by the i^{th} process may be written down as :

$$1 - \sum_{j=1}^n a_{ji}$$

To get the value added, we should include the estimate of the depreciation of various types of capital goods in the appropriate values of a_{ji} s. In this terminology, the traditional Capital-Output Ratio = K_1^T which can be represented as :

$$C_1 / \{1 - \sum a_{ji}\}$$

Leontief's Capital-Output Ratio

Leontief on the other hand maintains that not much useful purpose is served by considering the i^{th} commodity in isolation. If we have to produce one rupee worth of additional i^{th} commodity in an economy where each industry is working full capacity, we shall have to create not only the capital required to produce that much worth if the i^{th}

commodity, but also that required to produce a_{j1} rupee worth of the j^{th} commodity to be used as inputs in the production of the i^{th} commodity; where j assumes all the different values ranging from 1 to n . Nor is that all. a_{j1} worth of the j^{th} commodity requires the inputs of the various other commodities for its production and they again require further investment and so on. Thus, when planning for the production of the commodity 1, it is necessary to take into account all the indirect investment requirements generated by the process described above. Reckoning of the direct and indirect requirements of a production process is associated with the Leontief Input-Output System, and a concept of capital-output ratio which takes these requirements into consideration was first used by Leontief.¹⁵ Hence we may call it as 'Leontief Capital-Output Ratio'.

Assuming constant returns to scale and unique marginal technologies, the direct and indirect requirements of capital can be estimated as follows :

Let x_j be the ultimate output required to be produced of the j^{th} commodity in order that F_1 rupee worth of the extra i^{th} commodity be available to the economy. In order

15 Leontief, Wassily W., "Domestic Production and Foreign Trade : The American Capital Position Re-examined," Proceedings of the American Philosophical Society, September 1953; and "Factor Proportions and Structure of the American Trade: Further Theoretical and Empirical Analysis," Review of Economics and Statistics, November 1956.

that the j^{th} industry will be able to provide all the direct and indirect demands made on it by various industries in order that F_1 rupee worth of extra i^{th} commodity be available, the following simultaneous equations should be satisfied, which equalise the extra demand and extra supply of each of the n commodities in the economy.

$$\begin{aligned} (1 - a_{11})x_1 - a_{12}x_2 \dots - a_{1i}x_i \dots - a_{1n}x_n &= 0 \\ -a_{21}x_1 + (1 - a_{22})x_2 \dots - a_{2i}x_i \dots - a_{2n}x_n &= 0 \\ -a_{i1}x_1 - a_{i2}x_2 \dots + (1 - a_{ii})x_i \dots - a_{in}x_n &= F_1 \\ -a_{n1}x_1 - a_{n2}x_2 \dots - a_{ni}x_i \dots + (1 - a_{nn})x_n &= 0 \end{aligned}$$

Where a_{ji} s are as defined earlier and on the right hand side of all the equations except the i^{th} , is zero while for i^{th} it is F_1 .

In matrix notation, the above equations may be written as :

$$|I - A| |X| = F_1$$

where $|A|$ is the $n \times n$ matrix (a_{ji}) and $|X|$ is the column vector (nX_j) with F_1 in the i^{th} place and 0 everywhere else. The solution to this may be written as

$$|X| = |I - A|^{-1} F_1$$

where $|I - A|^{-1}$ is the inverse of the matrix $|I - A|$. Let the (i, j) element of this inverse be A_{ij} . Then the value of the X_j required will be equal to $A_{ji}F_1$ for $j = 1, 2, \dots, n$.

Therefore the total investment required for the extra availability of F_1 rupees worth of 1th commodity is

$$\begin{aligned} & (C_1^A_{11} + C_2^A_{21} + \dots + C_j^A_{j1} + \dots + C_n^A_{n1}) F_1 \\ & = \left(\sum_{j=1}^n C_j^A_{j1} \right) F_1 \end{aligned}$$

where C_j is as defined previously.

Thus the Leontief Capital-Output Ratio for the commodity 1 may be taken as the above divided by F_1 that is

$$K_I^L = \sum_{j=1}^n C_j^A_{j1}$$

Thus it is evident that for finding out the Leontief Capital-Output Ratio, we need :

- (a) an input-output table for the entire economy, and
- (b) a capital-coefficient vector showing capital per unit of gross value of output for each sector of the economy (and not only for the manufacturing industries), and all these in constant prices.

A pioneering work in this respect has been done by Messrs. Hashim and Dadi¹⁶ with respect to Indian manufacturing, where they have discussed the methodology of computing the Leontief Capital-Output ratios in great detail.

¹⁶ S. R. Hashim and M. M. Dadi, Capital-Output Relations in Indian Manufacturing (1946-1964), The M. S. University of Baroda, 1973.

In the capital coefficient matrix, the capital coefficient is a physical concept i.e. item of capital in the shape of good i required in the production of an extra unit of good j is represented by a coefficient B_{ij} . From that, the direct and indirect capital requirements of the j^{th} industry can be derived as the j^{th} column of the matrix $B(I - A)^{-1}$. This gives the capital-output ratio when capital is defined as the vector of commodities rather than as value. The Leontief Ratio can be calculated by evaluating this vector with appropriate prices. When the price structure changes, we have just to revalue this vector with the changed price structure to get the ratio appropriate to this new price structure.

The traditional capital-output ratio described earlier is a creature of price structure because value added is a function of the prices prevailing in the economy and therefore is only capable of describing a situation when price structure remains constant over a period. As in a developing economy this type of condition is not likely to be found, great caution is required in using the traditional capital-output ratio.

Messrs. Hashim and Dadi¹⁷ have worked out the traditional as well as Leontief Capital-Output Ratios for 29

17 Ibid., p. 65.

sectors of the Indian economy for the year 1963 (at purchasers' prices). For chemical industries, they have found that while the traditional capital-output ratio is 1.227898, the Leontief one is 1.919699. However, for the Dyestuff industry, it is not possible to calculate at present the Leontief Capital-Output Ratio as at the moment, it is not distinguished as a separate sector in any available input-output tables in India.

A recent study on the input structure of chemical industries in developed countries by Mr. Wittmeyer¹⁸ has brought out certain important conclusions, viz. to deal with the inputs of the chemical industries, proper consideration should be given to at least three points :

- (a) the categorization of chemical sub-sectors;
- (b) the functional significance of raw materials; and
- (c) the provision of information in terms of value as well as quantity.

(a) Categorization of Chemical Sub-Sectors

The higher the level of disaggregation of the chemical sub-sectors at which basic national data are made available, the more easily can they be regrouped into uniform aggregates

¹⁸ Hans Wittmeyer, A Comparative Study of the Input Structure of the Chemical Industries in Several Industrially Developed Countries, published in International Comparisons of Inter-Industry Data (Industrial Planning and Programming Series No.2), U.N.I.D.O.

common to as many countries as possible. A universal scheme would probably involve at first the following two broad sub-categories:

- (i) basic and intermediate chemicals, and
- (ii) special chemicals.

Basic and intermediate chemicals are mainly definite (monomer) chemical compounds such as sulphuric acid or methanol. As a rule they are not produced for a specific purpose fixed in advance, but serve as various intermediates. Only a small part of them leaves the chemical industry; most of them re-enter further various chemical processes.

Special chemicals are, however, produced for a specific purpose defined beforehand. They are not generally definite individual compounds but mixtures of compounds of the more varied types. Most of them leave the chemical industry and are processed in other industries or sold directly to consumers.

Basic and intermediate chemicals are usually divided into :

- (a) inorganic basic and intermediate chemicals, and
- (b) Organic basic and intermediate chemicals.

Special chemicals are further divided into :

- (i) products of organic synthesis, and
- (ii) derivatives of vegetable and animal origin.

Although special chemicals mainly belong to a higher production stage than basic and intermediate chemicals, their raw materials do not come exclusively from chemical industries. A considerable part of the external input goes directly into the special chemicals without passing through the basic or intermediate chemical sectors. When their bases can be identified, special chemicals may be classified as organic or inorganic; often however they are from both bases. The principal special chemicals are shown in the Table 1.1.

(b) Functional Specification of Raw Materials

Differentiation by main uses, especially between raw materials and energy, has proved more important than rather artificial division of chemical sectors for the analysis of structural relationships between inputs and production. The fact that functional relationships in quantity terms are subject to stoichiometric equations is of special advantage in the case of chemical production - an advantage that overweighs even the disadvantage arising from the complexity of chemical production patterns. The inputs or raw materials and energy can be estimated to some extent, without recourse to special inquiries, provided that the available production statistics are sufficiently reliable. If necessary, the inputs of maintenance and other auxiliary materials, which have less influence on the production pattern, can be taken from general statistics or other data.

Table 1.1 : Principal Special Chemicals (Their Primary Inputs and Major Users)

| Category | Primary inputs | | | | Major Users |
|---|----------------|---|---|---|---|
| | I | O | S | N | |
| Fertilizers | + | | | | Agriculture |
| Pesticides | + | + | | | Agriculture |
| Plastics and Synthetic rubber | | + | | | Various (especially construction, miscellaneous manufactures, vehicles) |
| Man-made Fibres | | + | | | Textiles, automobiles, Miscellaneous manufacturing |
| Synthetic Organic Dyestuffs | | + | | | Textiles, leather, paper |
| Pigments | + | | | + | Construction, lacquers |
| Paints and Varnishes | + | + | + | + | Construction, furniture, vehicles, machinery. |
| Printing Inks and Artists' Colours | | + | + | | Printing, arts and crafts |
| Pharmaceutical Products | | + | | + | Consumption |
| Tanning products, auxiliary products for textiles and other industries | + | + | | + | Leather, textiles, paper. |
| Food & building preserving agents, putty and Cement, linoleum, roofing felt | | + | | + | Construction |
| Photochemicals | | + | + | + | Consumption |
| Soaps and detergents | + | + | | + | Consumption |
| Toilet preparations | | + | | + | Consumption |
| Chemical supplies for offices | | + | + | + | Consumption |

I = Inorganic basic and intermediate chemicals.

O = Organic basic and intermediate chemicals.

S = Special chemicals. N = Non-chemical inputs.

(c) Quantity and Value

It is necessary to know not only the values but also the quantities of inputs. This is especially true of raw materials and energy, the quantity figures of which should first be collected in terms of actual weight and then converted into those of "active substance".

In view of the fact that, there are many branches of chemical industries with their different characteristics and different degrees of complexities, it is not possible to study all of them together. Hence it is proposed in this study to take a general review of chemical industries in general in brief in one chapter and then take up for detailed study, the Dyestuffs and Intermediates Industry in India in the subsequent chapters, in the Inter-Industry Framework.

1.8 Investigational Procedure and Sources of Data

Field Survey Data

After going through the available literature on the industry, a field survey of the Dyestuff and Intermediates industry was undertaken. Initially, letters were written to a large number of large-scale, medium-scale and small-scale firms in the industry but the response was shockingly poor. Out of about hundred firms to whom letters were posted requesting for their co-operation, hardly a dozen responded

without giving any definite commitment about making available the required data. Then the author approached a number of firms personally to obtain the data on product-mix, raw materials consumed for each product-group, plant and equipment employed, labour, services and other inputs, etc. The idea was to collect detailed information at a more disaggregative level than that available from the Annual Survey of Industries or the Reports of the Tariff Commission. Very soon, however, the author realised that it was not an easy task to extract information from the firms. This in fact is the difficulty faced by most research workers who go for the collection of first-hand data in India. The industry circles do not show adequate appreciation to economic or statistical research. Often, the majority of the firms do not keep separate staff for the compilation of statistical information. The research workers are treated with scant respect. Most of the Indian industries have been operating in the sellers' market in the post-Independence period either because, there was not much of competition or because of the tariff protection granted to them against competitors from abroad. Hence there is little appreciation of the importance of the economic and statistical research or the modern tools of management. The various controls imposed by the Government in recent years, has only increased their reluctance to part with information. Especially, the firms in the

chemical industry are more secretive and are most reluctant to part with information. They fear that their manufacturing formulae might be divulged to others and their cost structure and profitability are generally closely guarded sectors.

After repeated visits and with a great deal of persuasion at different levels of management, it was possible to obtain the product-groupwise data with respect to materials consumed along with the value of plant and machinery, services, etc. required from some of the firms which included the leading firms in the industry. Data on man-power requirements for each product-group could not be available although the author tried for the same. Similarly, capital equipment required was available only in aggregative form. The firms explained that virtually thousands of small components were required by the dyestuff plants and it was not possible for them to give the data in disaggregative form. In the case of the larger firms, all of which have been established with foreign collaboration, they explained that their principals had supplied them with entire plant on a turn-key basis and hence it was not possible for them to give the value break-up of the different assemblies separately, even if they wished to. However, with the co-operation of a Senior Chemist in a leading dyestuff plant, the author could collect the

information on the plants and equipments required to produce different individual products and this information has been presented in Chapter III. Such data from other firms, along with the values of the plants and equipments would have helped in computing the capital coefficients along with the flow-coefficients.

It was not possible to get the data on individual products because this is a multi-product industry, the products numbering virtually in thousands. However, product-groupwise input requirements could be obtained, which information could not be had from A.S.I. or any other published source. Some of the useful information was collected through the employees in the firms. For instance, the inputs of ten individual products, and the flow chart showing different cross-linkages in various products, presented in Chapter V were obtained from the plant manager of a leading large-scale firm.

The data collected from different firms refers to the year 1969-70 i.e. for only one year. If the data was available for a few years, it would have been much more useful in studying the trends. Unfortunately, it was not possible to get a time series data from the firms contacted.

The firms that co-operated in furnishing the data were :

Large-Scale Firms (Investment above Rs. 10 Crores)

- (1) M/s. Atul Products Ltd., Bulsar, Gujarat.
- (2) M/s. Indian Dyestuff Industries Ltd., Kalyan, Bombay (Maharashtra).
- (3) M/s. Colour Chem Ltd., Bombay, Maharashtra.
- (4) M/s. Amar Dye Chem Ltd., Bombay, Maharashtra.

Medium-Scale Firms (Investment above Rs. 50 Lakhs)

- (5) M/s. Aniline Dyestuff Industries Ltd., Bombay (Maharashtra).
- (6) M/s. Suhrid Geigy Ltd., Baroda, Gujarat.
- (7) M/s. Hickson & Dadajee Ltd., Bombay, Maharashtra.
- (8) M/s. Sudarshan Chemical Industries Ltd., Poona, Maharashtra.
- (9) M/s. Arlabs Ltd., Bhor (near Poona), Maharashtra.

Small-Scale Firms (Investment below Rs. 50 Lakhs)

- (10) M/s. Texdyes Corporation P. Ltd., Baroda, Gujarat.
- (11) M/s. Golden Dyestuffs P. Ltd., Bombay, Maharashtra.

More than ninety per cent of the industry is concentrated in Maharashtra and Gujarat which are the major consuming centres. The first four firms mentioned above are the largest in the industry and account for about 60 per cent of the total production of the industry. It is

obvious therefore that the firms covered represent the major portion of the industry.

Special mention must be made of M/s. Atul Products, Bulsar (Gujarat) and M/s. Indian Dyestuff Industries Ltd., Kalyan (Maharashtra) for their co-operation and help. Dr. Baijal and Dr. Shah of Atul Products Ltd. and Shri R. B. Desai and Shri R. Sankar of Indian Dyestuff Industries Ltd. contributed a great deal to this study.

Secondary Data

As mentioned earlier, the field survey data could be collected for only one point of time. To overcome the limitations of one point data, at least partly, the time series data published by the Annual Survey of Industries and other sources have been made use of.

The secondary data were collected mainly from the following sources:

(1) Annual Survey of Industries

Data on the dyestuff industry is available from the Annual Survey of Industries from 1960 to 1966. Prior to 1960, the time series data for industries is available from the Census of Manufacturing Industries (C.M.I.) from 1946 onwards. Unfortunately, C.M.I. classification does not give Dyestuffs as a separate industry. Hence it was not possible to go backwards beyond 1960. A.S.I. data were useful in

studying the trends of capital-output, labour-output and other ratios as also the behaviour of flow coefficients at an aggregative level.

(2) Tariff Commission Reports

The Dyestuff Industry was brought under Tariff Protection from 1952 onwards i.e. almost from the initial period of its growth and periodical reviews on the continuance of protection were undertaken by the Tariff Commission and Reports have been published. Hence useful data on the growth and problems of the industry could be obtained from the Reports of the Tariff Commission published in 1965, 1968 and 1972. Especially because the A.S.I. data could not be available beyond 1966, the data published by the Tariff Commission could be used to supplement the A.S.I. data for the later years.

(3) Annual Reports of the D.G.T.D.

Useful supplementary information was collected from the Annual Reports published by the Directorate General of Technical Development, New Delhi. Particularly since 1969-70, more elaborate information on chemical industries, including the dyestuff industry is published in these annual reports.

(4) Programmes of Industrial Development published by the Planning Commission, Government of India

The Planning Commission publishes the Programmes of Industrial Development along with Plan documents. Basic

data on most of the important industries is published in these reports. The historical figures of production and imports of dyestuffs and other chemicals were collected from these documents. Comparative figures for other related industries were also available from these reports.

(5) Monthly Statistics of the Foreign Trade of India

Figures of imports of chemicals and dyestuffs over the past few years were collected from the Monthly Statistics of the Foreign Trade of India.

(6) Data Published by the Indian Chemical Manufacturers' Association

Some useful information on the industry could be available from the various seminar proceedings published by the Indian Chemical Manufacturers' Association where the view of different experts were available on the various problems of the industry. Some figures of imports and exports of dyestuffs were also available from them.

1.9 The Chapter Scheme

In Chapter II, the nature, characteristics and the importance of the chemical industry have been discussed. This chapter brings out the growth of the chemical industries, important developments in the industry and the inter-industry linkages of chemical industries with illustrations from the Indian data wherever possible.

Chapter III examines the nature of the dyestuffs

industry as a separate branch of the chemical industry, its characteristics, and growth along with detailed manufacturing processes. Requirements of raw materials, intermediates, plant and equipments, etc. have been discussed at length. The important product-groups and their uses, economics of the dyestuff trade, value and importance of the industry to the national economy, etc. have been explained in brief. Consumption of dyestuffs by different industries and the proportion going to each of them has also been presented.

Chapter IV gives a detailed review of the Historical growth and the Present Position of the Dyestuffs and Intermediates Industry in India. The Tariff history and the role of protection in the development of the industry have been highlighted here. The problems of raw materials' supply, intermediates, etc. have also been discussed. Group-wise production of dyestuffs, imports and exports over the years, have been presented and the scope for expansion has been examined.

Chapter V examines the input structures of Specified Dye Groups. Flow coefficients have been computed from the field survey data for individual dye groups and inter-firm comparisons are made for the same groups of dyes. Cross-linkages of different stages of synthesis in the manufacture of dyes and intermediates have been examined at length and the effects of aggregation and disaggregation are studied.

In the Appendix to the chapter, flow coefficients at a detailed disaggregative level computed from the field survey data for some important groups of dyes are presented.

In Chapter VI behaviour of input-output ratios for the changing size of the firm have been examined for A.S.I. data and also for the field survey data.

In Chapter VII, the important conclusions emerging out of the study have been presented.

CHAPTER II

THE CHEMICAL INDUSTRY (ITS NATURE,
CHARACTERISTICS AND IMPORTANCE TO
THE NATIONAL ECONOMY)

"The chemical man sees his fellow human beings clothed in chemicals, sleeping in them, eating of them and off them, building and painting his houses with them. Yet ask the chemical executive what he does and he is likely to defy further inquiry with words like caprolactam and polypropylene. Thus have his predecessors have damned an exciting industry to a limbo of proto-Greek lexicography. Should the chemical industry go through a time of public misunderstanding, as it well may on the pollution issue, it would almost seem to deserve it for its pollution of the language."*

2.1 The Problem of Definition

Considerable mystery shrouds the chemical industry from the layman's view. Incomprehensible terminology, heterogenous raw materials, products and processes, and even the hazy history of the industry's development tend to make the industry a question mark to the public.

The boundaries of the chemical industry are not rigidly set. Actually there is no single group that could adequately cover the many thousands of companies which pertain to chemicals or chemically formed products. The clearest division of the industry separates:

- (1) the purely chemical concerns which manufacture basic materials such as acids, alkalies and organics;

* Quoted from an article in The Economist of London dated October 3, 1970 by Andrew Knight.

- (ii) the allied process industries, which produce soap, paints, fertilizers, plastics, synthetic fibres, etc.;
- (iii) the chemical process industries such as rubber, glass, paper and leather, using chemicals at one or more stages of their operation.

It would seem that in some respects the term chemical industry includes an entire family of widely varying industries. When a segment, such as plastics or fertilizers, becomes sufficiently large or important it tends, like rayon, soap and others to acquire a personality all of its own. Economic analysis then gives individual attention to the divorced member.

The Chemical Industry, therefore, is not just one industry but it embraces a large number of industries and also very different manufacturing processes. It is a multi-product and multi-process industry.

2.2 The Chemical Manufacturing

The manufacture of chemicals requires one or more chemical reactions as well as physical operations such as mixing, separation, purification, etc. Each reaction involves :

- (1) Preparation of raw materials (grinding, mixing, dissolving, etc.).
- (2) Production or manufacture (i.e. actual reaction).
- (3) Recovery (separation of the product by filtering crystals from a liquid).

(4) Purification to meet the required specifications.

The chemical manufacture is generally made up of about 15 to 20 unit processes and a similar number of unit operations, which are used in hundreds of different combinations. An example of the unit process is a reaction like chlorination, i.e. addition of chlorine, usually with hydrochloric acid resulting as a by-product. Some of the important reactions used in the chemical industries are explained in Chapter III.

In the synthesis of complex chemicals like dyes and pharmaceuticals, each of the unit process accomplishes a result comparable with that of manufacturing a sub-assembly in the production of an automobile.

The principal operations are grinding, mixing, evaporation, distillation drying, absorption, crystallization and filtration. Still more general are the operations like heat transfer and of fluid flow (handling of liquids and gases). For each operation there usually are several types of equipment. Solids may be separated from liquids, for example, by filtration, centrifugal equipment or settling. Crushing and grinding may be carried out with crushing rolls in mills with swinging hammers or pebble mills.

In batch operations, a given quantity of material is carried through an entire step and then transferred to

the next one. Solutions of two salts, for example, may be reacted in a kettle to form an insoluble pigment, with heating and mixing carried on until the right shade and particle size are attained. The kettle is then emptied, filtered and a new batch is started.

Continuous processes are those in which raw materials are added and finished products are removed continuously, as when nitrogen (N_2) and hydrogen (H_2) gases are passed through a reactor to form ammonia (NH_3).

Generally, in the case of complex chemicals, batch processes become inevitable in the final stages of synthesis. For instance, in the case of final dyes or pharmaceutical products, batch processes are to be necessarily employed. Conversely, most of the basic chemicals are produced by continuous processes.

2.3 The Classification of Chemical Products

The world chemical industry currently manufactures approximately 11,000 different products ranging from colourless gases to viscose adhesives and resin flakes, pellets and powders. Their number and nature necessitates extensive classification.

The two major chemical groupings are the organic and the inorganics. Organic chemicals are compounds containing the carbon atom. These are divided further into aliphatics

and aromatics, terms indicating the structure of their hydrocarbon base. Inorganics, except for minor anomalies in classification, do not derive from carbon.

Fine chemicals are more intricate compounds, made to specification in relatively small volume. They include medicinals, synthetic flavourings, reagents and analytical chemicals. Heavy chemicals are the big tonnage materials sold in bulk like the Caustic Soda, Soda Ash, Sulphuric Acid, etc.

Chemicals are also grouped by type, such as acids, alkalies and salts; by more restricted groupings such as phosphates and bromites; by use - pigments, solvents, dyes; by type of raw materials - petrochemicals; by processes used to make them - electrochemicals, fermentation chemicals, etc.

The term chemical industries generally includes:

- (1) Heavy chemicals including acids, alkalies, etc.
- (2) Chemical fertilizers based on nitrogen, phosphorus and potash.
- (3) Petro-Chemicals
- (4) Dyes and Intermediates
- (5) Drugs and Pharmaceuticals
- (6) Soaps and detergents.

The basic heavy chemicals like sulphuric acid, soda ash, caustic soda, sodium carbonate, nitric acid, etc. are used as raw materials in the manufacture of other chemical

products and also as process chemicals in various other industries. At the beginning of this century, these chemicals were in short supply in our country, their indigenous production being insignificant. The Second World War gave a fillip to the production of these items which in turn helped in strengthening our industrial base. In 1941, Alkali & Chemical Corporation of India and Tata Chemicals were established and the production of sulphuric acid, synthetic ammonia, caustic soda, bleaching powder and bichromates commenced. Later on, some more factories were established. In 1947, the indigenous production of sulphuric acid, soda ash and caustic soda was only 8,000 tonnes, 13,624 tonnes and 4,192 tonnes respectively. In order to protect these industries from international competition, the government imposed import duties in 1947. The production of sulphuric acid, which is regarded as an index of economic development, reached 11,89,000 tonnes in 1971 (over 14 times from the 1947 level). The production of Soda Ash was 4,78,000 tonnes (37 times the 1947 level) and the production of Caustic Soda increased to 3,73,900 tonnes in 1971 (about 94 times the 1947 level).

The production of chemical fertilizers, pharmaceuticals, dyes and other chemicals was also insignificant at the time of Independence. All these industries made real progress only in the post-Independence period in India.

Chemical Fertilizers

Nitrogen, phosphorus and potash are the three basic elements on which the production of chemical fertilizers is based. The nitrogen is useful in the initial stages for the proper development of stem and leaves. Phosphorus helps at the time of flowering and fruit-bearing while Potash helps in the development of starch and sugar in fruits and vegetables. This also protects the plants from crop diseases.

Great strides were made by the United States and other agriculturally prosperous countries in the production of crops with the help of chemical fertilizers.

Since our new agricultural strategy is based on the use of chemical fertilizers, high yielding variety seeds and improved agricultural practices, greater and greater priority is being accorded to the production of chemical fertilizers. In 1951-52 the production of nitrogenous fertilizers was only 11,000 tonnes against 8,86,000 tonnes in 1971. The production of phosphatic fertilizers was 2,50,000 tonnes in 1971. However, because of the increasing uses of these fertilizers, the production fell short of demand and large quantities had to be imported. It is estimated that the consumption of nitrogenous fertilizers in 1970-71 was of the order of 14,26,000 tonnes. For Potassium fertilizers, we are totally dependent on imports.

Petrochemicals

Petrochemicals have been replacing the traditional chemicals based on natural raw materials fast in most of the developed and developing countries. We in India, started thinking in terms of petrochemicals only since 1956. The Indian chemical industry till then was limited to the manufacture of certain chemicals in relatively smaller quantities based on naturally available raw materials such as manufacture of alcohol from sugar molasses, acetylene from calcium carbide, and aromatic chemicals from coal. In recent years, however, India has entered the petrochemicals field in a big way. The petroleum based naphtha is the most important raw material in the manufacture of petrochemicals and it is available in fairly large quantities in our country. Hitherto, however, we were lacking in machinery and the technical know-how in this field.

At present there are two naphtha cracking plants in our country. One is the Union Carbide's Bombay plant with a capacity of 60,000 tonnes and the second is Mafatlal Group's NOCIL (National Organic Chemical Industries Ltd.) with a capacity of 2,25,000 tonnes. The third plant is being established at Baroda by the Indian Petrochemical Corporation Ltd. Similarly, M/s. Herdilia Chemicals and Poliyolifins Industries Ltd. will start production of petrochemicals very soon. Similar plants under public sector

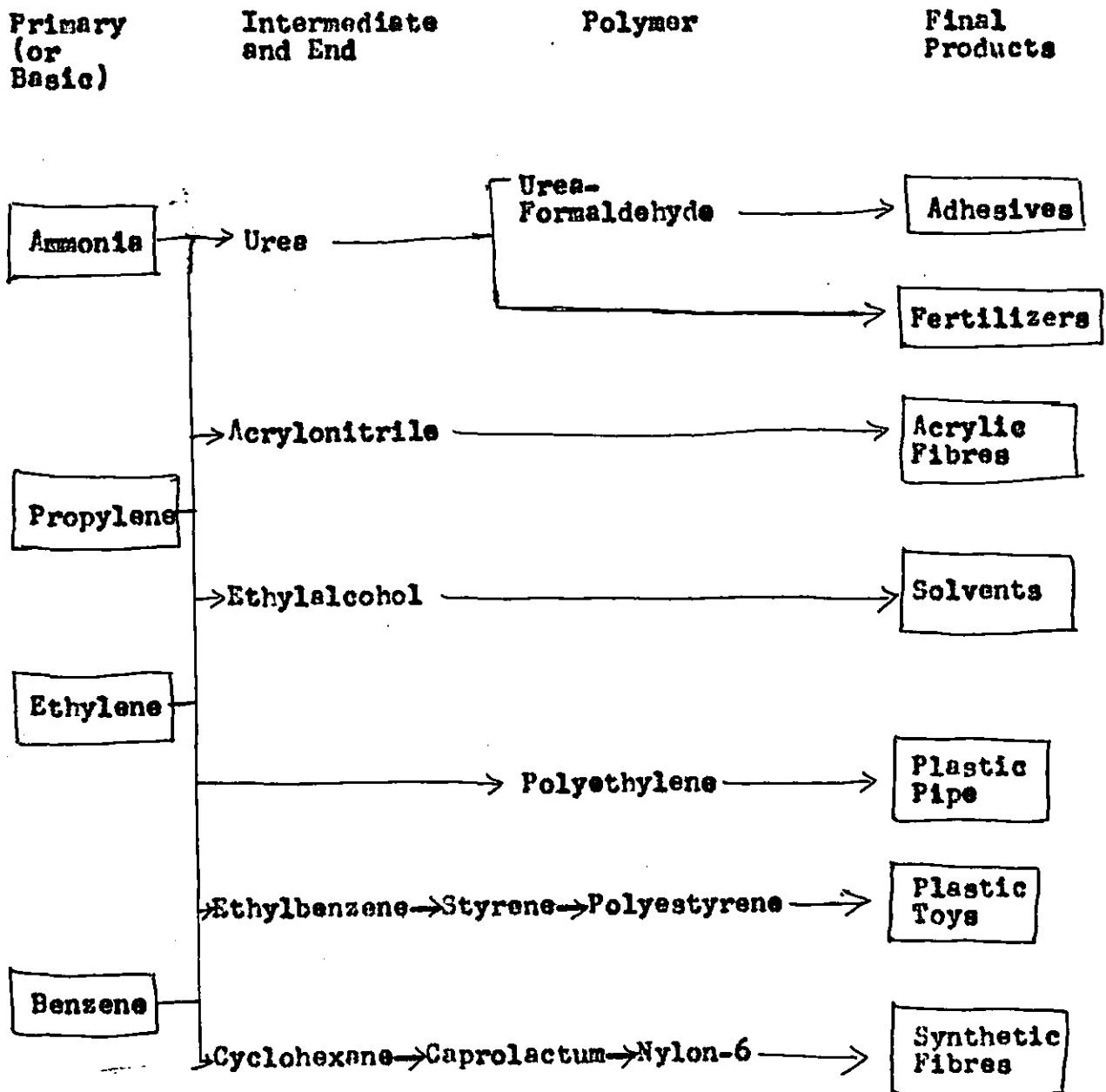
are under consideration. Clearance has already been given for the establishment of petrochemical plants at Koyali in Gujarat and Barauni in Bihar. Another plant in Andhra Pradesh is under consideration. When all these plants go on stream, they will give a great impetus to a large number of "downstream"* industries and will change the industrial map of India. Petrochemicals play an important part in the overall industrial development because the manufacture of synthetic fibres, plastics, chemical fertilizers, synthetic rubber, etc. can be produced on a large scale from petrochemicals. (See the Chart given on the next page.)

Dyes and Pharmaceuticals

The dyes and pharmaceutical industries have also made great progress in the post-independence period. These industries were almost non-existent before independence. The production of dyestuffs started in the real sense only in the fifties and at present it is around 14,000 tonnes. This helped a great deal in the development of textile industry, paints and varnish industry, leather tanning industry and other consuming industries.

As regards the pharmaceuticals, there were only a few companies—predominantly foreign companies—engaged in the manufacture of pharmaceutical products. Their production

* Industries based on the raw materials produced by these units.

WHAT A PETROCHEMICAL DOES

was negligible considering the indigenous demand and the prices were beyond the reach of the common people.

This position has been gradually changing since 1947. Many indigenous companies entered the field and the public sector also made its entry in this industry to break the monopolies and to bring down the prices of essential drugs. The notable public sector undertakings in the pharmaceutical industry are the Hindustan Antibiotics Ltd. at Pimpri near Poona, and the Indian Drugs and Pharmaceuticals Ltd. at Hyderabad and Rishikesh. The value of pharmaceuticals produced in 1970 amounted to about Rs. 300 crores and it is expected to be doubled in the next ten years.

Soaps and Detergents

The production of soaps and detergents also registered significant increases in recent years. The production of soaps was only 22,252 tonnes in 1950-51. It went up to 1,50,641 tonnes in 1960-61 and 2,32,694 tonnes in 1970-71.

The growth in the output of certain important chemicals is given in Table 2.1. This Table reveals the spectacular progress made by this industry since 1950-51.

The various indicators of growth show that the development of chemical industries in recent years has been impressive although the dependence on imports continued. The input based classification of the index numbers of

Table 2.1 : Output of Some Important Chemicals and Chemical Products (1950-51 to 1970-71)

| Item | (Tonnes) | | | | | | | | | | | | |
|----------------------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|-----------|-----------|-----------|
| | 1950-51 | 1955-56 | 1960-61 | 1961-62 | 1962-63 | 1963-64 | 1964-65 | 1965-66 | 1966-67 | 1967-68 | 1968-69 | 1969-70 | 1970-71* |
| Sulphuric Acid | 1,00,596 | 1,66,909 | 3,67,731 | 4,30,422 | 4,85,104 | 6,01,877 | 6,96,091 | 6,62,433 | 7,19,241 | 8,89,253 | 10,34,212 | 11,35,506 | 10,53,101 |
| Caustic Soda | 11,543 | 36,039 | 1,01,102 | 1,23,262 | 1,29,801 | 1,62,961 | 1,91,798 | 2,17,897 | 2,33,401 | 2,95,027 | 3,14,099 | 3,60,448 | 3,71,277 |
| Soda Ash | 45,338 | 81,812 | 1,51,948 | 1,88,197 | 2,36,205 | 2,74,801 | 2,87,212 | 3,31,135 | 3,48,513 | 2,74,511 | 4,04,616 | 4,27,434 | 4,49,327 |
| Bleaching Powder | 3,601 | 3,175 | 6,078 | 7,211 | 6,801 | 6,924 | 7,995 | 7,345 | 11,965 | 8,761 | 11,711 | 15,179 | 14,374 |
| Bichromates | 2,297 | 2,992 | 4,855 | 5,626 | 6,924 | 7,280 | 6,795 | 6,714 | 6,941 | 7,286 | 7,906 | 9,139 | 9,481 |
| Superphosphate | 56,706 | 71,361 | 52,263 | 63,197 | 78,750 | 1,02,155 | 1,21,701 | 1,09,510 | 1,20,204 | 1,47,704 | 1,14,172 | 1,12,879 | 1,30,242 |
| Ammonium Sulphate | 47,171 | 40,206 | 79,561 | 78,724 | 84,560 | 88,072 | 87,082 | 84,090 | 90,494 | 86,921 | 1,20,478 | 1,26,874 | 1,32,917 |
| Paints and Varnishes | 30,312 | 40,368 | 52,626 | 62,324 | 66,009 | 74,994 | 71,859 | 68,296 | 68,994 | 72,763 | 60,706 | 61,541 | 66,122 |
| Chlorine Liquid | 4,229 | 13,203 | 32,508 | 35,903 | 37,241 | 46,092 | 50,642 | 51,122 | 67,195 | 87,048 | 1,06,046 | 1,34,086 | 1,52,196 |
| Soap | 77,252 | 1,04,296 | 1,44,697 | 1,50,641 | 1,51,371 | 1,66,708 | 1,58,970 | 1,67,490 | 1,84,418 | 1,89,980 | 1,99,238 | 2,26,872 | 2,32,694 |

* Provisional.

Source : Basic Statistics Relating to the Indian Economy 1950-51 to 1970-71. Statistics and Surveys Division, Planning Commission, New Delhi, 1972.

industrial production presented in Table 2.2 clearly shows that the growth of chemical based industries was the fastest.

**Table 2.2 : Index Numbers of Industrial Production (1960=100)
Input Based Classification**

| Year | Agro-based Industries | Metal-based Industries | Chemical-based Industries |
|----------|-----------------------|------------------------|---------------------------|
| Weight : | 44.08 | 16.55 | 8.94 |
| 1961 | 105.2 | 115.9 | 111.6 |
| 1965 | 121.2 | 229.7 | 153.4 |
| 1966 | 120.0 | 205.4 | 170.9 |
| 1967 | 114.7 | 199.6 | 180.0 |
| 1968 | 118.8 | 211.0 | 205.6 |
| 1969 | 125.3 | 223.2 | 226.7 |
| 1970 | 131.0 | 236.0 | 244.9 |

Source: The Reserve Bank of India Bulletin, April 1972, p. 731.

The growth rate of fixed assets for the sample of 40 chemical companies analysed by K. Krishnamurthy and D. U. Sastry in a recent study¹ is around 16 per cent per annum over the years 1960-67 (see Table 2.3).

¹ K. Krishnamurthy and D. U. Sastry, "Some Aspects of Corporate Behaviour in India," Indian Economic Review, Vol. VI (New Series), No. 2, October 1971.

Table 2.3 : Some Growth Rates and Ratios for the Sample of 40 Chemical Companies

(In Percentages)

| Year | Growth rate of Sales | Growth rate of gross fixed assets | Growth rate of inventory | Growth rate of gross fixed assets plus inventory | Growth rate of gross profits net of taxes | Gross retained earnings to gross profits net of taxes | Retained earnings to gross fixed investment + inventory investment |
|---------|----------------------|-----------------------------------|--------------------------|--|---|---|--|
| 1958 | 14.78 | - | - | - | - | - | - |
| 1959 | 16.05 | - | - | - | - | - | - |
| 1960 | 16.45 | 15.84 | 19.67 | 16.95 | - | 67.06 | 55.75 |
| 1961 | 15.69 | 14.39 | 23.98 | 17.93 | 11.64 | 66.48 | 46.98 |
| 1962 | 12.01 | 15.25 | 11.23 | 14.00 | -4.99 | 61.22 | 44.63 |
| 1963 | 15.44 | 21.46 | 1.73 | 15.47 | 23.35 | 65.54 | 46.79 |
| 1964 | 16.13 | 21.66 | 5.38 | 17.31 | 39.42 | 70.46 | 54.27 |
| 1965 | 17.17 | 15.49 | 18.68 | 16.26 | 12.44 | 70.28 | 55.26 |
| 1966 | 13.22 | 9.89 | 17.79 | 11.82 | 8.75 | 70.10 | 70.89 |
| 1967 | 11.36 | 10.17 | 19.79 | 12.66 | -6.43 | 70.43 | 55.68 |
| Average | 14.83 | 15.68 | 14.78 | 15.30 | 12.03 | 67.70 | 53.78 |

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Source : K. Krishnamurty and D. U. Sastry, "Some Aspects of Corporate Behaviour in India," Indian Economic Review, Vol. VI (New Series), No. 2, October 1971, p. 155.

All this brief survey of the growth of the Indian chemical industries in recent years indicates that the industries have registered rapid growth and the scope for the further development of the chemical industry is very great. This conclusion is reinforced by the fact that the imports of chemicals into the country have also been increasing fast along with the growth of the industry. In other words, the growth of the industry, though rapid, could not keep pace with the ever increasing demand for various chemicals. This is evident from Table 2.4.

Table 2.4 : Value of Imports of Chemicals in India

| Year | (In Rupees) | | |
|---------|---------------------|-------------------|--------------|
| | Inorganic Chemicals | Organic Chemicals | Total |
| 1961-62 | 13,19,57,171 | 22,39,73,063 | 35,59,30,234 |
| 1962-63 | 16,67,81,939 | 21,10,55,274 | 37,78,37,213 |
| 1963-64 | 13,07,21,121 | 19,04,25,373 | 32,11,46,494 |
| 1964-65 | 13,95,65,907 | 20,80,22,784 | 34,75,88,691 |
| 1965-66 | 14,81,31,569 | 20,97,66,914 | 35,78,98,483 |
| 1966-67 | 16,82,80,326 | 37,22,23,121 | 54,05,03,447 |
| 1967-68 | 19,39,24,483 | 58,64,52,828 | 78,03,77,311 |
| 1968-69 | 13,91,90,086 | 68,94,92,678 | 82,86,82,764 |
| 1969-70 | 15,31,87,123 | 51,50,25,703 | 66,82,12,826 |
| 1970-71 | 15,28,72,728 | 52,69,75,815 | 67,98,48,543 |

Source : Monthly Statistics of the Foreign Trade of India.

2.4 Nature, Scope, Historical Growth
and Characteristics

Chemicals are rightly regarded as one of the nation's "growth" industries. The chemical industries along with one or two others - notably electronics - have not only been breaking production records, but have also been influencing the rate of expansion in other and widely different areas of industrial activity.

If chemistry as a science has made mankind less dependent upon a few naturally occurring substances, it has, at the same time, brought industries closer together.² Major products, joint products and by-products are being exchanged in ever increasing volume. Continuous operations, lending themselves more to automation, are also fostering a greater degree of industrial integration. Under these circumstances, the future of the chemical industry is hardly one which can be determined in isolation. Rather, its outlook and that of the mainstream of a country's economy are becoming ever more closely interwoven with each other.

Factory-made chemicals have been essential to industry ever since developments leading to the mass production of textiles helped to initiate the industrial revolution

2 See John Davis, The Canadian Chemical Industry, Royal Commission on Canada's Economic Prospects.

over a century ago. Since that time chemicals have been used more and more extensively as processing agents for, and vital constituents of, many types of manufactured goods; and more recently, as whole synthetic alternatives for naturally occurring products like rubber, agricultural fibres and wood resins. Also, because of its increasing diversification, a growing proportion of the output of the chemical industry is being sold directly to end users in the form of consumer and other fully manufactured goods.

The science of industrial chemistry was little known a century ago. Even in 1900 most of the world's industries were based upon processes discovered largely by accident and practised with modifications for many generations. Since then, however, the discoveries and services of chemists have been adopted by one industry after another. Today many more chemists are employed outside what one might call the chemical industry proper than are employed in it. What better indication could one have of the esteem in which chemistry is already held in the world of industry and business?

With the spreading of the scientific spirit and the initiation of systematic, scientific inquiries in the 18th and 19th centuries, a great body of chemical knowledge became available. Its application has ranged the whole gamut of industry, so that to talk of chemicals in industry is a far different thing than to talk of the chemical industry.

Chemistry in industry performs three main functions. First, in the physical change industries, it provides essential raw materials, methods of processing and tests and controls for maintaining the quality of raw materials and products. Second, in the older chemical change industries, it has allowed the replacement of empirical processes by scientifically proven methods that permit greater efficiency, closer quality control and the development of better products. Finally, chemical science is the basis of chemical industry itself.

Notable illustrations of the applications of chemistry in other industries are paper, which uses chemical processes to produce all but its mechanical pulps, the production of pig iron and steel, the smelting and refining of non-ferrous metals, synthetic or chemically treated foods, clothing and other textiles, etc.

As the basic chemical industry moves nearer to the consumer with plastics, synthetic fibres, films, protective coatings, etc., and the manufacturers themselves integrate backwards to supply their own chemical needs, there is a marked breaking down of the former distinction between the chemical industry and the others, and it is becoming increasingly difficult to define in any but rather arbitrary terms for statistical purposes.

2.5 Interdependence and Linkages

There is a very high degree of interdependence and linkages in the chemical industry. Today there are thousands of products which are classified as chemical and allied products. Chemical products are not only interdependent but they have alternative uses. There are today more than ten thousand commercial chemical products in the world which can be made from different raw materials and alternative processes.

The competition between products often constitutes a chain process to link producers who might seem to operate in quite different markets.

Linkages between products create overlapping spheres of interest for the various firms in the chemical industry, and the overlapping is intensified by the potential expansion of the output of each firm into additional lines for which their know-how and facilities are broadly suitable. For example, some of the large scale dyestuff firms produce some drugs while some of the Pharmaceutical Companies, produces some quantities of dyes and intermediates. The notable examples in India are M/s. Atul Products, Bulsar (Gujarat) who are the largest manufacturers of dyes and intermediates. They also produce fairly large quantities of drugs. M/s. Sandoz (India) Ltd. and M/s. Suhrid Geigy Ltd. are basically Pharmaceutical Companies but they also

produce fairly large quantities of dyes and intermediates. Similar examples could be found in other branches of the chemical industry also. This is perhaps one of the strongest justifications for grouping together producers who make apparently unrelated products and calling the group an industry.

As stated earlier, a distinct characteristic of the chemical industry is its complexity. Some industries start with a number of raw materials to make a single product, like automobiles; others take a single raw material like petroleum and make a number of end products from it. The basic raw material of the chemical industry is the molecule. Its tremendous scope enables the chemical industry to produce more than ten thousand distinct chemical entities to which hundreds more are added annually. Because of this complexity, the industry has developed several other characteristics which are distinct from most of the other industries.

Firstly, it is a multi-product industry. Some of the processes yield joint products and by-products and to get the highest returns one has to recover the by-products and the joint products.

Despite Adam Smith's emphasis on the virtues of specialization, there have always been sound reasons why many firms should make more than one product. These very

often apply to the chemical industry with particular force. The advantages of marketing a range of products is often considerable, because users often want small quantities of a large number (e.g. drugs, dyes, fine chemicals, etc.); research facilities are extremely important and one way of securing the necessary volume of output to support a well equipped laboratory is to add other lines to the firm's production. The world giants in the chemical industry like I.C.I., Bayer, and others produce virtually thousands of chemicals and chemical products. The considerations which explain why most firms produce more than one product also largely explain why so many different combinations are found as one moves from firm to firm.

The inorganic chemical industry which produces heavy chemicals like sulphuric acid, caustic soda, soda ash, bleaching powder, etc. gave a great push to the chemical industries as also the other industries during the 19th century in Europe. Since the middle of the 19th century, for instance, the production of sulphuric acid is considered to be a yardstick of the industrial activity of a country.

Among the alkalies, soda and potash have been known since quite olden days but their use has been increasing tremendously over the time. The demand has been continuously increasing from bleachers, soap and glass makers, apart from the manufacturers of chemicals and chemical products.

A look at the production figures of the basic heavy chemicals in India during the era of planned economic development will bring home this point. The figures are presented in Table 2.5.

Table 2.5 : Production of Sulphuric Acid, Caustic Soda and Soda Ash (1950-51 to 1973-74)

| Year | (Quantity in Tonnes) | | |
|---------|----------------------|--------------|----------|
| | Sulphuric Acid | Caustic Soda | Soda Ash |
| 1950-51 | 1,00,596 | 11,543 | 45,338 |
| 1960-61 | 3,67,731 | 1,01,102 | 1,51,948 |
| 1965-66 | 6,62,433 | 2,17,897 | 3,31,135 |
| 1970-71 | 10,53,101 | 3,71,277 | 4,49,327 |
| 1973-74 | 14,00,000 | 4,00,000 | 4,80,000 |

- Source:**
1. Basic Statistics Relating to the Indian Economy, Statistics and Surveys Division, Planning Commission, New Delhi.
 2. Guidelines to Industries (1974-75), India, Planning Commission.

In the earlier years, the coal-tar chemical extraction led to the development of so many chemical industries like dyes, drugs, synthetic fibres, plastics, pesticides, etc. Now the basic raw materials for these industries are also available from petrochemicals. With the tremendous growth of petrochemicals in recent years, these downstream industries have received a big push. The basic building blocks like benzene, toluene and xylene are made available

on a large scale by the modern petrochemical complexes. Earlier, these were entirely extracted from coal tar and hence their supplies were limited.

In India the newly established petrochemical complexes like the Union Carbide and NOCIL at Bombay and Indian Petrochemical Corporation at Baroda have been instrumental in the starting of a chain of downstream industries and in expanding the capacities of the dyestuffs, fine chemicals and other industries. For instance, a basic chemical like benzene used to be brought to Bombay from the coal carbonization plants at Bhilai and Durgapur. This chemical being bulky, the transport cost was quite heavy. M/s. Indian Dyestuff Industries Ltd., one of the largest dyestuff units in India located at Bombay, used to get their requirements of Benzene from Bhilai. Since the coming up of the NOCIL complex at Bombay, however, they have taken a pipeline from NOCIL complex to their factory and expanded their production of benzene based products significantly. Incidentally, it would be interesting to note that Indian Dyestuff Industries is a sister concern of NOCIL (both the concerns belong to the famous Mafatlal Group).

Not only the units located in Bombay and Gujarat had to depend for their supplies of benzene, toluene and xylene on the steel plants at Bhilai, Durgapur and Rourkela, thus thus incurring heavy transportation costs, but there was also a constraint on the total available supplies.

2.6 Other Characteristics

The great risk and uncertainty involved in this industry have given rise to some other characteristics such as :

(a) The ratio of capital to labour or to output is usually high in the production of chemicals, where one typically finds complex and expensive plants being tended by a relatively small number of workers. This is especially true of continuous processes which are generally employed in the production of basic chemicals. This implies that any given annual percentage of obsolescence of capital absorbs a bigger proportion of the selling price than in most other industries. Hence the gross profits are generally higher. This is also necessitated by the fact that the industry has to spend large sums on research and development.

(b) A chemical plant often takes a long time to design, build and get working. Plans for expansion or modernization must therefore be based on estimates of demand several years ahead: in particular if shortages are to be avoided, the growth of demand must be foreseen well in advance.

To illustrate this point, it may be worthwhile quoting the example of M/s. Hindustan Organic Chemicals Ltd., a Government of India undertaking which was floated in 1960-61 with the ambitious programme of manufacturing about

30 basic intermediates required by the Dyestuff, Pharmaceutical and Pesticides industries. Even today i.e. after 15 years, the plant for the manufacture of hardly a dozen intermediates have been commissioned. When the programme was initially drawn up, it was expected that all the 30 intermediates would be coming out within a decade i.e. by 1970-71. Meanwhile, the demand for these intermediates has shot up considerably since many units had planned their production taking into consideration the anticipated availability of intermediates from M/s. Hindustan Organic Chemicals Ltd. Since the plants could not be installed in time, the expansion plans of Dyestuffs, Pharmaceuticals and Pesticides units were greatly affected.

The private sector is also no exception to this. Union Carbide's naphtha cracking plant at Bombay took about 7 years for commissioning. Mafatlal Group's NOCIL complex took 6 years in commissioning and 10 years to reach its full capacity.

Anthraquinone (a dye intermediate) Plant of M/s. Indian Dyestuff Industries Ltd., Kalyan, Bombay, took 5 years for commissioning. The Company obtained the licence for the manufacture of 1000 tonnes of Anthraquinone per year in 1962-63. Collaboration Agreement was entered into with an Italian firm M/s. Aziende Colori Nazionali Affini (ACNA), for the supply of technical know-how. The project was completed in 1967-68.

Even a medium scale sulphuric acid plant put up by the same Company took almost 4 years in commissioning. It was launched in 1959-60 and was completed in 1963-64.

The Caustic Soda Plant put up by M/s. Atul Products, Bulsar (Gujarat) took over 5 years for commissioning.

(c) The changing nature of the industry makes it hard for the makers of an individual chemical to foresee the course of demand for their product, since developments in some other field may on the one hand call for a great increase in the supply, or on the other hand introduce a rival product to share the market - or even to produce a flood of the chemical in question as a by-product, to be sold almost regardless of cost.

2.7 Economic Behaviour of Chemical Firms

The historical development shows that the economic incentive to large-scale production also depended on factor proportions as well as on the role of technical effort. Capital using chemical firms like Caustic Soda, Soda Ash, Dyes and Intermediates manufacturers tended to be large and they generally have large plants. This was so because the production had to finance technical effort, itself subject to economies of scale. In India also, we find the same trend. There are only a few firms accounting for the major proportion of the production of Caustic Soda. Only four firms accounted for the entire production of 4,80,000 tonnes

of Soda Ash in 1973-74. Although, there are over 120 firms producing dyestuffs in the small scale sector, the largest five firms account for more than 60 per cent of the total production. In the developed countries, this trend is accentuated over the years.

Location was conditioned largely by factor proportions and scale. Heavy chemicals and dyes were made where transport, energy and water were freely available.

Virtually all chemical firms, and even individual plants, produced a number of products. From the earliest times, chemical processes had given a mix of inputs, and early technical effort was often directed at finding uses for by-products. As the industry matured, product diversity became less a technical necessity and more the result of technical effort. When a large part of the cost of production is the rent to technical effort, marginal cost is low, so that it pays a firm to continue making the product when the demand falls off. Then too, technical effort yields new ideas for products, and also makes for more carefully differentiated outputs to fulfil precisely defined needs. Marketing considerations also dictated product diversification in the chemical industry as is the case in many other industries.

It is in studying the change in the chemical industry that the full significance of technical effort in shaping

economic behaviour and destiny emerges. The industry first showed its character in breaking away from the users whose auxiliary it had first been. In the earlier years, for instance, Soda and Dyestuffs had been made by textile finishers in England. In later years, however, dye works came to be operated by chemical firms as application research facilities. Although textile finishers, glass and soap makers, and other traditional customers remained large users of chemicals, change in the industry ceased to be a direct reflection of economic conditions in particular sectors. This was particularly true of 'dyes' firms, where the rhythms of progress was set by technical effort. Not only were economic responses to external change rapid and smooth, but market changes provoked technical response, and the sources of profit were regenerated by new products, processes and end uses. 'Dyes' firms, for example, integrated backward and began to manufacture heavy chemicals when prices and qualities were not satisfactory. Bayer, for instance, began to make sulphuric acid, whose price was controlled by a cartel, while BASF developed the contact process for the same product when it required concentrated acid in large quantities.³

2.8 Horizontal and Vertical Integration

Traditionally the subject of organic chemistry is

³ See Paul M. Hohenberg, *Chemicals in Western Europe 1850-1914, An Economic Study of Technical Change*. Amsterdam: North Holland Publishing Company, 1967, pp. 93-94.

approached according to chemical function. There are cases in industry of firms specializing in the production of compounds having a common chemical function or that are made by a given unit process. For example, some companies produce several nitration derivatives, or fatty amines, or isocyanates.

The motivation to integrate horizontally may be due either to a desire to provide hedges against changes in market structures (as is the case of firms that produce various types of polymers or synthetic fibres) or to complement a line of products (e.g. when a company making polyols decides also to produce isocyanates).

Despite the significance of these types of motivation in the chemical industry, however, the main influence in recent years has been the need to integrate vertically. Firms that until recently content to produce intermediates or end products, have been under constant pressure either to integrate backwards by acquiring their own sources of raw materials, or to become the objects of the desire on the part of their suppliers to integrate forward by gaining control of their clients.⁴ The percentage of captive utilization of most major chemical intermediates is growing steadily. This is mainly because, unit profits being as a

⁴ See Albert V. G. Hann, *The Petrochemical Industry—Markets and Economics*. McGraw Hill Book Company, 1970.

rule higher at the finished product-end of the chain, large oil and chemical companies have rapidly enlarged the scope of their activities both by acquisition and by downward trend in chemical prices and a gradual increase in the relative power of companies that have consolidated their positions in this manner, compared to those content to maintain their original structure.

During the course of the field survey of the Dye-stuffs and Intermediates Industry, the author found that linkages and cross-linkages offered vast scope for horizontal integration in this industry. Horizontal integration occurs when a firm puts up additional sets of similar plants and equipment and adds to the product line. Most of the producers especially among the larger ones have taken up new product groups and intermediates over the years. Horizontal integration was found common to most firms whereas vertical integration was undertaken only by the larger firms since it required larger capital outlays and technical know-how. In most cases in India, the firms have resorted to backward integration i.e. manufacturing as many raw materials and intermediates within the factory, mostly for captive consumption. M/s. Atul Products, Bulsar (Gujarat), for instance, started with the production of final dyes way back in 1950-51 but gradually they entered the field of dye intermediates required for the manufacture of dyes. Recently, they have put up plants for the

manufacture of basic heavy chemicals like caustic soda and sulphuric acid which are required in very large quantities in the manufacture of dyes and intermediates.

Similarly, M/s. Indian Dyestuff Industries, Kalyan, have achieved both horizontal and vertical integration over the years. They started with the manufacture of Vat dyes quite early in the fifties. Then they expanded their factory space to undertake production of other groups of dyes like disperse dyes and reactive dyes. Simultaneously, they put up plants for the manufacture of intermediates like Anthraquinone, Ortho Benzoyl Benzoic Acid and other benzene derivatives required in the manufacture of Vat dyes. Soon they stopped purchasing their huge requirements of sulphuric acid from outside by putting up a sulphuric acid plant for captive consumption.

Similar trends are observed with regard to the other two large scale producers of dyestuffs in India viz. M/s. Amar Dye Chem. Ltd. and M/s. Colour Chem. Ltd., both situated at Bombay.

The Fertilizer Corporation of India has put up a large-scale sulphuric acid plant to meet the sulphuric acid requirements in the manufacture of fertilizers.

M/s. E. Merck (India) Ltd. and M/s. Themis Pharmaceuticals have recently put up plants for the manufacture of fine chemicals required in the manufacture of drugs and pharmaceuticals.

M/s. NOCIL, a petrochemical complex near Bombay, have floated a new Company (their sister concern) for the manufacture of final consumer products from the raw materials obtained from NOCIL (a case of forward integration).

Thus the chemical industry has witnessed many interesting developments and thrown up some special characteristics.

CHAPTER III

DYESTUFF AND INTERMEDIATES INDUSTRY
(A SEPARATE BRANCH OF THE CHEMICAL INDUSTRY)

3.1 What Is a Dye?

Although most organic compounds are colourless, a relatively few, almost exclusively aromatic, are intensely coloured substances, among which representatives of almost every shade occur; all principal dyes used at the present day are in fact aromatic compounds, the primary source of which is coal-tar.

That a dye must give rise to colour is, of course, obvious. But a coloured substance is not necessarily a dye, in the ordinary sense of the word, unless it is also capable of fixing itself, or being fixed, on the fabric to be dyed. In this sense, a given substance may be a dye for certain materials, but not for others.

3.2 Origin and Rise of Dvestuff Industry

In the technology of colour, fashion has been the chief diversifying factor, particularly in the field of textile dyes. Natural dyes were in existence since quite ancient times but these complex organic compounds were hardly ten in number and hence there was a severe limitation on diversification of colours and shades. Naturally efforts were being made to manufacture synthetic dyes.

Research efforts in industry chemistry played an important role in the development of the synthetic dye

industry. It was founded in 1857 by W. H. Perkin for the manufacture of Mauveine from coal tar benzene.¹ The previous year he had obtained in the laboratory, by the action of potassium dichromate and sulphuric acid on crude aniline, a coloured substance which he recognized as having the properties of a dye. More synthetic dyes followed as organic chemistry itself grew rapidly.

About 1870, great changes were afoot in the dye-stuffs branch of the chemical industry. First, traditional materials were rapidly being replaced by complicated organic compounds synthesized from derivatives of coal tar, which meant the establishment of an entirely new technology. Secondly, Germany was about to become the leading manufacturing nation in the synthetic dyestuff industry, replacing Great Britain and France where the earliest inventions had taken place.

As in many other fields, the synthetic revolution brought about an unprecedented and enormous growth of the dyestuff industry during the last half a century or so especially in Great Britain, Germany, U.S.A. and France. The modern dyestuffs industry is based on the aromatic branch of the organic chemistry and at present between 3500 and 4000 dyes and related organic pigments are being

¹ See E. N. Abraham. Dyes and Their Intermediates. Oxford : Pergamon Press, 1968, Chapter I.

produced in the world. Not only the number but the variety and the structural complexity of its products make the dyestuffs industry the least susceptible of comprehensive description or definition. Only the modern pharmaceutical industry, compares with it in this respect.

Unlike the heavy organic and inorganic chemicals, the dyestuff industry measures the output of its products in pounds and kilograms rather than in tonnes; most of its processes are of the batch type. Unlike the heavy branches of chemical industry, the history of the dye manufacture is hardly at all the history of its processes; dyes production has not been greatly affected by the rise of chemical engineering; its manufacturing technology is much more the product of the development of the aromatic branch of the organic chemistry than of the application of the principles of physical chemistry. In this respect the manufacture of dyes is in contrast to the techniques of dyeing. Most of the techniques of industrial dye making are those of laboratory organic chemistry, the flasks, etc. of the bench-chemist being replaced by stainless steel, enamelled, glass or rubber-lined mild steel vessels. The technical history of the industry is that of a quest for new molecular structures having the essential characteristics of a dyestuff colour. The four thousand or so dyestuffs now in commercial use in the world dye industry are the residuum

of the experimental synthesis in the laboratory of about a million coloured organic compounds.

The basic reason for the enormous number of separate dyes is the enormous variety of colours and 'effects' which the users wish to impart to their wares. But the number of colours, etc., has to be multiplied by two further factors - one for the need to use different dyes for the various products, and second to give the necessary price-and-quality range for each combination of colour and product.

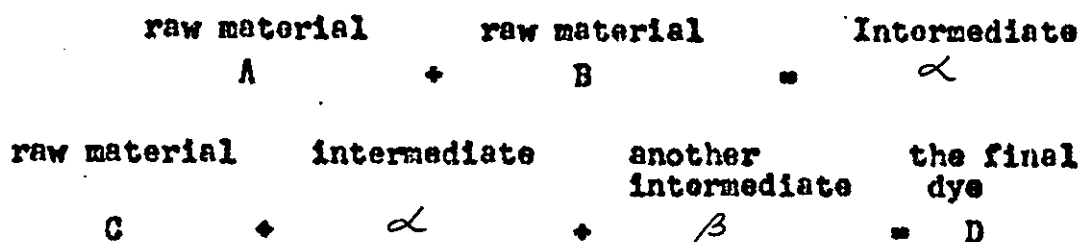
Major discoveries in the field of dyestuff chemistry in modern times can be made only as a result of sustained and costly research; it is natural and reasonable to expect, therefore, that the principal advances will be made by the largest firms only. This has been clearly established by the recent history of the industry in the U.K., Germany and the U.S.A.

3.3 The Manufacturing Processes of Intermediates and Dyes

One of the main problems in the organic chemical industry is how best to transfer the processes worked out on the small scale in the apparatus of the laboratory, to the specialized plant of large-scale manufacture. In the case of new products and untried routes to products, the new processes are tried out on a small-scale, "semi-technical" plants specially built for the purpose. Once

the details have been worked out, tentative trials are made in larger plant with the aim of establishing a process to give a satisfactory product at the lowest possible cost.

The manufacture of dyestuffs and intermediates is an extremely complex process because of a series of chain reactions involved, e.g. :



This is a simple three stage reaction. But in fact there can be as many as 15 to 20 stages of reactions in certain cases.

The raw materials for dyes are almost never directly useful in dye synthesis. It is necessary to convert them into a variety of derivatives which are in turn converted into dyes. These derivatives are called intermediates. They are produced by various chemical reactions on the basic raw material compounds. The more important among the general reactions involved in the dye manufacture are:

- (1) Sulfonation : Introduction of SO_3H group by Nitric Acid and Oleum.
- (2) Nitration : Introduction of NO_2 group by Nitric Acid and "Mixed Acid". *

* Mixture of Nitric Acid and Hydrochloric Acid.

- (3) Amination : Introduction of NH_2 group by Ammonia.
- (4) Halogenation : Introduction of chlorine, bromine and iodine.
- (5) Fusion Reactions : Combining two molecules by fusing in a given proportion.
- (6) Condensation : Condensing of two molecules by cooling.
- (7) Diazotization and Coupling : Introduction (-N=N-) group by Sodium Nitrite and HCl .
- (8) Oxidation : Oxidation may be effected by air in the presence of a catalyst or by a variety of chemical oxidants such as manganese dioxide and potassium permanganate.

Most of these reactions lead to the formation of substituted hydrocarbons which are functional in nature, that is, they bear groups capable of undergoing further chemical reaction. The number of dye intermediates actually or potentially available is very large, and the technology of their manufacture is an important part of industrial organic chemistry.

Because of the large number of compounds that are required, often in limited quantities, most dye intermediates are manufactured in batches. Some of the more fundamental processes can be run continuously, however, with a decided economic advantage. Where continuous production is not justified, the largest possible batches are made to hold the cost of operation to the minimum.

The many reactions employed in the manufacture of

dye intermediates and the delicate nature of the operations make it mandatory that all processes be well planned and controlled. Some of the processes, nitration for example, are inherently dangerous if not properly run. For these reasons, close supervision by technically trained men is the rule in plants where intermediates are made.

In the ultimate analysis, the manufacture of the final dyestuff is not so important. More important is the manufacture of intermediates which are derived from the basic building blocks like benzene, toluene, naphthalene, xylene, etc. If we take the Indian case, we find that a large number of small units produce dyes either by importing the intermediates or purchasing them from a few large units within the country. This is like assembling the car parts into a motor car. On the other hand, only the larger firms are capable of undertaking the manufacture of intermediates.

3.4 Chemical and Engineering Aspects

Many of the reactions involved in the manufacture of intermediates and dyes require the use of corrosive acids, caustic alkali and oxidising agents, so that the plant has to be made of suitably resistant constructional material. Strong autoclaves are necessary for several reactions which have to be carried out at high pressure. There are toxic explosion and fire hazards in handling some of the raw

materials and intermediates, and stringent precautions in the operation of plant and processes have to be followed in dyestuff factories. In addition to the kettles, tanks and other equipment for the chemical reactions (or "unit processes"), the manufacture of intermediates and dyes requires a variety of equipment for "unit operations" of chemical engineering, such as evaporation, distillation, heat transfer, crystallization, filtration, drying, grinding and mixing. The final and essential stage in the manufacture of a dyestuff is the standardization of shade, concentration and physical form on which depend the dyeing properties. In view of the number and the character of the steps by which an aromatic hydrocarbon is converted into a dye, some variation in the purity of the dye from batch to batch is to be expected. Secondly, the desired range of shades may not be available from homogeneous dyes and frequently a dye has to be "shaded" with a second dye or sometimes even with two or three dyes, keeping in mind the need for individual dyes in a mixture to have very similar dyeing and fastness properties. The diluents used in standardization should be such that they facilitate the application of the dyestuff. Diluents like sodium chloride, sulphate, bicarbonate and carbonate and dispersing agents are sometimes added.

3.5 Stock-Flow Peculiarities

Today the materials of construction available to a

chemical manufacturer are much more diverse than formerly. These include cast-iron, mild steel, cast steel (autoclaves), glass-lined steel, stainless steel, lead, copper, rubber-lined vessels, ceramic tiles on rubber lining, borosilicate glass, etc. For special applications, despite the cost, the less common metals like nickel, titanium, zirconium and tantalum are also used.

Lead and copper, formerly widely used in chemical plant manufacture, are now no longer used extensively. Plastics and polymers are being introduced for the construction of piping, flange, packings and seatings for valves; poly-tetrafluoroethylene is greatly favoured as a packing material on account of its remarkable resistance to chemical attack. It is however expensive and is normally used in thin sheets covering cheaper material such as rubber. Laminated fibre-glass is now being used for ducting, coverings for filters, vessels, and so on, but being bonded with an organic resin, is rapidly attacked by concentrated sulphuric acid. Cloths are now very rarely used on vacuum filters, porous tiles having largely superseded them. Cloths must of course be used for filter-process and in addition to cotton and wool, the newer fibres - polyester, polyamide and poly (vinyl chloride) - are used extensively.

As stated earlier, chemical manufacture involves a number of reactions and the stock-flow requirements differ

depending upon the chemical conditions. Materials of construction required for different chemical conditions are given in Table 3.1.

Table 3.1 : Chemical Conditions and Constructional Materials

| Conditions | Materials of construction |
|---|---|
| Nitration with mixed acid | Cast-iron, steel, stainless steel |
| Sulphonations | Cast-iron, steel, enamelled cast-iron, glass-lined steel |
| Becham reductions | Tile-lining on steel or cast-iron |
| Alkylations (alkaline) | Steel |
| Alkylations (acid) | Enamelled cast-iron or glass-lined steel |
| Reactions in refluxing solvents under acid or neutral conditions | Enamelled cast-iron or glass-lined steel. Reflux condenser and pipes in mild steel or glass. |
| Potash or caustic soda fusions | Cast-steel |
| Chlorination using chlorine gas | Nickel (where iron would act as a carrier and must be excluded), or cast-iron, steel, or stainless steel. |
| Brominations | Enamelled cast-iron, glass-lined steel |
| $AlCl_3$ fusions | Enamelled cast-iron, glass-lined steel |
| Reactions in dilute aqueous acid or alkali (dilutions or "quenches", diazotization, coupling, etc.) | Rubber-lined or tile-lined on rubber-lined mild-steel vessels |

Source : E. N. Abraham, Dyes and Their Intermediates.
Oxford : Pergmon Press, 1968.

It is seen from the above Table that for certain reactions and manufacturing processes, the same type of capital equipment can be used but in other cases, such substitutability is not possible.

By and large, however, the dyestuff factories employ a chain of different sets of capital equipment a detailed classification of which is almost an impossible task. For different intermediates and individual final dyes, the set of equipments needed vary considerably depending upon the number of reactions involved in the manufacture of a given product and the batch sizes as also the by-products and the residual process chemicals recovered. Table 3.2 gives an illustration of capital equipment employed in the manufacture of Intermediates and Dyes by a large scale factory. Here only a few products are chosen for illustration out of around 200 individual products, to get an idea of the stock-flow peculiarities of the industry.

3.6 The Control of Manufacture

(1) Raw Materials

The raw materials entering a dye making factory are subjected to regular scrutiny as to quality. This principle applies not only to purchased intermediates but also to intermediates produced within the factory for conversion into dyes or other sales products. Well-equipped analytical laboratories are thus a necessity and in addition to the

Table 3.2 : Illustration of Capital Equipment Employed in the Manufacture of Some Intermediates and Dyes by a Large Scale Firm

| Product/Batch Size | Chemical inputs | Quantity Kgs. | Capital Equipments | Capacities | Utilities |
|--|--|--|--|--|---|
| <u>Intermediates</u> | | | | | |
| 1) Ortho-Benzoyl Benzoic Acid (O.B.B.) Batch Size: 1080 Kg. O.B.B. + Bi-product 110 kgs. of Hydrochloric Acid 100% strength. | Benzene Phthalic Anhydride Aluminium Chloride Sulphuric Acid (60%) Caustic Soda Solution (30%) | 6090 750 1400 1740 1260 | 1 Cast Iron Reaction Kettle with cooling coil for cool- ing the inside material and attached with 7.5 H.P. motor for Stirrer. 1 Drawing Kettle of mild steel with acid resistant brick lining inside. 1 Distillation Still 1 Precipitation Kettle of mild steel with lead lining inside. 1 Nutsche lined with bricks for filtering precipitated O.B.B. | 10000 Litres 10000 Litres N.A. N.A. | 13000 Litres Chilled Water 200 Kwts. electricity. |
| 2) Anthraquinone from O.B.B. Batch Size : 1400 Kgs. Anthraquinone + Bi-product 4500 kgs. 60% Sulphuric Acid. | Ortho-Benzoyl (Benzoic Acid) (O.B.B.) Oleum (20%) Sulphuric Acid (98%) Sulphuric Acid (60%) | 1500 3100 400 2500 | 1 Cast Iron Reaction Kettle 1 Lead Lined M.S. Kettle 1 Tile lined Nutsche 1 Drier | | Electricity 50 kwts. Process Water Compressed air 3 kg./Cm ² Steam low pressure 4 kg./Cm ² |
| 3) Di-Hydroxy-Di-Benzanthrone Batch Size: 368 kgs. | Di-Oxybenzoyl 98% H ₂ SO ₄ Manganese Dioxide NaOH Sodium Bi-Sulphite | 400 6188 480 160 300 | 1 M.S. Kettle 1 Mixer 2 Tile lined Nutschews 1 Tile lined Kettle 2 Wooden Presses 2 Centrifugal Pumps | 4550 Litres 21300 " - " 21300 " 25 Plates - | Steam (Low-pressure) Air Vacuum Chilled Water Water |
| 4) Dibenzanthronyl/Sulphide Batch Size: 260 kgs. | Bromo-Benzanthrone Sodium Sulphide Sulphur | 325 150 19 | 1 Venuleth 1 Filter-press | | Nitrogen Air Steam (low) |
| 5) Bromobenzanthrone Batch Size: 390 kgs. | Benzanthrone 98% H ₂ SO ₄ 30% HCl (Hydrochloric Acid) Acetic Acid Bromine Sodium Bisulphite | 300 2400 252 252 252 10 | 1 M. S. Kettle 1 Tile lined vessel 1 Pfaulder 2 Filter presses | | Chilled Water ₂ Air 3 Kg./Cm ² Steam 10 kg./Cm ² |

(continued)

Table 3.2 : (continued)

| Product/Batch Size | Chemical inputs | Quantity Kgs. | Capital Equipments | Capacities | Utilities |
|--|--|--|--|------------|--|
| 6) Quinizarin Batch Size: 350 Kg. | P-Chloro Phenol Phthalic Anhydride Boric Acid 98% H ₂ SO ₄ 20% Oleum Soda Ash 30% HCl | 275 330 155 1231 769 40 50 | 1 M. S. Reaction Kettle | | |
| 7) Di-Nitro-Di-Anthrimide | 1:1 Dianthrimide 98% H ₂ SO ₄ 20% Oleum 100% HNO ₃ Boric Acid | 350 1090 1760 145 70 | 1 Stainless Steel Kettle 1 M. S. Kettle 1 Tiles lined vessel 2 Wooden filter presses | | Chilled Water Air Vacuum Steam Water |
| 8) 1-Chloro-3-Nitro | AQ 1-Sulphuric Acid 98% H ₂ SO ₄ HNO ₃ Sodium Chlorate Sodium Chloride Sodium Bi-sulphite | 800 3336 95 88 168 5 | | | |
| 9) 1-Chloro Anthraquinone Batch Size: 178 kg. | AQ 1-Sulphonic Acid 98% H ₂ SO ₄ Sodium Chlorate Salt Sodium Bisulphite | 250 580 110 200 5 | | | |
| 10) Benzenthrone | O.B.E. 20% Oleum 98% H ₂ SO ₄ Copper Sulphate Glycerine Iron Powder Turkey Red Oil NaOH 45% Hydro Sulphite | 550 1015 5000 100 280 280 10 35 30 | 1 Cast Iron Kettle 1 Tiles lined Kettle 1 Tiles lined Nutsche 1 Venuleth/Compartment Dryer Receivers for 20% Oleum 98% H ₂ SO ₄ and NaOH 45% | | Chilled Water Water Air Vacuum Steam (low) |

(continued)

Table 3.2 : (continued)

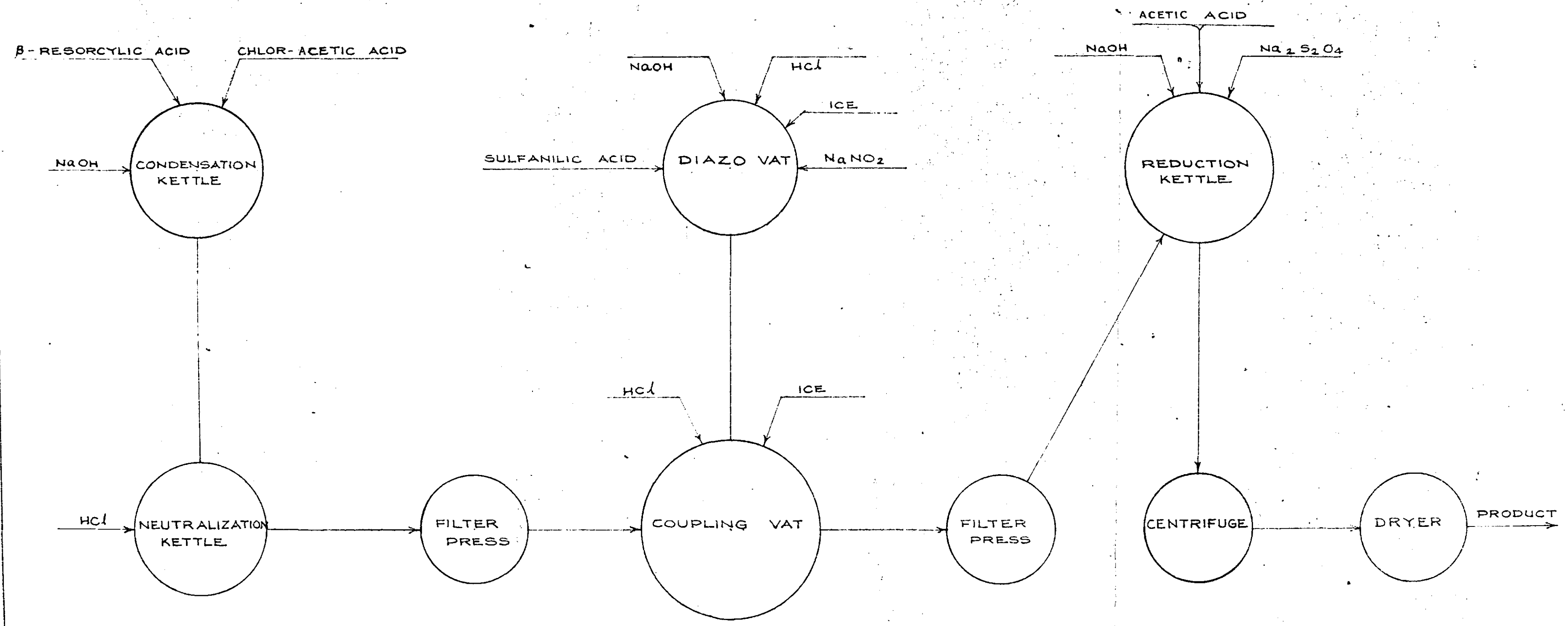
| Product/Batch Size | Chemical Inputs | Quantity Kgs. | Capital Equipments | Capacities | Utilities |
|---|---|--|--|---|--|
| 11) Dibenzanthrone Batch Size: 200 kg. | Benzanthrone NaOH KOH Sodium Acetate Naphthalene * Hydro Sulphite | 200 250 620 75 680 125 | 1 Stainless Steel Kettle (Distillation Unit) 2 M. S. Tanks 2 Cast Iron Filter Presses 2 Compartment driers | | Steam Air |
| | * 500 kg. Naphthalene recovered back. | | | | |
| 12) Indenthrono Batch Size: 300 kg. | 2 Amino AQ NaOH KOH Sodium Acetate Sodium Chlorate Sodium Phenate Sodium Hydro Sulphite Sulphuric Acid Sodium Carbonate | 300 370 960 95 45 100 60 90 75 | 1 Stainless Steel Kettle 1 M. S. Tank 1 C. I. Filter Press 2 Wooden presses 1 M. S. Tank 1 M. S. Receiver 2 Centrifugal Pumps 2 Compartment driers | | Steam (low) Burshane gas Air |
| <u>Dyes</u> | | | | | |
| 1) Blue B. C. Batch Size: 448 Kgs. | Indenthrono 98% H ₂ SO ₄ Manganese Dioxide Chlorine 20% Oleum Aluminium Tricresol Tamol | 400 7235 20 175 1490 8 16 10 | 1 Pfaulder 1 M. S. Kettle 1 Tiles lined vessel 1 Tiles lined vessel 1 Tiles lined Nutsche 2 Wooden Presses Rotameter for Chlorine Receivers for H ₂ SO ₄ Oleum and 74% H ₂ SO ₄ 2 Centrifugal Pumps | 3500 6800 6800 21300 - 25 Plates | Steam (low) Air 3 kg./Cm ² Vacuum Chilled Water Water |
| 2) Green FFB Batch Size: 300 Kg. | Crude Green 98% H ₂ SO ₄ Soda Ash Idet | 300 4400 3 3 | 1 M. S. Kettle 1 Tiles lined vessel 2 Wooden Presses 1 Centrifugal Pump | 4550 21300 30 Plates | Chilled Water Air 3 kg./Cm ² Water |
| 3) Black BB Batch Size: 240 Kg. | Dibenzanthrone Acetic Acid Nitric Acid Soda Ash | 200 240 300 5 | 1 Stainless Steel Kettle 1 Tiles lined Nutsche 1 Receiver 1 Steam Ejector | | Steam Air Vacuum |

(continued)

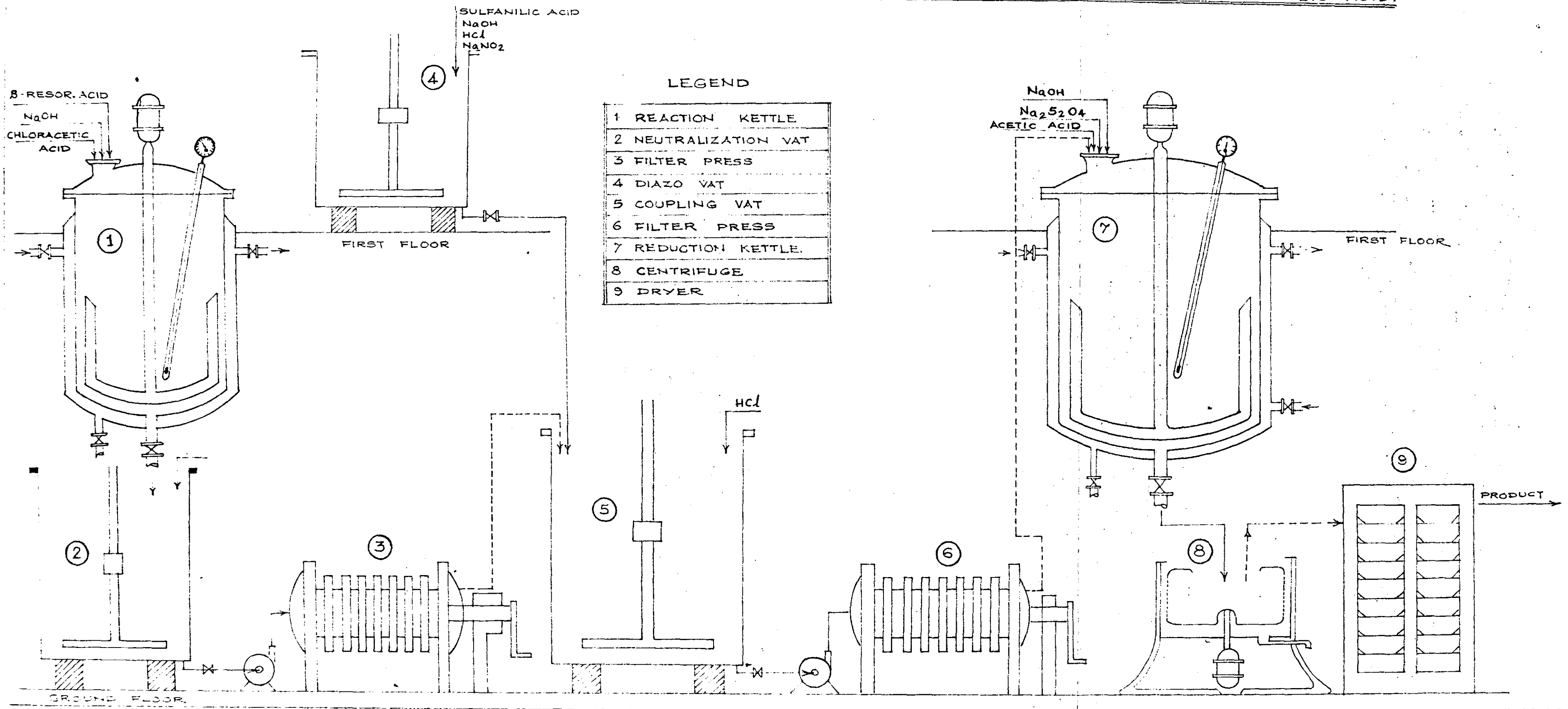
Table 3.2 : (continued)

| Product/Batch Size | Chemical Inputs | Quantity Kgs. | Capital Equipments | Capacities | Utilities |
|-------------------------------------|---|---------------------------------------|--|-------------------------------------|---|
| 4) Green 2G Batch Size: 256 Kg. | Crude Green 98% H ₂ SO ₄ 20% Oleum Bromine Sodium Nitrite Sodium Bi-Sulphite | 220 1338 612 108 16 25 | 1 Glass lined pfaulder 1 Tiles lined vessel 2 Wooden Filter Presses 1 Centrifugal Pump | 3500 21300 25 Plates | Steam 10 kg./Cm ² Chilled Water Air Water |
| 5) Orange 3G Batch Size: 120 Kg. | Anthrimide for Orange 3G 98% H ₂ SO ₄ 20% Oleum Sodium Dichromate | 200 2508 320 53 | 1 M. S. Reaction Kettle 1 Tiles lined Nutsche 1 Tiles lined vessel 1 Wooden Press 1 Centrifugal Pump | 4550 21300 21300 25 Plates | Steam 10 kg./Cm ² Chilled Water Air Water |
| 6) Brown R Batch Size: 240 Kg. | Anthrimide for Brown R 98% H ₂ SO ₄ Sodium Chlorate | 300 1700 200 | 1 M. S. Kettle 1 Tiles lined vessel 1 M. S. Kettle 1 Wooden Filter Press | | Chilled Water Steam Air Water |
| 7) Olive R Batch Size: 278 Kg. | Dibenzyl Dianthrimide 98% H ₂ SO ₄ Sodium Chlorate | 300 3000 60 | Same as above for Brown R | | Chilled Water Steam Air Water |
| 8) Yellow GCN | Intermediate for Yellow GCN 98% H ₂ SO ₄ Sodium Hypochlorite NaOH | 300 3000 1975 35 | 1 M. S. Reaction Kettle 1 Tiles lined vessel 2 Wooden Filter Presses 1 Tiles lined vessel | | Chilled Water Steam Air |

FLOW DIAGRAM FOR THE MANUFACTURE OF 5-AMINO 4-CARBOXYMETHYL β -RESORCYLIC ACID 100 kg/ DAY



PLANT ASSEMBLY FOR THE MANUFACTURE OF 5-AMINO 4-CARBOXYMETHYL β -RESORCYLIC ACID.



LEGEND

| | |
|---|--------------------|
| 1 | REACTION KETTLE |
| 2 | NEUTRALIZATION VAT |
| 3 | FILTER PRESS |
| 4 | DIAZO VAT |
| 5 | COUPLING VAT |
| 6 | FILTER PRESS |
| 7 | REDUCTION KETTLE |
| 8 | CENTRIFUGE |
| 9 | DRYER |

classical chemical methods of analysis involving acidimetry, alkalimetry and the determination of functional groups, physical operations such as specific gravity, refractive index, ultraviolet, visible and infra-red absorption spectra and especially the separation techniques of gas-liquid, alumina column, paper and thin-layer chromatography are employed for purposes of identification and comparison.

(2) Plant Operation

In the modern plant full advantages must be taken of the advances in instrument technology that have taken place over the past twenty years, if consistent, low-cost operating is to be assured. The control by instrument of the flow or rate of flow of mixed acid in nitrations, and of oleum and sulphonations according to the temperature of the reaction mixture or to whether or not the agitator is in motion, is becoming common in modern plants. Such control may also be linked to other parameters such as pressure, pH value of reaction mixture, and is applied not only to the flow rates of engineering chemicals but also to those of services such as steam (through external jackets or internal coils), cooling water, circulating oil, etc. Again it is often necessary, in certain processes, to subject a reaction mixture, contained in a vessel capable of being heated or cooled as required, to a cycle of temperature changes which, in the absence of control

instruments, have to be carried out by hand operation of steam and cooling water valves. Such a cycle can be accurately reproduced by means of a cam-controller, in which a cam is cut from a disc of metal, the profile corresponding to the various temperatures desired. The cam is rotated by clockwork mechanism and in rotating actuates a control arm by moving it up and down (or keeping it steady where a set temperature is required, the cam at this stage being part of a circle). Such movements are transmitted, by electronic means, to mechanisms which actuate steam, water and other service valves as required. In this way very consistent operation can be obtained with obvious savings in man-hours and supervisory effort.

(3) Process Control

The importance of chemical control during manufacture is obvious. The methods employed are mainly those of the analytical laboratory together with preparative tests in which aliquot samples are taken from the plant and either subjected to special tests, devised by the works chemist in charge of the manufacture, or worked up in laboratory apparatus by processes corresponding to those to be undergone by the main batch. These small-scale preparations and samples of the finished batch itself are submitted to the analyst or colourist for testing against specification or standard sample. Among the direct methods of assessing

the quality of dye present in a solution, the use of titanous chloride is important. Special apparatus, which be swept out with carbon dioxide to remove atmospheric oxygen which would interfere if present during the determination, is used. The method depends on the ability of certain chromophoric systems, e.g. the triaryl-methane system, to undergo reduction and hence decolourisation by the action of titanous chloride. Another method, the determination of optical density, relies on absorption spectrometry, the intensity of absorption at a principal absorption peak being measured in comparison with a similar sample of known strength.

There are many qualitative or semi-quantitative tests used by the dye-works chemist in following the course of his manufactures. A time honoured method is the use of filter paper, on which small samples of the batch in progress may be spotted and the appearance of the edge of the spot or "run-out" examined, or its behaviour noted towards reagents spotted alongside in such a way that the edges merge. This method, of great use in azo-chemistry, can be used to confirm the presence or absence of diazo or coupling components as the case may be. Such methods have, in recent years, undergone considerable extension and refinement by the introduction of chromatographic techniques. Of these the latest development, that of thin-layer chromatography, is perhaps the most important and useful in dye chemistry.

3.7 Dye Testing

Although synthetic dyes and pigments may be regarded as organic chemicals possessing certain properties, their ultimate role is to impart colour to some subordinate surface as the case may be. As such their ultimate evaluation and testing is the prerogative of the colourist. The colourist is a skilled dye or pigment technologist whose function is to test the products of the dye maker under the same or closely similar conditions to those employed by the dyer, printer or other user. In this, the colourist is guided by the recognized criteria and fastness tests. The colour testing laboratory, usually described by the all embracing term "dye-house", is not only a service to the manufacturing departments and sales organizations but also provides customer service, a strong tradition in the industry dating from the time of Perkin. It is not always understood that very rarely does a dyer or printer use a simple dye for a given purpose but mostly uses combinations of dyes to achieve the desired hue or fashion shade. In this the advice of the colourist is invariably sought by the dyer before work on an important contract or commission is begun. Not least among the colourist's difficulties is to hit upon a combination of dyes that are not only a match in daylight but also in artificial light (metameric match). In this, computer methods are currently being successfully developed

by which mixtures of dyes can be selected having closely similar absorptive properties in the visible region to those of the pattern.

3.8 Classification of Dyes

Depending upon their application, the various dyes are classified into the following broad groups :

(1) Acid Dyes

Acid dyes depend on the presence of one or more acidic groups for their attachment to textile fibres. These are usually sulfonil acid groups which serve to make the dye soluble in water. These dyes find their main application in the textile field on wool, but are also used on silk, polyamide, acrylic and regenerated protein fibres as also paper and leather: they are normally applied from a dye liquor containing sulphuric, formic, or acetic acids; neutral and even slightly alkaline dye baths are occasionally used. Chemical types involved are azo, anthraquinone, triarylmethane, azine, xanthene, ketonimine, nitro and nitroso compounds. They include dyes giving very bright hues and have a wide range of fastness properties from very poor to very good. These can be removed from fibre by washing under drastic conditions.

(2) Basic Dyes

Basic dyes become attached to fibres by formation of salt linkages with acidic groups in the fibres. The

dyeing process may be regarded as similar to that for the application of acid dyes. Basic dyes are used primarily on protein fibres, modified acrylic fibres and mordanted cotton. Application is usually made from mildly acidic dye liquors. Like acid dyes, basic dyes can be removed from fibres by washing under sufficiently drastic conditions.

(3) Direct Dyes

Direct dyes are a class of dyes that become strongly absorbed on cellulose. They usually bear sulfonic acid groups, but are not considered acid dyes since these groups are not used as a means of attachment to the fibre. Direct dyes are large, flat, linear molecules which can enter the water-swollen amorphous regions of cellulose and orient themselves along the crystalline regions. Common salt or Glauber's salt is often used to promote dyeing with a minimum of dye remaining in the dye bath. Since direct dyes are held in cellulosic fibres by absorption, the dyeing process is reversible. Unless after-treated with resins and dye fixing agents, direct dyes, as a class, have poor fastness to washing. They are used mainly because they are economical and easy to apply.

These dyes are used primarily to colour plain grounds which are later to be printed in a pattern with vat dyes. The sodium-hydrosulphite used to reduce the vat dyes destroys the ground colour upon contact. On oxidation of the reduced vat dyes, two-colour effects are produced.

(4) Sulphur Dyes

Sulphur dyes are insoluble dyes which must be reduced with sodium sulphide before use. In the reduced form they are soluble and exhibit affinity for cellulose. They dye by absorption, as do the direct dyes, but upon exposure to air they are oxidized to re-form the original insoluble dye inside the fibre. Thus, unlike the direct dyes, they become very resistant to removal by washing.

The exact constitution of most sulphur dyes is unknown, although the conditions required to reproduce the given types are well established. They are fairly cheap and give dyeing of good fastness to washing. However, their fastness and brightness to bleaching are often inferior.

(5) Vat Dyes

Vat dyes, like sulphur dyes, are insoluble. They are reduced with sodium hydrosulphite in strongly alkaline medium to give a soluble form that has affinity for cellulose. This reducing operation was formerly carried out in wooden vats, giving rise to the name vat dyes. After the reduced dye has been absorbed in the fibre, the original insoluble dye is re-formed by oxidation with air or chemicals. The dyeings produced in this way are very fast to washing, and, in most cases, the dyes are designed to be fast to light and bleaching as well.

Vat dyes are quite expensive and must be applied

with care. They offer excellent fastness when properly selected and are the dyes most often used on cotton fabrics which are subjected to severe conditions of washing and bleaching.

(6) Reactive Dyes

Reactive dyes are a relatively new class of dyes that form covalent bonds with fibres possessing hydroxyl or amino groups. They offer excellent fastness to washing since the dye becomes a part of the fibre. The other properties depend on the structure of the coloured part of the molecule and the means by which it is attached to the reactive part.

The reactive dyes were originally developed for the direct dyeing of cotton and cellulosic fibres. Their outstanding properties, however, have led to great research activity in a search for dyes applicable not only to cotton but also to wool, silk and polyamides.

(7) Disperse Dyes

Disperse dyes, sometimes called acetate rayon dyes, are dyes of low-water solubility which are capable of dissolving in certain textile fibres. They were first introduced for cellulose acetate but are used with a variety of synthetic fibres as well. They are supplied in a very fine state of sub-division to permit their dispersion in water. They dye the fibre in the molecular state, however,

and for this reason must possess some solubility in water. Disperse dye molecules are small and usually bear amino groups.

Since disperse dyes become dissolved in textile fibres, the dyeing process is reversible. Fibres that are swollen easily by water can be dyed with disperse dyes under moderate conditions, but the dyeings have only modest fastness to washing. Fibres that are more difficult to swell must be dyed under more drastic conditions, but offer the advantage that these conditions are not duplicated during normal washing procedures, thereby reversing the process. For example, most polyester fibres must be dyed under pressure or with the use of organic swelling agents. The washing fastness of disperse dyes on these fibres is excellent.

(8) Mordant Dyes

Mordant dyes require a pre-treatment of the fibre with a mordant material designed to bind the dye. The mordant becomes attached to the fibre and then combines with the dye to form an insoluble complex called a "lake". An example of a mordant is aluminium hydroxide that has been precipitated in cotton fibre. This mordant is capable of binding such dyes as Mordant Red LL (Alizarin) by formation of an aluminium "lake".

Mordant dyes have declined in importance in recent

years mainly because their use is no longer necessary. Equal or superior results can be obtained with other classes of dyes at less expense in time and labour.

(9) Azoic Dyes

Azoic dyes are produced inside textile fibres, usually cotton, by azo coupling. The dye is firmly occluded and is fast to washing. A variety of hues can be obtained by proper choice of diazo and coupling components.

In the usual procedure for the development of azoic dyes, the fibre is first impregnated with an alkaline solution of the coupling component and then treated with a solution of the diazonium compound. Finally, the dyed goods are soaped and rinsed.

The diazonium compound may be produced in the dye-house by diazotization of the azoic diazo component, or it may be purchased as a stabilized complex ready for use. Examples of stabilized diazonium complexes are the zinc double salts, nitrosamines and diazoamino compounds.

Special techniques have been developed for the use of azoic dyes on synthetic fibres. It is sometimes possible to apply both the diazo component and the coupling component simultaneously from the aqueous dispersion and then to treat the goods with nitrous acid to produce the colour.

(10) Oxidation Dyes

Oxidation dyes are produced in textile fibres by oxidation of a colourless compound. For example, aniline may be oxidized in cotton with sodium bichromate in the presence of a metal catalyst to produce aniline black. This is an economical way to produce full black shades. The appearance and fastness of the dyeing may be varied over a wide range by the choice of the oxidant, conditions and catalyst. The exact structures of the aniline blacks are not known.

(11) Ingrain Dyes

Ingrain dyes are produced inside textile fibres. The Azoic and oxidation dyes already discussed are examples. In addition, there is a small number of ingrain dyes on the market which do not fall into these classes. One such group, called precursors, is capable of generating a very bright blue dye, copper phthalocyanine, inside cotton fibres. The dyeings are extremely fast to light and washing.

(12) Pigments

In general pigments are inert, stable, coloured substances, insoluble in water, which are used for imparting colour by incorporation within an article during manufacture, e.g. moulding from an evenly coloured mass of plastic material or by surface application in the form of paint. Colour is the result of absorption of light of certain

wavelengths and the reflection of other wavelengths from individual particles of pigments. The physical form of the pigment is a priori of great importance.

The I.C.I. distinguishes among "pigments", "lakes" and "dyes for lakes" for the purposes of classification. The lakes of acid dyes are precipitated from aqueous solution by (a) organic acids such as tannic acid, or (b) inorganic complex acids such as phosphotungstomolybdic acid. The metal salts of mordant dyes are also used as lakes. All the above lakes are technically pigments.

3.9 The Economics of Dyestuff Trade

For a user like the textile manufacturer, the cost of the dye input in the total cost of the fabric manufactured forms a very small part of his total cost or the selling price of his product. However, the quality of the dye used can make a very great difference to the marketability of his product. Hence the user of dyes attaches great importance to the availability of a wide range of reliable dyestuffs and also the 'service' which the dye maker offers—notably in finding and explaining the best technique for applying each dye. Compared to the basic heavy chemicals like sulphuric acid, a dye may be priced much higher say about 80 to 100 times per tonne. This is because of the complex manufacturing process whereby value goes on adding through each stage of the manufacturing

processes. However, though the dyes are comparatively high priced, the user does not buy many tonnes and purchases are in terms of kilograms. Hence greater importance is attached to the quality in all its aspects than to price. For this very reason even the leading manufacturing and exporting countries import some dyes. This is a reflection of the importance attached by the using industries to a supply of foreign specialities, usually patented.

International Trade

The dyestuff industry is one in which there are great gains to be had from international trade, since the market for individual dyes is so limited that many should be produced in only one or two countries - perhaps even by one plant. All the major producing countries have, however, given drastic protection to their industry, and thereby limited the possibilities of specialization and exchange. A mutual agreement between the countries concerned, as Reddaway points out, to reduce progressively the scale of this protection (no matter what form it takes) should bring benefits to all of them, which would outweigh the transitional difficulties.

Competition in international market is intensified by the great economy in production costs which can be obtained by having a longer run of production for any

particular dye. The cost of changing over the plant from one dye to another - or of holding plants idle - are a large part of the total cost of the batch.

3.10 The Value and Importance of the Dyestuff Industry to the National Economy

As far back as 1901, emphasizing the crucial importance of the dyestuff industry in the economy of a country, Prof. A. G. Green had said: "The coal-tar colour manufacture has well been called the flower of the chemical industry. Although in absolute money value of its products not equalling some other branches of chemical industry, it represents the highest development of applied chemical research and chemical engineering, and may well be taken to be the pulse of the whole chemical trade. Indeed, a country which allows this most scientific branch of chemical industry to languish cannot expect to maintain pre-eminence for long in any simpler branch of chemical manufacture." These remarks made in 1901 apply with even greater force today.

The dyestuff industry acts as an important link in the chain of other essential chemical industries, such as the heavy inorganic chemical industry and coal tar industry on the one hand, and the fine chemical and pharmaceutical industry, explosives, synthetic plastics and solvent industries on the other.

3.11 Importance of the Dyestuff Industry for the Indian Economy

As far back as 1947, a National Planning Committee on Chemical Industries had stressed the vital importance of this industry to the Indian economy. Making out a strong case for the Indian dyestuff industry, they wrote :

"The history of the British Dyestuff Industry is an object lesson to us in our present position. Before the last war, Great Britain did not possess a dyestuff industry of any importance, over 90 per cent of the dyes used being imported from Germany. As the last Great War progressed, the situation became very serious and it was realised that the British dependence on Germany for dyes was really tantamount to much wider and more fundamental weakness of the British Chemical industry, as the production of dyes was intimately connected with the production of chemicals in general. Having realised the vital necessity of the development of a dyestuff industry, the British Government took immediate and far reaching steps in this direction. Beginning with a direct and large subsidy for the formation of a new company, millions were spent on the rapid development of every branch of the industry, with very special reference to research. As a result, the British dyestuff factories are now producing over 90 per cent of their home requirements and have in addition a considerable export trade.

"With textiles as our primary industry, and the incidence of a host of diseases responsible for the consumption of immense quantity of medicinal chemicals, the immediate establishment of a coal-tar dyestuff industry is a matter of such urgent necessity that the fullest resources of the state and the individual must be mobilised for the purpose. In the earlier stages, it may be suggested that the intermediates may even be bought from foreign markets till a coal-tar industry is established in the country."

With a modest beginning in the early fifties, the dyestuff industry in this country has helped enormously the development of the textile industry including the synthetic textiles. It has also given a boost to the development of ancillary chemical industries.

The textile industry is no doubt the major consumer of dyestuffs but there are a number of other industries also who consume dyestuffs though their relative share is small. The annual survey of industries data for the years 1960-66 provide some indication of the pattern of consumption of dyes by the cotton textiles, other textiles and other industries over the years. A.S.I. data gives us the raw materials consumed by each industry. In Table 3.3 A.S.I. data has been retabulated by turning columns into rows to get the market structure of dyestuff industry. From this Table, it is seen that the percentage share of cotton textiles in the consumption of dyes has been gradually

Table 3.3 : Industrywise Consumption of Dyestuffs (1960 to 1966)

| Industry No. (ASI) | Name of the Industry | Value of Dyestuffs Consumed in Rupees | | | | | | |
|--------------------|--|---------------------------------------|-------------------------|-------------------------|------------------------|-------------------------|-------------------------|-------------------------|
| | | 1960 | 1961 | 1962 | 1963 | 1964 | 1965 | 1966 |
| 203 | Canning and Preserving of Fruits and Vegetables | - | - | - | 1,79,305 (Neg.) | 95,903 (Neg.) | 1,65,484 (Neg.) | 1,70,933 (Neg.) |
| 231-1 | Cotton Textiles | 14,56,66,997 (73.94) | 20,31,04,892 (71.84) | 14,30,20,024 (66.84) | 15,05,87,660 (66.6) | 16,05,66,937 (63.70) | 19,20,71,586 (61.95) | 18,57,17,067 (59.69) |
| 231-2 | Jute Textiles | 6,84,501 (0.35) | 6,65,970 (0.24) | 9,91,251 (0.46) | 8,71,875 (0.38) | 8,82,582 (0.35) | 10,48,660 (Neg.) | 9,51,472 (0.30) |
| 231-3 | Woollen Textiles | 26,29,962 (1.33) | 34,41,811 (1.22) | 43,68,762 (2.04) | 50,50,063 (2.22) | 73,61,801 (2.92) | 66,04,878 (2.38) | 11,68,457 (0.37) |
| 231-4 | Silk Industry | 4,486 (0.002) | 35,769 (0.012) | 55,535 (Neg.) | 81,746 (Neg.) | 1,05,282 (Neg.) | 36,782 (Neg.) | 1,42,411 (Neg.) |
| 231-5 | Art Silk | 55,58,485 (2.82) | 1,11,23,793 (3.93) | 1,41,93,898 (6.63) | 1,54,77,985 (6.84) | 1,93,15,448 (7.66) | 1,92,32,482 (6.92) | 1,98,96,674 (6.39) |
| 231-6 | Webbing, embroidery, etc. | 3,22,567 (0.16) | 4,89,181 (0.17) | 5,84,795 (0.27) | 7,18,953 (0.32) | 1,85,481 (0.07) | 2,74,766 (0.09) | 15,54,444 (0.50) |
| 231-7 | Textile Dyeing, bleaching, etc. | 2,13,54,467 (10.84) | 3,68,00,509 (13.01) | 2,86,60,219 (13.39) | 2,93,14,591 (12.96) | 3,45,51,855 (13.70) | 3,90,04,374 (14.04) | 4,31,04,757 (13.85) |
| 231-8 | Thread and Threadball making | 4,36,798 (0.22) | 3,94,733 (0.14) | 2,87,903 (0.13) | 5,12,538 (0.22) | 3,99,099 (0.16) | 4,92,001 (0.17) | 6,41,413 (0.21) |
| 231-9 | Carpet Weaving | 1,53,916 (0.13) | 98,828 | 2,80,165 (0.13) | 1,76,334 (Neg.) | 2,08,341 (Neg.) | 3,19,721 (0.11) | 3,57,572 (0.11) |
| 232 | Knitting Mills (Hosiery and other knitted goods) | 74,004 (0.04) | 49,543 (0.03) | 94,673 (Neg.) | 70,654 (Neg.) | 2,40,471 (0.09) | 1,98,149 (0.07) | 3,21,653 (0.10) |
| 239-4 | Coir Manufacture | 2,62,434 (0.13) | 2,95,422 (0.10) | 3,24,732 (0.15) | 2,14,515 (0.95) | 3,01,121 (0.12) | 2,53,721 (0.09) | 2,06,328 (0.06) |
| 239-5, 6 | Manufacture of Artificial Leather and Oil Cloth, Linoleum and Similar Products | 6,71,934 (3.54) | 9,62,261 (0.34) | 11,54,535 (0.53) | 11,05,792 (0.49) | 17,71,771 (0.70) | 17,31,411 (0.62) | 28,64,248 (0.92) |

(continued)

Table 3.3 : (continued)

| Industry No. (ASI) | Name of the Industry | Value of Dyestuffs Consumed in Rupees | | | | | | |
|--------------------|--|---------------------------------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|------------------------|
| | | 1960 | 1961 | 1962 | 1963 | 1964 | 1965 | 1966 |
| 271-4 | Paper Board and Straw Board | 10,27,723 (0.52) | 10,30,539 (0.36) | 10,27,621 (0.48) | 9,71,828 (0.42) | 1,15,738 (Neg.) | 10,86,073 (0.39) | 10,02,591 (0.32) |
| 271-5 | Paper for Packaging (Corrugated Paper, Craft Paper, Paper Bags and Paper Containers, etc.) | 4,57,883 (0.23) | 6,40,763 (0.22) | 7,03,479 (0.32) | 8,65,523 (0.38) | 1,55,162 (Neg.) | 2,27,467 (0.08) | 5,39,380 (0.17) |
| 291 | Tannery and Leather Finishing Plants | 2,617 (Neg.) | 4,11,771 (p.14) | 3,46,626 (0.16) | 4,40,113 (0.19) | 4,45,829 (0.17) | 5,94,486 (0.21) | 10,03,141 (0.32) |
| 311-3 | Synthetic Resins and Plastics | 1,62,860 (0.08) | 65,104 (Neg.) | 2,79,445 (0.13) | 4,02,521 (0.18) | 28,94,099 (1.15) | 5,72,211 (0.20) | 47,10,928 (1.51) |
| 311-7 | Dyestuffs | 1,55,00,619 (7.87) | 1,97,77,450 (6.99) | 1,37,06,186 (6.40) | 1,43,61,814 (6.35) | 1,67,51,631 (6.64) | 1,84,11,093 (6.63) | 3,59,37,211 (11.55) |
| 313 | Manufacture of Paints, Varnishes and Lacquers | 18,67,920 (0.95) | 28,36,251 (1.00) | 31,56,701 (1.47) | 17,39,248 (0.77) | 21,72,190 (0.86) | 34,03,004 (1.22) | 49,74,756 (1.60) |
| 319-3, 4 | Textile Auxiliaries and Sizing Materials | - | - | - | 22,38,324 (0.99) | 27,85,411 (1.10) | 1,11,41,448 (4.01) | 47,41,118 (1.52) |
| 319-6 | Soaps and Glycerine | 1,61,198 (Neg.) | 1,89,326 (Neg.) | 2,47,468 (0.11) | 2,76,198 (0.12) | 3,50,621 (0.14) | 4,06,772 (0.15) | 4,48,522 (0.14) |
| 399-7 | Plastic Moulded Goods | 430 (Neg.) | 2,59,244 (Neg.) | 4,62,210 (0.22) | 5,35,447 (0.23) | 3,78,277 (0.15) | 3,98,997 (0.14) | 5,96,931 (0.19) |
| 399-10 | Brooms and Brushes | - | 34,860 (Neg.) | 16,286 (Neg.) | 18,240 (Neg.) | 30,336 (Neg.) | 48,132 (Neg.) | 40,740 (Neg.) |
| Total | | 19,70,01,801 | 28,27,08,020 | 21,39,62,514 | 22,62,01,267 | 25,20,65,386 | 27,77,23,698 | 31,10,92,747 |

Neg. = Negligible.

Figures in brackets are percentages.

Source : Computed from Annual Survey of Industries.

Table 3.4 : Production of Cotton Textiles*

| (In '000 Metres) | | | |
|------------------|-----------|------|-----------|
| Year | Quantity | Year | Quantity |
| 1951 | 47,40,264 | 1961 | 70,73,442 |
| 1952 | 55,17,995 | 1962 | 69,72,354 |
| 1953 | 58,70,968 | 1963 | 72,98,587 |
| 1954 | 60,81,908 | 1964 | 77,19,509 |
| 1955 | 62,78,388 | 1965 | 76,43,466 |
| 1956 | 65,15,340 | 1966 | 73,35,883 |
| 1957 | 66,73,247 | 1967 | 72,76,536 |
| 1958 | 64,73,217 | 1968 | 78,96,091 |
| 1959 | 65,78,812 | 1969 | 77,06,390 |
| 1960 | 66,29,206 | 1970 | 78,49,094 |

* Mill Sector + Decentralized Sector.

Source: Indian Textile Bulletin, Vol. No. 6, September 1971.
Office of the Textile Commissioner, Bombay.

Table 3.5 : Production of Man-made Fibre Fabrics*

| (Million Metres) | | | |
|------------------|----------|------|----------|
| Year | Quantity | Year | Quantity |
| 1961 | 572.4 | 1966 | 862.0 |
| 1962 | 611.2 | 1967 | 882.0 |
| 1963 | 651.6 | 1968 | 992.0 |
| 1964 | 835.2 | 1969 | 894.0 |
| 1965 | 867.6 | 1970 | 933.6 |

* Production by Powerloom and Handlooms + Production by Cotton Textile Mills.

Source: Indian Textile Bulletin, Vol. XVII, No. 6, September 1971. Office of the Textile Commissioner, Bombay.

declining although they continue to account for the highest share. It is understood that during the last 7-8 years, the consumption of dyes by synthetic resins and plastics, paints and varnishes, leather tanning, etc. has increased considerably which is not sufficiently reflected in Table 3.3 since the data presented here is only upto 1966.

Tables 3.4 and 3.5 give the growth of the cotton textiles and man-made fibre industries in recent years. It is seen that in recent years the production of cotton textile industry has been almost stagnant which is one reason why the relative share of cotton textiles in the consumption of dyes has been declining. Because of the rapid growth of the man-made fibre fabrics industry in recent years, special dyes of Disperse and Reactive Groups have been developed and their production has been on the increase.

CHAPTER IV

THE HISTORICAL GROWTH AND THE PRESENT
POSITION OF THE INDIAN DYESTUFF INDUSTRY

4.1 Origin and Growth

The beginnings of the synthetic dyestuff industry in India can be traced back to 1940 when attempts were made by Associated Research Laboratories in Maharashtra to manufacture rapid fast dyes on a small scale. Like the British Textile Industry during the First World War, the Indian Textile Industry faced during the Second World War a shortage of dyestuffs, the entire requirements of which had till then been met by imports. During this period, attention was paid to the development of the dyestuff industry within the country. In 1941, the Government of India set up a Dyestuffs Exploratory Committee which submitted its report in August 1945. In its report, the Committee drew the attention to the vital importance of the Dyestuffs Industry to the national economy and suggested early establishment of such an industry. It recommended a five year plan for the phased manufacture of 51 dyes and some of the dye intermediates.

In 1947, M/s. Atul Products Ltd., one of the largest units in the industry was registered with the object of manufacturing Azo Dyes including Congo Red, Sulphur Black and Alizarine in collaboration with the Calico Division of the American Cynamid Company. This went on stream in 1950. During the next five years, other units also came up.

It is evident therefore that the dyestuff industry is of very recent origin in India. It had its origin and

growth in the real sense only in the post-Independence period in India.

During the First Plan period, only a few simple dyes were manufactured with the help of imported intermediates in small quantities as may be seen from Table 4.1. Hence the country had to depend on large scale imports. Table 4.2 gives group-wise imports of dyes in quantities and values from 1951-52 to 1954-55.

Table 4.1 : Production of Dyestuffs (in lbs.) during the First Plan Period

| Year | Sulphur Black | Azodyes | Stabi- lised azoics | Solubi- lised Vats | Develop- ing Salts |
|------|------------------|-----------|---------------------------|--------------------------|--------------------------|
| 1951 | - | - | 32,166 | 5,894 | 41,000 |
| 1952 | 14,573 | 66,965 | 56,755 | 7,276 | 20,332 |
| 1953 | 5,99,748 | 5,77,470 | 5,96,200 | 64,137 | 1,34,146 |
| 1954 | 10,00,000 | 16,33,684 | 4,65,000 | 1,24,347 | 3,54,300 |
| 1955 | 16,97,000 | 15,89,431 | 4,02,810 | 94,216 | 3,20,570 |

Source : Government of India, Planning Commission.
Programmes of Industrial Development, 1956-61.

Textile industry is the major consumer of dyes. Since the Indian textile industry is well developed and second largest in the world, the demand for dyestuffs has always been quite high. It is seen from Table 4.2 that the imports of dyes were on the increase from 1951-52 to 1954-55,

Table 4.2 : Import of Dyss into India during 1951-52 to 1954-55

| Item | (Quantity in '000 Lbs and Value in Rs. Lakhs) | | | | | | | |
|--|---|---------------|---------------|--------------|---------------|---------------|---------------|---------------|
| | 1951-52 | | 1952-53 | | 1953-54 | | 1954-55 | |
| | Quan- tity | Value | Quan- tity | Value | Quan- tity | Value | Quan- tity | Value |
| 1) Alizarine, dry & moist | 218 | 4.1 | 2 | 0.09 | 101 | 1.9 | 583 | 11.9 |
| 2) Gango red | 1,178 | 43.8 | 393 | 10.2 | 315 | 8.4 | 316 | 10.1 |
| 3) Naphthols | 1,487 | 153.5 | 969 | 90.4 | 2,131 | 184.4 | 2,829 | 222.9 |
| 4) Rapid fast colours (Rapid Salts) | 254 | 38.9 | 254 | 40.1 | 217 | 34.4 | 92 | 13.2 |
| 5) Bases | 988 | 99.6 | 660 | 55.8 | 1,455 | 125.7 | 2,387 | 190.3 |
| 6) Other Salts | 928 | 50.1 | 422 | 20.8 | 841 | 43.2 | 196 | 5.1 |
| 7) Indigo Vats | 661 | 35.2 | 347 | 18.4 | 974 | 54.8 | 701 | 36.7 |
| 8) Carbazole blue (Vats) | 40 | 5.8 | 4 | 0.4 | 20 | 2.2 | 17 | 2.0 |
| 9) Paste | 343 | 44.3 | 79 | 10.0 | 341 | 44.4 | 600 | 68.9 |
| 10) Powder | 1,192 | 546.4 | 671 | 303.6 | 1,565 | 663.8 | 1,775 | 707.2 |
| 11) Sulphur black | 3,067 | 72.7 | 1,147 | 24.0 | 3,478 | 66.5 | 1,092 | 30.0 |
| 12) Metanil Yellow | 264 | 11.0 | 118 | 5.1 | 397 | 15.4 | 423 | 14.7 |
| 13) Auramine of Concen- tration of 15 per cent and less | 39 | 3.0 | - | - | 6 | 0.4 | 10 | 0.7 |
| 14) Rhodamine (Cathamine) of concentration of 15 per cent and less | 18 | 3.0 | - | - | 8 | 1.1 | 12 | 1.4 |
| 15) Aniline Salt | 628 | 8.6 | 11 | 0.1 | 285 | 3.4 | 449 | 5.8 |
| 16) Others | 4,035 | 307.3 | 2,134 | 171.8 | 3,552 | 295.8 | 3,801 | 322.5 |
| Total | 15,340 | 1427.3 | 7,211 | 750.8 | 15,686 | 1545.8 | 15,283 | 1643.4 |

Source: Government of India, Planning Commission, Programmes of Industrial Development, 1956-61.

except for the year 1952-53. The imports of finished dyes in terms of value were of the order of Rs. 142.73 million in 1951-52 and Rs. 164.34 million in the year 1954-55.

During the Second Plan period, however, the growth of the industry was rapid. Not only the production increased rapidly during this period but it was diversified into more dye groups. Relatively more complex and costlier dyes were manufactured. Consequently, the imports both in quantity and value terms declined fast. The imports of finished dyes declined from Rs. 164.34 million in 1954-55 to Rs. 131.4 million in 1957 and to Rs. 81.4 million in 1958. The imports in 1959 were of the value of Rs. 82.7 million but they registered a rise again in 1960 to Rs. 104.7 lakhs due to increased demand. The figures of production and imports of dyestuffs during the Second Plan period are given in Table 4.3.

The total production of dyestuffs in 1963 was 9265 tonnes (6169 tonnes in the organized sector and 3096 tonnes in the small scale unorganized sector. In 1965, the total production was 11,001 tonnes (8006 tonnes in the organized sector and 2995 tonnes in the unorganized sector).*

The production of finished dyes in the organized sector in 1965, 1966 and 1967 is given in Table 4.4.

* These figures have been quoted from the Report of the Tariff Commission (1968) on Continuance of Protection to the Dyestuff Industry.

Table 4.3 : Production of Dyestuffs in the Second Plan Period

| Dyestuffs | ('000 Lbs.) | | | | |
|------------------------------------|--------------|--------------|--------------|---------------|---------------|
| | 1956 | 1957 | 1958 | 1959 | 1960 |
| 1) Azodyes | 1,772 | 2,162 | 1,872 | 2,720 | 2,616 |
| 2) Fast Colour Bases | 4 | 222 | 356 | 860 | 998 |
| 3) Fast Colour Salts | 334 | 272 | 289 | 280 | 476 |
| 4) Ink Blue and Methylene Blue | 8 | 10 | 32 | 60 | 110 |
| 5) Naphthols | 188 | 1,285 | 998 | 1,630 | 1,895 |
| 6) Optical Bleaching Agents | 8 | 77 | 180 | 280 | 364 |
| 7) Solubilised Vats | 101 | 111 | 142 | 172 | 231 |
| 8) Stabilised Azoics | 483 | 521 | 594 | 639 | * |
| 9) Sulphur Black | 3,461 | 3,000 | 1,858 | 3,030 | 3,280 |
| 10) Vat Dyes (Commercial Strength) | 46 | 263 | 416 | 720 | 1,045 |
| 11) Printing Pigment Emulsions | - | - | - | 92 | 406 |
| 12) Organic Pigments | - | - | - | 135 | 572 |
| Total | 6,403 | 8,732 | 6,737 | 10,618 | 11,998 |

* Production is included in item No.3, i.e. Fast Colour Salts.

Import of Dyes during the Second Plan Period

| | Coal-tar Dyestuffs and Neutral Indigo | | Naphthols and others | |
|---------|---------------------------------------|-------------------|----------------------|-------------------|
| | Quantity ('000 Lbs.) | Value (Rs. Lakhs) | Quantity (Cwts.) | Value (Rs. Lakhs) |
| 1956-57 | 10,611 | 1,217 | N.A. | N.A. |
| 1957 | 9,947 | 1,089 | 16,515 | 225 |
| 1958 | 6,359 | 670 | 10,532 | 144 |
| 1959 | 5,854 | 714 | 11,826 | 113 |
| 1960 | 6,612 | 906 | 17,077 | 141 |

Source: Government of India, Planning Commission. Programmes of Industrial Development, 1961-66.

**Table 4.4 : Production of Dyestuffs in 1965, 1966 and 1967
in the Organized Sector**

| Dye Group | (In Tonnes) | | |
|--------------------------------|--------------|--------------|--------------|
| | 1965 | 1966 | 1967 |
| 1) Direct Dyes | 952 | 944 | 1,084 |
| 2) Acid Dyes | 467 | 545 | 652 |
| 3) Basic Dyes | 284 | 268 | 256 |
| 4) Mordant Dyes | 55 | 39 | 35 |
| 5) Naphthols | 1,045 | 975 | 818 |
| 6) Fast Colour Salts | 35 | 25 | 36 |
| 7) Rapid Fast and Rapidogens | 140 | 153 | 106 |
| 8) Fast Colour Bases | 529 | 460 | 305 |
| 9) Vat Dyes | 798 | 1,058 | 1,080 |
| 10) Solubilised Vat Dyes | 120 | 120 | 88 |
| 11) Sulphur Dyes | 1,442 | 1,803 | 1,453 |
| 12) Organic Pigments | 624 | 825 | 778 |
| 13) Pigment Printing Emulsions | 848 | 1,010 | 813 |
| 14) Reactive Dyes | 54 | 90 | 97 |
| 15) Optical Whitening Agents | 388 | 458 | 458 |
| 16) Disperse Dyes | 4 | 3 | 4 |
| 17) Ingrain Dyes | - | - | - |
| 18) Miscellaneous Dyes | 142 | 185 | 191 |
| Total | 7,927 | 8,961 | 8,254 |

Source : Tariff Commission. Report on Continuance of Protection to the Dyestuff Industry, 1968.

Reliable figures for the production of dyestuffs in the small scale sector are not available. However, the estimates of the Tariff Commission give the figures for 1965, 1966 and 1967 as 2,995 tonnes, 3,159 tonnes and 3,352 tonnes respectively. Thus the total production for these years was around 1,099 tonnes, 12,120 tonnes and 11,606 tonnes respectively.

It is seen that the overall production of dyestuffs

increased between 1963 and 1966 but fell in 1967. The fall in production in 1967 has been attributed largely to general slackness in demand. It is seen that the share of the small scale sector had gone down from 33 per cent in 1963 to 26 per cent in 1966 in the total production.

As a result of increased production and greater diversification, the imports of dyes during 1965-66 to 1967-68 were considerably reduced compared to the earlier years yet they were of the order of rupees three to four crores per year the value of imports being Rs. 3,77,17,620, Rs. 4,08,07,968 and Rs. 3,99,49,478 for the years 1965-66, 1966-67 and 1967-68 respectively. The break-up of groupwise imports for these years is given in Table 4.5.

By this time a modest beginning was made in exporting the dyes the value of exports being Rs. 35,49,038, Rs. 27,87,787 and Rs. 29,76,727 for the years 1965-66, 1966-67 and 1967-68 respectively. The groupwise exports of dyes is given in Table 4.6.

While the total production of dyes in 1968 was 10,165 tonnes in 1968, the installed capacity was 15,061 tonnes. The installed capacity increased to 21,311 tonnes by 1973 thus registering a rise of 41 per cent. During the period from 1968 to 1973 there was a marked improvement in installed capacity in respect of Rapid Fast and Rapidogens and Vat Dyes which worked out to more than 50 per cent. While in

Table 4.5 : Imports of Dyes during 1965-66, 1966-67 and 1967-68

| Dye Group | (Quantity in Kgs. and Value in Rs.) | | | | | |
|--------------------------------|-------------------------------------|--------------------|-----------------------|--------------------|-----------------------|--------------------|
| | April 1965-March 1966 | | April 1966-March 1967 | | April 1967-March 1968 | |
| | Quantity | Value | Quantity | Value | Quantity | Value |
| 1) Direct Dyes | 1,16,110 | 24,19,277 | 86,954 | 22,09,779 | 40,578 | 12,14,077 |
| 2) Acid Dyes | 1,71,712 | 33,54,639 | 99,792 | 30,83,139 | 84,277 | 28,90,794 |
| 3) Basic Dyes | 1,54,728 | 33,26,976 | 85,534 | 20,99,854 | 50,171 | 19,19,789 |
| 4) Mordant Dyes | 10,862 | 75,224 | 16,569 | 93,734 | 12,840 | 1,14,841 |
| 5) Naphthols | 18,818 | 5,21,095 | 82,237 | 16,15,208 | 20,367 | 10,44,435 |
| 6) Fast Colour Salts | - | - | - | - | - | - |
| 7) Rapid Fast and Rapidogens | 12,711 | 2,79,677 | 14,721 | 5,16,958 | 6,798 | 2,52,176 |
| 8) Fast Colour Bases | 74,034 | 10,56,375 | 58,276 | 24,02,487 | 78,050 | 18,00,630 |
| 9) Vat Dyes | 5,05,056 | 1,57,79,105 | 3,34,870 | 1,69,70,084 | 3,62,344 | 2,01,35,489 |
| 10) Solubilised Vats | 10,523 | 5,36,019 | 5,603 | 3,79,414 | 1,902 | 1,54,552 |
| 11) Sulphur Dyes | 47,958 | 5,49,827 | 48,976 | 8,03,710 | 36,304 | 6,78,861 |
| 12) Organic Pigments | 64,092 | 17,22,816 | 76,541 | 32,92,315 | 48,253 | 23,26,323 |
| 13) Pigment Printing Emulsions | 20,934 | 1,92,149 | 2,224 | 80,307 | 10,717 | 2,04,081 |
| 14) Reactive Dyes | 22,391 | 33,69,459 | 59,294 | 29,99,127 | 51,592 | 26,13,575 |
| 15) Optical Whitening Agents | 14,023 | 2,92,648 | 17,731 | 4,54,762 | 27,861 | 6,38,024 |
| 16) Dispersed Dyes | 1,34,578 | 37,52,108 | 97,035 | 33,24,538 | 75,955 | 32,24,673 |
| 17) Ingrain Dyes | 12,162 | 2,94,399 | 5,474 | 3,49,003 | 7,792 | 4,15,768 |
| 18) Miscellaneous Dyes | 15,861 | 1,95,827 | 13,738 | 1,33,499 | 12,703 | 2,21,388 |
| Total | 14,66,553 | 3,77,17,620 | 10,55,614 | 4,08,07,968 | 9,28,504 | 3,99,49,478 |

Source: Tariff Commission. Report on Continuance of Protection to the Dyestuff Industry, 1968.

Table 4.6 : Exports of Dyes during 1965-66, 1966-67 and 1967-68

| Dye Group | (Quantity in Kgs. and Value in Rs.) | | | | | |
|--------------------------------|-------------------------------------|------------------|-----------------------|------------------|-----------------------|------------------|
| | April 1965-March 1966 | | April 1966-March 1967 | | April 1967-March 1968 | |
| | Quantity | Value | Quantity | Value | Quantity | Value |
| 1) Direct Dyes | 17,653 | 2,61,147 | 11,750 | 2,64,598 | 12,656 | 1,27,763 |
| 2) Acid Dyes | 59,396 | 3,74,584 | 38,361 | 2,99,896 | 41,097 | 3,14,963 |
| 3) Basic Dyes | 18,981 | 2,93,853 | 8,286 | 1,60,955 | 16,019 | 2,55,048 |
| 4) Mordant Dyes | 836 | 1,910 | - | - | - | - |
| 5) Naphthols | 16,754 | 1,73,268 | 8,694 | 1,68,076 | 17,728 | 3,00,033 |
| 6) Fast Colour Salts | 40 | 788 | - | - | - | - |
| 7) Rapid Fast and Rapidogens | - | - | - | - | - | - |
| 8) Fast Colour Bases | 10,832 | 1,10,714 | 5,343 | 70,607 | 13,039 | 2,51,660 |
| 9) Vat Dyes | 41,521 | 13,76,000 | 24,946 | 4,72,616 | 16,666 | 6,14,484 |
| 10) Solubilised Vats | - | - | 520 | 2,210 | - | - |
| 11) Sulphur Dyes | 37,160 | 85,417 | 34,550 | 50,503 | 26,250 | 68,745 |
| 12) Organic Pigments | 67,290 | 1,36,117 | - | - | 2,801 | 52,238 |
| 13) Pigment Printing Emulsions | - | - | - | - | - | - |
| 14) Reactive Dyes | 30 | 990 | - | - | - | - |
| 15) Optical Whitening Agents | 65,488 | 4,52,484 | 89,483 | 10,98,709 | 42,723 | 7,75,825 |
| 16) Disperse Dyes | 25,555 | 70,242 | 2,480 | 24,422 | 13,044 | 9,122 |
| 17) Ingrain Dyes | 10,000 | 24,102 | 502 | 2,255 | 9 | 120 |
| 18) Miscellaneous Dyes | 30,848 | 1,87,422 | 21,175 | 1,74,940 | 23,107 | 2,06,726 |
| Total | 3,95,384 | 35,49,038 | 2,46,090 | 27,87,787 | 2,13,399 | 29,76,727 |

Source : Tariff Commission. Report on the Continuance of Protection to the Dyestuff Industry, 1968.

case of some other items taken together such as Direct Dyes, Acid Dyes, Basic Dyes, Mordant Dyes, Sulphur Dyes, Organic Pigments, Printing Emulsions, Reactive Dyes and Miscellaneous Dyes, the increase accounted for about 40 per cent. The overall utilization of capacity in the organized sector of the Dyestuff Industry was about 69 per cent in 1973. The Indian Chemical Manufacturers' Association has attributed the under-utilization of capacity to shortage of raw materials.

As regards the total production, in this sector, it registered a rising trend from 10,165 tonnes in 1968 to 14,563 tonnes in 1973. Compared to 1968, the output of various groups of dyes like Direct Dyes, Basic Dyes, Organic Pigments, Pigment Printing Emulsions, Reactive Dyes, and Disperse Dyes showed substantial increase ranging from 54 per cent to 655 per cent. The other dyes like Acid Dyes, Mordant Dyes, Naphthols, Vat Dyes, Fast Colour Bases, Optical Whitening Agents also recorded a rise in production but it ranged from 9 per cent to 47 per cent during this period. The fall in production was noticed in respect of Fast Colour Salts, Rapid Fasts and Rapidogens, Solubilised Vat Dyes, Sulphur Dyes and Miscellaneous Dyes during 1973 compared to 1968. The group-wise production of dyes in the organized sector from 1968 to 1973 is given in Table 4.7.

For the small scale sector, no data is available for

Table 4.7 : Group-wise Production of Dyes in the Organized Sector from 1968 to 1973

| Dye Group | (In Tonnes) | | | | | |
|---|---------------|---------------|---------------|---------------|---------------|---------------|
| | 1968 | 1969 | 1970 | 1971 | 1972 | 1973 |
| 1) Direct Dyes (Azo and non-azo) | 1,149 | 1,193 | 1,225 | 1,612 | 1,450 | 1,771 |
| 2) Acid Dyes (Azo and non-azo) | 659 | 702 | 756 | 884 | 854 | 720 |
| 3) Basic Dyes (Azo and non-azo) | 373 | 441 | 604 | 663 | 663 | 713 |
| 4) Mordant Dyes | 45 | 66 | 37 | 56 | 59 | 51 |
| 5) Fast Colour Salts | 44 | 23 | 49 | 35 | 37 | 32 |
| 6) Sulphur Dyes including Sulphur Black and Sulphurised Vat Dyes | 1,854 | 1,911 | 1,668 | 1,447 | 1,597 | 1,044 |
| 7) Organic Pigments including Lakes and Toners | 1,000 | 1,290 | 1,660 | 1,332 | 1,602 | 1,938 |
| 8) Pigment Printing Emulsions | 1,128 | 1,227 | 1,813 | 1,694 | 2,417 | 2,487 |
| 9) Reactive Dyes | 142 | 230 | 576 | 519 | 750 | 973 |
| 10) Naphthols | 878 | 888 | 1,126 | 1,254 | 1,339 | 1,238 |
| 11) Fast Colour Bases | 547 | 724 | 900 | 744 | 838 | 802 |
| 12) Azoic Printing Compositions including Rapid Fast and Rapidogens | 183 | 163 | 196 | 181 | 292 | 179 |
| 13) Vat Dyes | 1,159 | 1,325 | 1,368 | 1,122 | 1,253 | 1,419 |
| 14) Solubilised Vat Dyes | 105 | 137 | 144 | 129 | 137 | 102 |
| 15) Optical Whitening Agents | 559 | 712 | 866 | 800 | 805 | 752 |
| 16) Disperse Dyes | 29 | 61 | 149 | 136 | 187 | 219 |
| 17) Ingrain Dyes | - | - | 11 | 2 | 5 | 3 |
| 18) Miscellaneous Dyes | 311 | 450 | 404 | 464 | 128 | 120 |
| Total | 10,165 | 11,543 | 13,552 | 13,074 | 14,413 | 14,563 |

Source : Tariff Commission. Report on the Review of Dyestuffs Industry, 1974.

this period to indicate the growth since 1967. In 1967, there were 102 units in the small scale sector with a total capacity of 6,470 tonnes for various groups of dyes. The estimated production was 3,352 tonnes. The Tariff Commission estimate for the production in the small scale sector is around 30 to 35 per cent of the total production in the organized sector.

As a result of the progress made by the industry in recent years, the imports of finished dyestuffs are on the decline while exports have increased considerably. The value of exports in 1972 was Rs. 471.32 lakhs and for January-October 1973 Rs. 404.40 lakhs. The quantities and values of imports and exports of 18 groups of dyes are given in Tables 4.8 and 4.9.

The total availability or apparent consumption of different groups of dyes is given in Table 4.10. Figures for apparent consumption are obtained by adding production and imports and subtracting exports. However, the production figures are for the organized sector only and to arrive at a better approximation, we may add the estimated production of around 30 per cent in the small scale sector.

Table 4.11 gives at a glance group-wise production of dyestuffs from 1965 to 1973. From this data, Linear and Semi-log growth curves have been computed for different dye groups for the years 1965 to 1973, and the results have been

Table 4.8 : Groupwise Imports of Dyes during the Years 1968 to 1973 (January-October)

| Sr. No. | Name of the Dye-Group | (Quantity in Tonnes and Value in Rs. Lakhs) | | | | | | | | | | | |
|---------|---|---|--------|----------|--------|----------|--------|----------|--------|----------|--------|------------------|--------|
| | | 1968 | | 1969 | | 1970 | | 1971 | | 1972 | | 1973 (Jan.-Oct.) | |
| | | Quantity | Value | Quantity | Value | Quantity | Value | Quantity | Value | Quantity | Value | Quantity | Value |
| 1) | Direct Dyes (Azo and non-azo) | 50 | 18.42 | 56 | 16.66 | 48 | 16.05 | 89 | 18.41 | 31 | 10.01 | 23 | 10.53 |
| 2) | Acid Dyes (Azo and non-azo) | 108 | 32.11 | 122 | 29.37 | 119 | 40.42 | 85 | 29.83 | 60 | 28.03 | 66 | 36.51 |
| 3) | Basic Dyes (Azo and non-azo) | 89 | 31.02 | 38 | 12.38 | 33 | 12.84 | 57 | 19.74 | 58 | 26.70 | 44 | 28.35 |
| 4) | Mordant Dyes (Azo and non-azo) | 11 | 1.85 | 20 | 4.08 | 13 | 3.13 | 15 | 3.84 | 17 | 5.29 | 5 | 1.81 |
| 5) | Naphthols | 4 | 2.96 | 21 | 14.09 | 58 | 30.69 | 86 | 35.85 | 34 | 26.28 | 12 | 7.17 |
| 6) | Fast Colour Salts | - | - | - | - | - | - | - | - | - | - | - | - |
| 7) | Azoic Printing Compositions including Rapid Fasts and Rapidogen | 3 | 1.48 | 4 | 1.62 | 4 | 1.23 | 9 | 3.35 | 5 | 2.07 | 1 | 0.70 |
| 8) | Fast Colour Bases | 53 | 14.43 | 68 | 19.31 | 98 | 25.53 | 72 | 19.87 | 36 | 9.67 | 29 | 10.58 |
| 9) | Vat Dyes | 348 | 198.97 | 228 | 93.24 | 259 | 133.98 | 250 | 135.32 | 143 | 67.09 | 161 | 71.24 |
| 10) | Solubilised Vat Dyes | 3 | 2.03 | 1 | 0.78 | 1 | 0.79 | 2 | 1.79 | 1 | 0.46 | 1 | 0.78 |
| 11) | Sulphur Dyes including Sulphur Black and Sulphurised Vat Dyes | 72 | 7.44 | 72 | 12.31 | 61 | 9.65 | 57 | 8.68 | 65 | 12.39 | 70 | 17.11 |
| 12) | Organic Pigments including Lakes and Toners | 21 | 6.79 | 20 | 10.92 | 18 | 13.48 | 52 | 25.59 | 38 | 20.66 | 42 | 29.19 |
| 13) | Pigment Printing Emulsions | 16 | 2.13 | 13 | 1.90 | 4 | 1.05 | 16 | 2.59 | 28 | 4.35 | 7 | 1.45 |
| 14) | Reactive Dyes (Azo and non-azo) | 92 | 51.89 | 39 | 19.93 | 64 | 31.83 | 47 | 23.14 | 37 | 17.97 | 42 | 21.77 |
| 15) | Optical Whitening Agents | 20 | 2.55 | 27 | 9.48 | 22 | 8.40 | 9 | 5.10 | 15 | 7.16 | 10 | 6.59 |
| 16) | Disperse Dyes (Azo and non-azo) | 137 | 60.38 | 97 | 38.58 | 176 | 76.15 | 127 | 57.84 | 109 | 43.31 | 92 | 50.62 |
| 17) | Ingrain Dyes | 12 | 5.97 | 1 | 0.34 | 5 | 2.61 | 3 | 1.52 | 14 | 7.01 | 9 | 4.74 |
| 18) | Miscellaneous Dyes | 9 | 2.02 | 2 | 0.80 | 4 | 1.60 | 5 | 3.29 | 6 | 3.41 | 4 | 4.14 |
| Total | | 1,048 | 442.26 | 829 | 285.79 | 987 | 409.43 | 981 | 395.75 | 697 | 291.86 | 618 | 303.28 |

Source : Tariff Commission, Government of India. Report on the Review of Dyestuff Industry, 1974.

Table 4.9 : Groupwise Export of Dyes during the Years 1968 to 1973 (January-October)

| Sr. No. | Name of the Dye Group | (Quantity in Tonnes and Value in Rs. Lakhs) | | | | | | | | | | | |
|---------|---|---|--------|----------|--------|----------|--------|----------|--------|----------|--------|------------------|--------|
| | | 1968 | | 1969 | | 1970 | | 1971 | | 1972 | | 1973 (Jan.-Oct.) | |
| | | Quantity | Value | Quantity | Value | Quantity | Value | Quantity | Value | Quantity | Value | Quantity | Value |
| 1) | Direct Dyes (Azo and non-azo) | 45 | 5.76 | 55 | 7.89 | 216 | 28.26 | 203 | 28.38 | 343 | 64.37 | 158 | 37.53 |
| 2) | Acid Dyes (Azo and non-azo) | 83 | 6.69 | 77 | 5.68 | 192 | 19.39 | 216 | 22.22 | 269 | 37.57 | 178 | 20.21 |
| 3) | Basic Dyes (Azo and non-azo) | 34 | 6.83 | 23 | 4.17 | 61 | 9.95 | 153 | 24.88 | 217 | 46.80 | 181 | 40.35 |
| 4) | Mordant Dyes (Azo and non-azo) | - | - | - | - | - | - | - | - | - | - | - | - |
| 5) | Naphthols | 6 | 2.01 | 10 | 1.57 | 9 | 0.97 | 66 | 7.99 | 83 | 17.07 | 65 | 23.54 |
| 6) | Fast Colour Salts | - | - | - | - | - | - | - | - | - | - | - | - |
| 7) | Rapid Fast and Repidogens | - | - | Neg. | 0.12 | Neg. | 0.08 | 1 | 0.34 | 1 | 0.16 | - | - |
| 8) | Fast Colour Bases | 13 | 2.42 | 26 | 6.32 | 25 | 4.19 | 32 | 4.82 | 146 | 20.74 | 96 | 17.81 |
| 9) | Vat Dyes | 110 | 38.71 | 85 | 32.74 | 170 | 54.85 | 71 | 28.18 | 200 | 101.11 | 132 | 55.38 |
| 10) | Solubilised Vat Dyes | - | - | - | - | - | - | Neg. | 0.23 | 1 | 0.33 | Neg. | 0.17 |
| 11) | Sulphur Dyes including Sulphur Black and Sulphurised Vat Dyes | 86 | 1.78 | 144 | 7.13 | 259 | 12.99 | 650 | 37.17 | 751 | 55.39 | 804 | 104.43 |
| 12) | Organic Pigments including Lakes and Toners | 13 | 2.05 | 29 | 6.09 | 153 | 14.94 | 146 | 25.12 | 436 | 67.66 | 529 | 72.48 |
| 13) | Pigment Printing Emulsions | 2 | 0.53 | Neg. | Neg. | 172 | 13.36 | 15 | 1.91 | 6 | 0.60 | 2 | 0.20 |
| 14) | Reactive Dyes (Azo and non-azo) | Neg. | 0.11 | 6 | 2.35 | 7 | 2.50 | 29 | 9.35 | 79 | 28.27 | 24 | 9.61 |
| 15) | Optical Whitening Agents | 151 | 36.89 | 202 | 30.38 | 222 | 41.84 | 132 | 22.60 | 130 | 15.93 | 112 | 13.64 |
| 16) | Disperse Dyes | Neg. | - | 5 | 0.94 | Neg. | 0.13 | 10 | 2.82 | 22 | 10.61 | 19 | 4.82 |
| 17) | Ingrain Dyes | Neg. | 0.01 | Neg. | 0.01 | 2 | 0.22 | 2 | 0.47 | 9 | 1.05 | 1 | 0.17 |
| 18) | Miscellaneous Dyes | 17 | 1.23 | 312 | 33.49 | 271 | 27.33 | 54 | 10.70 | 10 | 3.66 | 19 | 4.06 |
| Total | | 560 | 105.02 | 974 | 138.88 | 1,759 | 231.00 | 1,780 | 227.18 | 2,703 | 471.32 | 2,320 | 404.40 |

Source : Tariff Commission, Government of India. Report on the Review of the Dyestuff Industry, 1974.

Table 4.10 : Consumption of Various Groups of Dyestuffs during 1968 to 1972

| Item | (In Tonnes) | | | | |
|--------------------------------|--------------------------|---------------|---------------|---------------|---------------|
| | *Apparent consumption in | | | | |
| | 1968 | 1969 | 1970 | 1971 | 1972 |
| 1. Direct Dyes | 1,154 | 1,194 | 1,057 | 1,498 | 1,138 |
| 2. Acid Dyes | 684 | 747 | 683 | 753 | 645 |
| 3. Basic Dyes | 428 | 456 | 576 | 567 | 504 |
| 4. Mordant Dyes | 56 | 86 | 50 | 71 | 76 |
| 5. Naphthols | 876 | 899 | 1,175 | 1,274 | 1,290 |
| 6. Fast Colour Salts | 44 | 23 | 49 | 35 | 37 |
| 7. Rapid Fasts and Rapidogns | 186 | 167 | 200 | 189 | 295 |
| 8. Fast Colour Bases | 587 | 766 | 973 | 784 | 728 |
| 9. Vat Dyes | 1,397 | 1,468 | 1,457 | 1,301 | 1,196 |
| 10. Solubilised Vat Dyes | 108 | 138 | 145 | 131 | 137 |
| 11. Sulphur Dyes | 1,840 | 1,839 | 1,470 | 854 | 911 |
| 12. Organic Pigments | 1,008 | 1,281 | 1,525 | 1,238 | 1,204 |
| 13. Pigment Printing Emulsions | 1,142 | 1,240 | 1,645 | 1,695 | 2,439 |
| 14. Reactive Dyes | 234 | 263 | 633 | 537 | 708 |
| 15. Optical Whitening Agents | 428 | 537 | 666 | 677 | 690 |
| 16. Disperse Dyes | 166 | 153 | 325 | 253 | 274 |
| 17. Ingrain Dyes | 12 | 1 | 14 | 3 | 10 |
| 18. Miscellaneous Dyes | 303 | 140 | 137 | 415 | 124 |
| Total | 10,653 | 11,389 | 12,780 | 12,275 | 12,407 |

* Production + Import - Export.

Note : The figures exclude the production in the unorganized sector. The approximate estimate of production in the unorganized sector is about 30 per cent of the production in the organized sector. Thus apparent consumption is about 30 per cent more than the above figures.

Source: Tariff Commission's Report on the Review of the Dyestuffs Industry 1973.

Table 4.11 : Groupwise Production of Dyestuffs from 1965 to 1973

| | | (In Tonnes) | | | | | | | | |
|---------|----------------------------|-------------|-------|-------|-------|-------|-------|-------|-------|-------|
| Sr. No. | Dye Group | 1965 | 1966 | 1967 | 1968 | 1969 | 1970 | 1971 | 1972 | 1973 |
| 1. | Direct Dyes | 955 | 944 | 1,084 | 1,149 | 1,173 | 1,225 | 1,612 | 1,450 | 1,771 |
| 2. | Acid Dyes | 467 | 545 | 652 | 659 | 702 | 756 | 884 | 854 | 720 |
| 3. | Basic Dyes | 284 | 268 | 256 | 373 | 441 | 604 | 663 | 663 | 713 |
| 4. | Mordant Dyes | 55 | 39 | 35 | 45 | 66 | 37 | 56 | 59 | 51 |
| 5. | Naphthols | 1,045 | 975 | 818 | 878 | 888 | 1,126 | 1,254 | 1,339 | 1,238 |
| 6. | Fast Colour Salts | 35 | 25 | 36 | 44 | 23 | 49 | 35 | 37 | 32 |
| 7. | Rapid Fast and Rapidogens | 140 | 153 | 106 | 183 | 163 | 196 | 181 | 292 | 179 |
| 8. | Fast Colour Bases | 529 | 460 | 305 | 547 | 724 | 900 | 744 | 838 | 802 |
| 9. | Vat Dyes | 798 | 1,058 | 1,080 | 1,159 | 1,345 | 1,368 | 1,122 | 1,253 | 1,419 |
| 10. | Solubilised Vat Dyes | 120 | 120 | 88 | 105 | 137 | 144 | 129 | 137 | 102 |
| 11. | Sulphur Dyes | 1,442 | 1,803 | 1,453 | 1,854 | 1,911 | 1,668 | 1,447 | 1,597 | 1,044 |
| 12. | Organic Pigments | 624 | 825 | 778 | 1,000 | 1,290 | 1,660 | 1,332 | 1,602 | 1,938 |
| 13. | Pitment Printing Emulsions | 848 | 1,010 | 813 | 1,128 | 1,227 | 1,813 | 1,694 | 2,417 | 2,487 |
| 14. | Reactive Dyes | 54 | 90 | 97 | 142 | 230 | 576 | 519 | 750 | 970 |
| 15. | Optical Whitening Agents | 388 | 458 | 458 | 559 | 712 | 866 | 800 | 805 | 752 |
| 16. | Disperse Dyes | 4 | 3 | 4 | 29 | 61 | 149 | 136 | 187 | 219 |
| 17. | Ingrain Dyes | - | - | - | - | - | 11 | 2 | 5 | 3 |
| 18. | Miscellaneous Dyes | 142 | 185 | 195 | 311 | 450 | 404 | 464 | 128 | 120 |

Table 4.12 : Linear Growth Curves of Different Dye Groups for the Years 1965 to 1973

| $(Y_t = \alpha + \beta t)$ | | | | |
|----------------------------|----------------------------|----------------|----------------------|---------|
| Sr. No. | Name of the Dye Group | $\hat{\alpha}$ | $\hat{\beta}$ | R^2 |
| 1) | Direct Dyes | 98.57 | 190.21 (7.1468)** | 0.8795 |
| 2) | Acid Dyes | 41.66 | 92.45 (4.3333)** | 0.7284 |
| 3) | Basic Dyes | 65.76 | 55.47 (8.8303)** | 0.9176 |
| 4) | Mordant Dyes | 1.30 | 1.98 (0.9235) | 0.1086 |
| 5) | Naphthols | 49.73 | 313.77 (2.8076)** | 0.5296 |
| 6) | Fast Colour Salts | 0.45 | 1.24 (0.4034) | 0.0227 |
| 7) | Rapid Fast and Rapidogens | 12.26 | 28.08 (2.3146)** | 0.4335 |
| 8) | Fast Colour Bases | 57.62 | 277.27 (3.4601) | 0.6310 |
| 9) | Vat Dyes | 56.03 | 249.73 (3.5457) | 0.6423 |
| 10) | Solubilised Vat Dyes | 1.66 | 6.28 (0.6646) | 0.0594 |
| 11) | Sulphur Dyes | -40.13 | 1156.94 (-1.1799) | 0.1659 |
| 12) | Organic Pigments | 155.92 | 400.87 (7.7873)** | 0.8965 |
| 13) | Pigment Printing Emulsions | 220.40 | 918.42 (7.2726)** | 0.8831 |
| 14) | Reactive Dyes | 115.36 | 223.26 (7.7209)** | 0.8949 |
| 15) | Optical Whitening Agents | 58.13 | 130.98 (5.0794)** | 0.7866 |
| 16) | Disperse Dyes | 29.93 | 11.36 (8.8787)** | 0.9184 |
| 17) | Ingrain Dyes | 0.69 | 0.19 (1.5979) | 0.2672 |
| 18) | Miscellaneous Dyes | 6.20 | 378.94 (0.3185) | 0.01428 |

(Figures in brackets are Student t values)

** Significant at 1% level of significance.

* Significant at 5% level of significance.

Table 4.13 : Semi-Log Growth Curves for Different Dye Groups for the Years 1965 to 1973

(Log $Y_t = \alpha + \beta_i$)

| Sr. No. | Name of the Dye Group | $\hat{\alpha}$ | $\hat{\beta}$ | R^2 |
|---------|-------------------------------|----------------|---------------------------|--------|
| 1) | Direct Dyes | 0.0334 | 0.00001498 (8.6309)** | 0.9141 |
| 2) | Acid Dyes | 0.0277 | 0.00003829 (4.4742)** | 0.7409 |
| 3) | Basic Dyes | 0.0636 | 0.00006353 | 0.9008 |
| 4) | Mordant Dyes | 0.0122 | 0.00016049 (0.9622) | 0.1168 |
| 5) | Naphthols | 0.0198 | 0.00005661 (2.6290)** | 0.4968 |
| 6) | Fast Colour Salts | 0.00628 | 0.00020212 (0.4424) | 0.0272 |
| 7) | Rapid Fast and Rapidogen Dyes | 0.0294 | 0.00014524 (2.4388)** | 0.4594 |
| 8) | Fast Colour Bases | 0.0416 | 0.00019590 (2.9710) | 0.5577 |
| 9) | Vat Dyes | 0.0221 | 0.00004078 (3.4591)** | 0.6309 |
| 10) | Solubilised Vat Dyes | 0.0059 | 0.00009060 (0.6298) | 0.0536 |
| 11) | Sulphur Dyes | -0.0128 | 0.00010011 (-1.2803) | 0.1897 |
| 12) | Organic Pigments | 0.0586 | 0.00005072 (8.2389)** | 0.9065 |
| 13) | Pigment Printing Emulsions | 0.0642 | 0.00006145 (8.1847)** | 0.9053 |
| 14) | Reactive Dyes | 0.1641 | 0.00014573 (13.5920)** | 0.9635 |
| 15) | Optical Whitening Agents | 0.0426 | 0.00006128 (5.4478)** | 0.8091 |
| 16) | Disperse Dyes | 0.2685 | 0.00132993 (7.3632)** | 0.8856 |
| 17) | Ingrain Dyes | 0.9274 | 0.04552571 (4.3468)** | 0.7297 |
| 18) | Miscellaneous Dyes | 0.00157 | 0.00108786 (0.0476) | 0.0180 |

(Figures in brackets are Student t values)

** Significant at 1% level of significance.

* Significant at 5% level of significance.

Table 4.14 : Linear and Compound Growth Rates for Different Dye Groups Over the Years 1965 to 1973

| Sr. No. | Name of the Dye Group | Linear Growth Rate (%) * | Compound Growth Rate (%) ** |
|---------|-----------------------------|--------------------------|-----------------------------|
| 1) | Direct Dyes | 7.79 | 7.99 |
| 2) | Acid Dyes | 6.01 | 6.58 |
| 3) | Basic Dyes | 13.87 | 15.76 |
| 4) | Mordant Dyes | 2.64 | 2.84 |
| 5) | Naphthols | 4.68 | 4.66 |
| 6) | Fast Colour Salts | 1.28 | 1.45 |
| 7) | Rapid Fast & Rapidogen Dyes | 6.93 | 7.00 |
| 8) | Fast Colour Bases | 8.86 | 10.05 |
| 9) | Vat Dyes | 4.76 | 5.22 |
| 10) | Solubilised Vat Dyes | 1.38 | 1.39 |
| 11) | Sulphur Dyes | -2.54 | -2.91 |
| 12) | Organic Pigments | 12.70 | 14.46 |
| 13) | Pigment Printing Emulsions | 14.76 | 15.92 |
| 14) | Reactive Dyes | 30.28 | 45.91 |
| 15) | Optical Whitening Agents | 9.02 | 10.32 |
| 16) | Disperse Dyes | 34.01 | 85.57 |
| 17) | Ingrain Dyes | - | *** |
| 18) | Miscellaneous Dyes | 2.32 | 0.36 |

*Computed from Linear growth curve by using $r = \frac{\beta}{t} \times 100$

**Computed from the Semi-log growth curve by using
 $r = (e^{\beta} - 1) \times 100.$

*** Not computed because only four observations are available.

presented in Tables 4.12 and 4.13 respectively. Linear and Compound Growth Rates in percentage terms have been presented in Table 4.14.

It is evident that the growth of the dyestuff industry in recent years has been spectacular. Initially, the growth was horizontal starting from the penultimate stage and making only the final dyestuffs in as many groups as possible. This involved simpler processes and lesser capital investment. Later on, some large-scale units like Atul Products, Amar Dye Chem, Indian Dyestuff Industries and Colour Chem came forward to undertake the manufacture of complex intermediates with the help of foreign collaboration.

4.2 The Role of Foreign Collaboration

Foreign collaboration played an important role in the development of the Dyestuff Industry in India. Almost all the large-scale units that have been instrumental in producing the complex intermediates and thus laying the foundation of the Industry in India have been established with foreign collaboration. The know-how, plants and equipments, etc. have been imported. This can be seen from the following :

| <u>Name of the Unit</u> | <u>Foreign Collaborators</u> |
|---|---|
| 1. M/s. Indian Dyestuff Industries Ltd. | M/s. Azienda Colori Nazionali Affini (ACNA), Italy. |
| 2. M/s. Amar Dye Chem Ltd. | - do - |

| <u>Name of the Unit</u> | <u>Foreign Collaborators</u> |
|------------------------------|---|
| 3. M/s. Atul Products Ltd. | American Cynamide, U.S.A. |
| 4. M/s. Cibatul Ltd. | CIBA, Basle. |
| 5. M/s. Atic Industries Ltd. | I.C.I., U.K. |
| 6. M/s. Suhrid Geigy Ltd. | Geigy Ltd., Basle |
| 7. M/s. Colour Chem Ltd. | Fareen Vabrikan & Hoechest, West Germany |
| 8. M/s. Sandoz (India) Ltd. | Sandoz, Basle |

In the past two decades there was substantial foreign investment and collaboration because of the technology intensiveness of the industry. However, foreign collaboration is now generally not permitted for the production of many groups of dyestuffs.

4.3 Diversification of the Product-Mix

The earliest units, viz. Arlabs and Atul Products, had to face the most difficult times in view of the unrestricted imports and very high cost of production. The first Tariff Inquiry into the Dyestuff Industry was conducted in 1953-54 at the instance of Messrs. Atul Products Ltd. and in its report the Tariff Commission recommended that the protection to the industry should be granted for a period of ten years ending 31st December 1964 subject to periodical review of the working of protection and the level of protection. Thereafter, a number of units came into existence in the organised as well as small scale unorganized sector and in the last two decades, the industry made all-round

progress so much so that except for a few very recently developed sophisticated dyestuffs, specially meant for specific purposes, practically all the conventional dyestuffs are made in the country, to cover almost all the consuming industries like textiles, paper, leather, paints, printing inks, etc. These include azos, direct, acid and basic, naphthols, fast colour bases, vats, solubilised vats, stabilised azoics, sulphur, pigments, pigment printing emulsions, optical whitening agents, disperse dyes for acetate and other synthetic fibres and fibre reactive dyes. From the various Tables presented earlier in this chapter it is seen that the product-mix has been changing a great deal in recent years. The share of more complex and better quality dyes, optical whitening agents, organic pigments, reactive dyes and disperse dyes has increased tremendously. While the growth of the textile industry is mainly responsible for the growth of the dyestuff industry, the increasing share of pigments is accounted for by the growth of the paints and plastics industries. Increasing importance of reactive dyes and disperse dyes is because of the rise of the synthetic fibre industry in recent years.

This spectacular growth was made possible by the Tariff Protection granted to the dyestuff industry from 1954 onwards i.e. almost from the beginning.

4.4 Tariff History

The first reference to the Tariff Commission was made

in 1952 by the Ministry of Commerce and Industry, Government of India on the request of M/s. Atul Products Ltd. The firm in question had requested the Government that a proper classification of chemicals be made for the purpose of assessment of import duty. They had pleaded for the reduction or abolition of duties in respect of raw materials and intermediates used by the new chemical industries for the manufacture of dyes, drugs and pharmaceuticals. Subsequently, in 1953 on the initiative of the same firm, the Ministry referred to the Commission the issue of protection to be granted to the groups of dyes manufactured by the Company.

The First Tariff Inquiry into the dyestuff industry was conducted in 1953-54 and in its Report, the Tariff Commission recommended that protection should be granted to the industry for a period of ten years ending 31st December 1964, subject to periodical reviews of the working of protection and the level of protection. The Government accepted this recommendation and protective duties were imposed with effect from 2nd February 1955 on most of the dye groups that were being produced at that time viz. Rapid Fast Colours, Rapidazols, Fast Colour Salts, Solubilised Vat Colours (12 per cent ad valorem) and acid azo dyes, direct azo and sulphur black (20 per cent ad valorem); 20 per cent ad valorem was the maximum rate permissible at that time under the provisions of GATT (protective duty). In 1956 the protective duty on Rapid fast colours, Rapidogens, Rapidazols, Fast

colour salts and solubilised vats were also covered by 20 per cent ad valorem protective duty instead of 12 per cent. This protection continued till December 1964 when a new Inquiry was instituted.

1964 Inquiry

Since the protection granted to the industry was to expire by the end of 1964 a further inquiry into the industry was undertaken during that year. The scope of the inquiry however was widened to include all coal tar dyes. In addition, on reference from the Government, the Commission also examined the question of granting protection to two intermediates manufactured by the Indian Dyestuff Industries Ltd., i.e. beta-amino-anthraquinone and benzanthrone. As per the recommendations of the 1964 enquiry, the 20 per cent ad valorem protective duty on dyestuffs was decided to be continued till December 1967. On Naphthols, fast colour bases and on the two above referred intermediates manufactured at the time, the protective duty was raised, the raised duty varying from 50 to 75 per cent.

On the recommendation of the Tariff Commission the Government granted concessional duties at 10 per cent ad valorem (standard) and nil (preferential) to the thirty specific intermediates mentioned below. Out of the 30 intermediates, 8 were GATT items for which the maximum permissible rate of duty was 10 per cent ad valorem. In

- | | |
|--|-----------------------------------|
| 1) Dinitro-chloro benzene | (16) H-acid |
| 2) O-anisidine | (17) Chicago acid |
| 3) P-anisidine | (18) Gamma acid |
| 4) Alpha-naphthylamine | (19) Para-nitro aniline |
| 5) O-toluidine | (20) Aceto-acetic ester |
| 6) O-tolidine | (21) P-toluidine |
| 7) O-nitro toluene | (22) 3:3 dichloro benzidine |
| 8) Benzidine and benzidine dihydrochloride | (23) C-acid |
| 9) 2:5 dichloro nitro benzene | (24) Aceto-acet-o-toluidine |
| 10) Laurents acid | (25) Aceto-acet-o-chloride |
| 11) O-dichloro benzene | (26) Tobias acid |
| 12) O-nitro-chloro benzene | (27) Phenyl peri acid |
| 13) Meta-dinitro benzene | (28) 2-chloro-4-nitro aniline |
| 14) J-acid urea | (29) Aceto-acet anilide |
| 15) Anthraquinone | (30) P-toluidine-o-sulphonic acid |

August 1965, the tariff rates were rationalized by the Government and excepting for the 8 GATT items, the tariff rates were raised to 40 per cent ad valorem. However, with the devaluation of the rupee on 6th June 1966, these rates were reduced to 27.1/2 per cent. The duty concessions were also extended to some of the alkali and metal salts and other raw materials exclusively used in the manufacture of dyes.

The protection to the dyestuff industry which was to expire in December 1967 was extended till 31st December 1968 on an ad-hoc basis because of the preoccupation of the Tariff Commission with other inquiries.

1968 Report

In its 1968 Report, the Tariff Commission recommended

discontinuance of protection granted to the Dyestuff Industry covered by the Indian Customs Tariff (ICT) item Nos. 30(1)(b)(1), 30(1)(b)(11), 30(15) and 30(16) beyond 31st December 1968. However, since in the foreseeable future the quantitative control over imports was likely to continue, the Commission recommended that the Dyestuff industry may be deemed to be protected within the meaning of Section 11(a) of the Tariff Commission Act, 1951, and be subject to periodical reviews. This recommendation was accepted by the Government of India and accordingly, the latest review was made in 1974 the main recommendations of which could be summarized as follows :

(1) "Government should keep up-to-date the data of capacity and production of dyes in the small scale sector; there should be a 'co-ordinating authority also to study the entire position in the organized sector and the small scale sector as a whole so that the development of both the sectors is planned and pursued on healthy lines'.

(2) Since the capacities in the case of most of the dye-groups are inter-changeable, the industry should plan the production programme in a manner which would ensure the maximum utilization of the available raw materials.

(3) Authorities concerned should work out a realistic estimate of future demand to plan production properly and take steps to augment capacity if necessary.

(4) Producers must ensure a constant and close check on quality.

(5) Dyestuffs manufacturers must take all available steps to ensure economies in their cost of production so that they are not priced out in the competitive international market."

These recommendations are very general in nature and there is nothing new or far-reaching. The Government has accepted these recommendations by a resolution.

It is unfortunate that although this industry witnessed its origin and growth in the era of planned economic development in this country was allowed to grow in a very haphazard manner. The growth of the industry over the years has not followed any planned pattern—the natural law of supply and demand taking its course. As a result, a plethora of small units have come up creating problems. The small units fared well when demand was good and there were no difficulties in raw material supplies. In fact they enjoyed certain advantages when Government's avowed policy of helping small units gave them a better position in respect of imported raw materials. The special consideration shown while giving the imported raw materials gave rise to a large number of bogus units. The author was informed by the Dyestuff Manufacturers' Association that the number of bogus units cannot be easily ascertained but it may be

anywhere around 30 to 40 per cent of the total units reporting in the small scale sector. It was more profitable for these units to sell the imported raw materials at a premium than to produce the final products.

It is only recently with the change in the international picture with regard to the availability of raw materials, particularly intermediates, that many small units, especially those with a weak base, are facing problems. That they have to buy their intermediates from the bigger units is a prospect which they do not like.

The Tariff Commission has not suggested any remedy to this situation. The fact however remains that the small scale sector with around 200 units has come to stay but ultimately the small scale units must be in a position to depend on their own strength. While the large scale units get the advantage of a diversified product-mix in a changing market situation, the smaller units, with their flexibility to change the production pattern and because of their lower overheads, should be in a position to stand on their own.

4.5 Raw Materials and Intermediates

The essential raw materials required by the dyestuff industry are (a) basic coal tar primaries, (b) ancillary chemicals and (c) intermediates.

Coal Tar Primaries : Coal tar primaries are required

for the manufacture of dye intermediates. The most essential basic coal tar primaries required by the industry are benzene, toluene and naphthalene. Now these are also available from petrochemicals. Other coal tar primaries required by the industry are xylene, solvent naphtha, anthracene, phenol/sodium phenate, creasel and xylenol, carbazole and pyridine.

Hindustan Steel Plants at Bhilai, Rourkela, Durgapur are the main producers of basic coal tar primaries. Other producers are Fertilizer Corporation of India, Sindri; Tata Iron and Steel Co. Ltd., Jamshedpur; Indian Iron and Steel Co. Ltd., Burnpur and Durgapur Projects Ltd., Durgapur. During the last four to five years, petro-chemical complexes have emerged as important sources of primary chemicals. National Organic Chemicals, Bombay and Gujarat Refinery have started production of benzene and toluene.

At the time of the 1968 Tariff Inquiry, the Indian Chemical Manufacturers' Association had stated in a written memorandum that the two major hardships felt by the dye-stuff industry were the non-availability of raw materials in adequate quantities and the prevailing high prices.

As the industry registered rapid progress, especially during the Third Plan period, there were shortages of coal tar primaries. The supply of benzene, toluene and naphthalene had fallen short of the requirements of the industry.

At the public inquiry in 1967 also it was pointed out by the dyestuff producers that coal tar primaries, particularly naphthalene and toluene were in considerably short supply. There was also a specific complaint regarding the unduly high price of naphthalene. In this connection it was stated on behalf of Hindustan Steel that its entire output of toluene had been earmarked for Defence.

Since basic coal tar primaries are the main raw materials for the manufacture of dye intermediates, their adequate supply at reasonable prices is important for the proper growth of the dyestuff industry. The Tariff Commission's latest report on the Review of the Dyestuff Industry published in 1974 also mentions the shortages of naphthalene, benzene and toluene. The Indian Chemical Manufacturers' Association attributes the shortages of these basic chemicals to the restrictions imposed on their imports.

4.6 Ancillary Chemicals

Various organic and inorganic chemicals such as caustic potash, soda ash, sulphuric acid, nitric acid, hydrochloric acid, phosphorous trichloride, sodium nitrate, potassium hydroxide and cyanuric chloride are required by the dyestuff industry. Data in respect of capacity, production and imports relating to important chemicals from 1965 to 1967 is given in the Table 4.15.

Table 4.15 : Capacity, Production and Imports of Ancillary Chemicals

| Name of Chemicals | Installed Capacity | (In Tonnes) | | | | | |
|---------------------------|--------------------|-------------|------|------|---------|------|------|
| | | Production | | | Imports | | |
| | | 1965 | 1966 | 1967 | 1965 | 1966 | 1967 |
| 1) Bromine | 265 | 192 | 217 | 150 | 120 | 51 | 42 |
| 2) Phosphoric Trichloride | 420 | 200 | 217 | 161 | N11 | N11 | N11 |
| 3) Aluminium Chloride | 5000 | 79 | 197 | 275 | 174 | 194 | 143 |
| 4) Cyanuric Chloride | 340 | - | 70 | 142 | N11 | N11 | N11 |
| 5) Potassium Hydroxide | - | 400 | 1100 | 400 | 3708 | 2956 | 1846 |
| 6) Sarcosine | - | 26 | 26 | 21 | 28 | - | - |
| 7) Sodium Nitrate | - | - | - | - | 2164 | 2891 | 3154 |
| 8) Chloro-Sulphonic Acid | 13200 | 1100 | 2200 | 2521 | N11 | 28 | N11 |
| 9) Sodium Sulphate | 2960 | 468 | 611 | 587 | 556 | 195 | 3 |

Source: Directorate General of Technical Development.

The above Table reveals large scale under-utilization of capacity in most chemicals. There was no production of Sodium Nitrate and hence the entire requirement of the industry had to be met through imports. The shortages of ancillary chemicals led to sharp rise in the prices of some chemicals required in large quantities by the industry. The Table 4.16 shows the extent of price rise in some of the important chemicals.

Table 4.16 : Rise in Prices of Certain Chemicals

| Name of the Product | Unit | Price in 1964 | Price in 1966 and early 1967 |
|----------------------|--------|---------------|------------------------------|
| 1) Sulphuric Acid | Tonne | Rs. 170 | Rs. 425 |
| 2) Caustic Potash | Tonne | Rs. 2,200 | Rs. 3,150 |
| 3) Sodium bisulphate | 50 kg. | Rs. 35.25 | Rs. 58 |
| 4) Copper Sulphate | 50 kg. | Rs. 125 | Rs. 300 |
| 5) Sulphur Chloride | Tonne | Rs. 2,800 | Rs. 5,000 |
| 6) Oleum-25% | Tonne | Rs. 265 | Rs. 600 |

Lack of steady supplies result in wide fluctuations in the prices of chemicals and as a result the industry cannot work at full capacity.

At the time of the latest Tariff Inquiry in 1973 also manufacturers of Dyestuffs as well as the Indian Chemical Manufacturers' Association stated that some of the ancillary chemicals as well as intermediates were in short supply. The Association was of the opinion that as a matter of policy, the industry should be encouraged to step up production of basic intermediates and chemicals. The availability of the basic chemicals, in its opinion, would lead to larger production of dye-intermediates which in turn would enable the dyestuff manufacturers to utilize their existing capacities more effectively.

4.7 Dye Intermediates

As we have seen in Chapter III, the manufacture of

final dyestuffs is relatively simple compared to the manufacture of intermediates which go into the production of final dyes. Heavy capital investment and more sophisticated technology are required for the manufacture of the dye intermediates.

Till 1960 the dye intermediates industry (as distinct from the dye-stuff industry) was practically non-existent in India. The decade 1960 to 1970 proved very significant in the rapid development of the dye intermediates industry. The Tariff protection which was given to this industry for the first time in 1964 gave it a big fillip. In 1962 the production of 26 intermediates was established in the country and the manufacturing programme of nearly 100 dye-intermediates was at various stages of implementation in the private sector. Further, a plan to manufacture about 30 important intermediates in the public sector at Hindustan Organic Chemicals at Panvel, Maharashtra, was drawn up. Out of the total requirement of over 200 intermediates, 85 intermediates were being produced within the country by 1968. This number rose to 149 by 1971.

The number of units manufacturing dye intermediates was only 13 in 1962 and it increased to 17 in 1971. In addition to this, a number of units in the small scale sector also came into operation to manufacture dye intermediates though precise details about the same are not available.

The annual production of dye intermediates which was practically nil prior to 1960, reached to 7,143 tonnes by 1968. In the next two years, the progress was even more spectacular and the production of intermediates touched a figure of 20,885 tonnes in 1970.

Imports : Although bulk of the intermediates are made within the country today, till quite a few of the more complex (and required in fairly small quantities) intermediates have to be imported to the extent of rupees two to three crores. A summary of the figures relating to the imports of intermediates compiled on the basis of the Monthly Statistics of Foreign Trade of India is given in Table 4.17.

Table 4.17 : Imports of Dye-Intermediates

| Year | Number of Intermediates Imported | Quantity (Tonnes) | Value (Rs. Lakhs) |
|------|----------------------------------|-------------------|-------------------|
| 1972 | 38 | 4753.1 | 212.31 |
| 1973 | 40 | 5365.5 | 279.10 |

Source : Directorate General of Commercial Intelligence and Statistics.

Even these imports are likely to go down in the coming years. Some of the intermediates which are currently being imported could be made locally by 1973-74 as indicated in Table 4.18.

Table 4.18 : Intermediates Likely to be Manufactured by 1973-74

| | | (In Tonnes) |
|---------|---------------------------|--|
| Sr. No. | Item | Recommended licensed capacity by 1973-74 |
| 1) | Anthraquinone | 2,250 |
| 2) | Betanaphthol | 1,578 |
| 3) | Dianisidine | 38.7 |
| 4) | Diethyl-m-amino phenol | 82 |
| 5) | Dimethylaniline | 316.3 |
| 6) | 2:4-dinitrochloro benzene | 1,167 |
| 7) | J-Acid | 152 |
| 8) | m-nitrobenzene | 304 |
| 9) | O-anisidine | 247 |
| 10) | o-tolidine | 147 |
| 11) | o-toluidine | 270 |
| 12) | p-anisidine | 68 |
| 13) | Tobias Acid | 368 |

Source : Directorate General of Technical Development.

The Table 4.19 gives the list of intermediates whose consumption exceeded 10 tonnes in 1967 and indigenous production in the same year.

4.8 Present Status

The industry is divided into three groups: large, medium and small. There are about half a dozen large units in the organized sector; 15 to 20 units in the medium sector and more than 120 in the small scale sector. The

**Table 4.19 : Intermediates Whose Consumption Exceeded
10 Tonnes in 1967**

| Sr. No. | Name of the Intermediate | (In Tonnes) | |
|------------|-----------------------------------|-----------------------|----------------------|
| | | Consumption (1967) | Production (1967) |
| 1) | Di-nitro-chloro-benzene | 1,300 | - |
| 2) | Beta-Naphthol | 1,200 | - |
| 3) | Anthraquinone | 1,200 | 1 |
| 4) | BON Acid | 700 | 501 |
| 5) | Benzanthrone | 430 | 480 |
| 6) | Aniline | 400 | - |
| 7) | Nitrobenzene | 400 | 250 |
| 8) | Beta amino anthraquinone | 350 | 355 |
| 9) | Phthalic anhydride | 350 | - |
| 10) | Dimethylaniline | 300 | - |
| 11) | Metanilic acid | 220 | 70 |
| 12) | Aceto-acet-ester | 175 | - |
| 13) | Diamino Stilbene disulphonic acid | 170 | 171 |
| 14) | O-anisidine | 140 | 31 |
| 15) | Alpha naphthylamine | 125 | - |
| 16) | p-toluidine | 125 | 8 |
| 17) | Di-nitrostilbene disulphonic acid | 109 | 109 |
| 18) | Sodium naphthionate | 100 | 140 |
| 19) | Naphthionic acid | | |
| 20) | O-toluidine | 100 | 17 |
| 21) | O-tolidine | 100 | - |
| 22) | Dichloro-nitro-benzene | 100 | - |
| 23) | Monochlorobenzene | 95 | - |
| 24) | H-acid | 90 | 91 |
| 25) | Tobias Acid | 90 | 39 |
| 26) | Para nitro toluene sulphonic acid | 90 | 90 |
| 27) | Benzidine | 80 | - |
| 28) | Phenol | 75 | - |

(continued)

Table 4.19 : (continued)

| Sr. No. | Name of the Intermediate | Consumption (1967) | Production (1967) |
|---------|---|--------------------|-------------------|
| 29) | M-nitro-aniline | 70 | 17 |
| 30) | Aceto-acet-anilide | 70 | 4 |
| 31) | Meta-di-nitro benzene | 68 | - |
| 32) | Amino anthraquinone | 65 | 62 |
| 33) | Ortho nitro chloro benzene | 64 | - |
| 34) | Meta nitro para toluidine | 60 | 51 |
| 35) | Nitro-toluene | 60 | - |
| 36) | P-nitro-toluene | 50 | - |
| 37) | 3:3 Dichloro-benzene | 50 | - |
| 38) | Diphenylamine | 50 | - |
| 39) | 4-chloro-2-nitro-anisole | 49 | 47 |
| 40) | Sodium phenate | 48 | 48 |
| 41) | Sulphanilic acid | 40 | 205 |
| 42) | Aceto-acet-o-chloro anilide | 40 | 2 |
| 43) | O-chloro-p-nitro-aniline | 40 | - |
| 44) | 4-chloro-2-anisidine | 36 | 36 |
| 45) | Para-dichloro-benzene | 36 | - |
| 46) | P-anisidine | 35 | 13 |
| 47) | Diethyl-m-amino-phenol | 31 | 31 |
| 48) | Ortho nitro anisole | 30 | 30 |
| 49) | 1-chloro anthraquinone | 28 | 28 |
| 50) | Phenyl J Acid | 28 | 18 |
| 51) | Anthraquinone-sulphonic acid sodium salt | 27 | 27 |
| 52) | O-nitro-toluene | 25 | - |
| 53) | Para-toluidine meta sulphonic acid | 25 | 11 |
| 54) | p-chloro-o-nitro aniline (4-chloro-2-nitro aniline) | 25 | 10 |
| 55) | Amino iso G. Acid | 24 | 24 |
| 56) | Gamma acid | 22 | 11 |
| 57) | Meta phenyl dismine | 22 | 10 |

(continued)

Table 4.19 : (continued)

| Sr. No. | Name of the Intermediate | Consumption (1967) | Production (1967) |
|---------|---|--------------------|-------------------|
| 58) | P amino aro benzene | 22 | 1 |
| 59) | 2-chloro 5-toluidine 4-sulphonic acid | 22 | 4 |
| 60) | G. Salt | 20 | 36 |
| 61) | J. Acid | 20 | 14 |
| 62) | M-chloro-nitro benzene | 20 | - |
| 63) | Metanitro chloro benzene | 20 | - |
| 64) | 2-nitro-4-chloro toluene | 20 | - |
| 65) | 1:5 diamino anthraquinone | 19 | 19 |
| 66) | 5-chloro-ortho-toluidine | 19 | 19 |
| 67) | Mono methyl amine | 19 | - |
| 68) | Peri acid | 18 | 18 |
| 69) | Trichloro benzene | 18 | - |
| 70) | Chicago acid | 17 | 10 |
| 71) | Para nitro anisole | 17 | 17 |
| 72) | 2:5 dimethyl-4-chloro-phenyl thioglycollic acid | 17 | 17 |
| 73) | 2:6 diaminoanthraquinone | 16 | 16 |
| 74) | H.W. Acid | 16 | 4 |
| 75) | Aceto-acet-o-toluidine | 15 | 1 |
| 76) | Di-ethyl aniline | 15 | 1 |
| 77) | 4-chloro ortho toluidine | 15 | 15 |
| 78) | 1:4 diamino anthraquinone | 14 | 14 |
| 79) | Benzoyl J. acid | 14 | 2 |
| 80) | Mono-chloro-para-xylene | 14 | - |
| 81) | Rhoduline acid (di-J-acid) | 13 | 14 |
| 82) | M-chloro-aniline | 12 | 14 |
| 83) | Phenylmethyl pyrazolone | 12 | - |
| 84) | 1 amino-6-nitro 2 naphthol 4-sulphonic acid | 11 | 11 |

(continued)

Table 4.19 : (continued)

| Sr. No. | Name of the Intermediate | Consumption (1967) | Production (1967) |
|---------|-------------------------------------|--------------------|-------------------|
| 85) | J. Acid urea | 10 | 9 |
| 86) | 2:5 dichloro-aniline | 10 | 10 |
| 87) | O-chloro-aniline | 10 | 10 |
| 88) | 1-amino-2-naphthol-4-sulphonic acid | 10 | 10 |
| 89) | 4-toluidine-3-sulphonic acid | 10 | - |
| 90) | Benzidine dihydrochloride | 10 | - |
| 91) | Para nitro chloro benzene | 22 | - |
| 92) | 2:5 dichloro nitro benzene | 28 | - |

Source : Tariff Commission Report on Dyestuff Industry (1968).

large scale units and some of the medium scale units manufacture intermediates for captive consumption as well as for supply to the market; mainly to the small-scale units. The small scale units manufacture a few items according to demand starting from the penultimate stage. The industry, therefore, has progressed more or less in a balanced manner although regionwise it is concentrated in the western part of the country, mainly because of the location of the textile industry.

The industry still depends to a considerable extent on import of raw materials. The volume of imports differs from one group of dyestuffs to another. Capital equipment

for the production of most of the groups is now largely indigenous and imports are confined to certain special types only. The government has reserved the development of basic dyes and azo dyes for the small scale sector.

4.9 Scope for Expansion

The scope for expansion during the Fifth Plan is in terms of the following categories: Mordant dyes (excluding acid and direct), disperse dyes, fast colour bases, naphthols, optical whitening agents, reactive dyes, sulphur dyes and vat dyes.

The Ministry of Industrial Development envisages development in respect of various groups of dyestuffs. Some of these are :

(1) Basic Dyes : Basic dyes have the widest range of uses of any class of dyes. They can be dyed and printed on all the natural fibres as they have direct affinity for wool and silk and are dyed on cotton. Basic dyes are also used in the dyeing of leather, sheep skins and furs and for colouring paper. Many of their free bases are used as solvent dyes.

There are six units producing around 700 tonnes. Imports during 1971-72 were 57 tonnes worth Rs. 18 lakhs. The total capacity approved is 1012 tonnes. On the basis of 1978-79 demand estimated by the Directorate General of

Technical Development (DGTD) at 1,000 tonnes, there is not much scope for approving additional capacity. The exports of basic dyes are picking up. In 1971-72 these amounted to Rs. 21.83 lakhs which went up to Rs. 39.72 lakhs in the subsequent year.

(2) Acrylic Fibre Dyes : The demand for acrylic fibre dyes is rather limited. There is no indigenous production of this group of dyestuffs and it is being imported for meeting actual user requirements. A capacity of 720 tonnes per year has been approved of which a capacity of about 500 tonnes is expected to be implemented by 1975. Additionally, a capacity of 100 tonnes has been reserved for development in the small scale sector. The demand for 1978-79, according to the DGTD, will be 900 tonnes per year corresponding to an installed capacity of about 1,100 tonnes. The Ministry thinks that there is scope for considering proposals for additional capacity. However, the dependence on imports for bulk of the raw materials is a constraint at present.

(3) Azo Dyes : These are mostly used for textile printing. There are seven units with a production of 2,500 tonnes per annum. Imports during 1971-72 have been 124 tonnes, valued at about Rs. 36 lakhs. Exports in 1972-73 were Rs.26.3 lakhs as against Rs.21.19 lakhs in 1971-72.

A capacity of 3,480 tonnes has so far been installed.

The balance is also expected to materialize shortly. This would by and large meet the 1978-79 demand estimated by the DGTD at 4,000 tonnes. There is marginal scope for mordant dyes. Further development of this group is reserved for the small scale sector.

(4) Disperse Dyes : Disperse dyes are mainly used for the dyeing of cellulose acetate fibre and nylon. These dyes can be used for the coloration of polyester and other synthetic fibres as also for the surface dyeing of thermoplastics. These dyes are also widely used for the production of level pasted shades on woolled sheepskins and furs and have been used for colouring swan pelts.

There are five units producing about 235 tonnes of disperse dyes. Imports were 180 tonnes during 1970-71 worth Rs. 81 lakhs. In the subsequent year the imports declined to 112 tonnes valued at Rs. 49 lakhs. Exports of disperse dyes have gone up from Rs. 2.12 lakhs in 1971-72 to Rs.10.60 lakhs in 1972-73.

The total capacity approved in this field so far amounts to 929 tonnes of which about 500 tonnes has been installed. According an assessment by the DGTD, the demand by 1978-79 will be 1,200 tonnes. This would require an installed capacity of 1,500 tonnes per year. There is, therefore, scope for establishing additional capacity for disperse dyes.

(5) Fast Colour Bases : There are seven units with an annual production of 1,000 tonnes. Imports during 1971-72 have been 65 tonnes. The capacity of 1,348 tonnes so far approved has been installed. The DGTD has estimated that the demand by 1978-79 for fast colour bases will be 1,700 tonnes. Thus there is scope for setting up additional capacity.

(6) Naphthols : There are five units accounting for annual production of about 1,330 tonnes. The installed capacity is being utilized fully. There were imports of 83 tonnes in 1971-72 valued at Rs. 41 lakhs. The demand by 1978-79 is estimated at 2,000 tonnes. This would require an installed capacity somewhat in excess of this level. Thus there is scope for the establishment of additional capacity.

(7) Vat Dyes : The main use of solubilised vat dyes on cotton or rayon is for the production of level pale shades on piece goods, for yarns in package form and for materials difficult to penetrate.

There are seven units manufacturing vat dyes with an annual production of about 1,134 tonnes. Imports in 1971-72 were 187 tonnes, valued at Rs. 1.13 crores. Vat dyes are a big item in exports. In 1971-72, these exports were for the value of Rs. 48.91 lakhs, which went up to Rs. 80.55 lakhs in 1972-73.

Against a total capacity of 2,283 tonnes approved in this item, 1,441 tonnes capacity has already been installed. The balance capacity is under implementation. The DGTD has estimated the demand by 1978-79 at 2,200 tonnes. The scope for additional capacity for vat dyes is, therefore, marginal.

(8) Sulphur Dyes : Sulphur dyes are widely used for dyeing cellulose in most of its textile forms. They find their primary use on cotton but can be applied just as satisfactorily to loose viscose rayon and viscose yarn. All types are suitable for linen, flax and jute. Sulphur dyes are also used on material to be given a resin finish. A slight change in hue is noticeable afterwards.

There are four units with a production of 1,600 tonnes per year. In 1971-72 the imports were 76 tonnes valued at Rs. 13 lakhs. The export of sulphur dyes was of the value of Rs. 27.43 lakhs in 1971-72 which went up to Rs. 51.29 lakhs in 1972-73. The capacity requirement would be 3,000 tonnes by 1978-79. Hence there is scope for establishment of further capacity.

(9) Reactive Dyes : The reactive dyes are a new usage group and were marketed first in 1956. These dyes give very bright shades. The versatility of reactive dyes in methods of application and in the dyeing and printing effects that can be produced has resulted in a very rapid expansion of ranges.

There are five units with an annual production of about 800 tonnes. In 1971-72 there were imports of 37 tonnes. The exports of reactive dyes have gone up from Rs. 11.14 lakhs in 1971-72 to Rs. 24.28 lakhs in 1972-73.

Against a total capacity of 1,570 tonnes so far approved in this field, 845 tonnes have been installed. The installed capacity is expected to increase to 1,400 tonnes by 1975. The demand by 1978-79 is estimated at 1,500 tonnes. The additional capacity needed therefore would be marginal.

(10) Organic Pigment Colours : There are nine units in this group accounting for an annual production of 1,600 tonnes. Imports in 1971-72 were 59 tonnes valued at Rs. 31 lakhs. Out of a capacity of 3,507 tonnes so far approved, 2,857 tonnes has been established. The rest of the capacity is under various stages of progress. The demand by 1978-79 is estimated at 2,500 tonnes. The Ministry has decided that proposals for production of special ranges which are not in the manufacturing programme of the existing factories will be considered on merits.

(11) Optical Whitening Agents: There are six units with an annual production of about 800 tonnes and installed capacity of 845 tonnes. Imports during 1971-72 were 13 tonnes valued at Rs.7 lakhs. The DGTD has estimated that the demand for the optical whitening agents would be 1,500 tonnes by 1978-79. Thus there is a big potential for development of further capacity for this item.

CHAPTER V

INPUT STRUCTURES OF SPECIFIED DYE GROUPS

5.1 Stability of Input-Output Coefficients

One of the major controversies in input-output analysis has centered around the original Leontief assumption of constant input coefficients. This implies that over sufficiently long periods, the input coefficients in a particular industry remain stable. Because of this assumption, it is possible to arrive at the proportionate increases in input requirements with a given increase in the capacity of the industry and vice versa. A controversy has raged over this simplifying assumption because it goes against the traditional thinking about production functions. It may not always be realistic to assume that each industry has a production in which all inputs vary proportionately with the industry's output. There are at least four implications of this assumption which are often contradicted by general observation. Firstly, the assumption implies that all inputs are uniformly affected by a change in the scale of production irrespective of whether they are fixed inputs or variable inputs. Also no distinction is made between short run and long run. In reality, however, fixed and variable inputs may be affected disproportionately in the short run and in the long run.

Secondly, the assumption implies that a detailed and very disaggregative industrial classification is possible. It does not take into account the multi-product industries

and the processes leading to joint products. A change in the product-mix of the output of multi-product industries affects the input structure.

Thirdly, it implies that substitution among alternative inputs due to changes in relative prices or availability do not affect the input structures significantly.

And finally, the assumption ignores the changes arising out of technological changes. It means that technological changes in input-structures are not frequent and that they are sufficiently slow so that they can be adjusted in a simple fashion.

All these difficulties, however, need not minimise the utility of working out the input-structures of different industries. After all, the assumption of constant input coefficients can only be regarded as a first approximation to the more complex production functions observed in reality. It is not suggested that non-proportional inputs, changes in product-mix, substitution between inputs and technological changes do not occur. These things do occur. But it should be understood that after-all input coefficients of an industry cannot be constants like the constants of physics. If they do not change at all, economic progress is unlikely. Changes in input coefficients may be caused by:¹

¹ See Anne Grosse and James Duesenberry, *Technological Change and Dynamic Models*, Conference on Research in Income and Wealth, October 1952, Harvard University Mimeo.

- (1) Changes in the processes used to produce a particular product or products;
- (2) Changes in the internal product-mix of the industry group in question; and
- (3) Variations in the input coefficients of plants producing the given products.

Even after considering all these aspects, the question that is really important is how violent are these changes or errors involved in making a simplifying assumption of constant coefficients? The important question is really an empirical one: are the errors involved in the assumption satisfactorily small?²

Here really comes the importance of separate industry studies in inter-industry framework. Since each industry has its own peculiarities, it is useful to study how far one could find out the fair estimates of input requirements of a given industry.

It is also necessary to study the effects of aggregation and disaggregation on the stability of input-output coefficients. It has been observed that aggregation in input-output tables tends to exhibit both the tendencies viz. to make the coefficients more stable as well as to make them more variable. At times the aggregation of the sectors leads to increased stability because the raw

2 For a detailed discussion of this point see Hollis B. Chenery and Paul G. Clark, Interindustry Economics. New York : John Wiley & Sons, Inc., 1964, Chapter 6.

materials which are close substitutes and which are shown as separate inputs get combined. However, when two or more sectors with different coefficients get combined, the aggregate coefficients will be an average of the coefficients of individual sectors. Thus the average will depend on the relative weight of the production in each sector. With a variation in these weights, the average coefficients will vary even when the individual coefficients are stable.³ Thus it is clear that the stability or otherwise of the sectors aggregated will depend on the extent to which the coefficients of the sectors are substitutes or different from each other.

At times a fundamental difficulty is encountered because the commodities which come out as outputs may be substitutes while the inputs going into those commodities may not be substitutes. This has been illustrated by Barna⁴ with the example of cotton and rayon yarn or textiles which are substitutes for the consumers who buy them and hence there may be justification in aggregating the

³ See Per Sevaldson, "The Stability of Input-Output Coefficients," in A. P. Carter and A. Brody. (ed.). Applications in Input-Output Analysis, Vol. 2. Amsterdam: North Holland Publishing Co., 1970, pp. 207-08.

⁴ See Tibor Barna, "Classification and Aggregation in Input-Output Analysis," in Tibor Barna. (ed.). The Structural Interdependence of the Economy.

production of these commodities into a single industry. However, the raw materials used for making cotton yarn are very much different than those used for rayon. The manufacturing processes are also different. This therefore, calls for disaggregating the sectors.

At times, the complexities involved are so great that it becomes extremely difficult to take into account all the inter-relations and alternative combinations of product-mix that can be produced with the same input or a slight variation of the given inputs. This difficulty is often experienced in the organic chemical industries. This is all the more so because even within the same firm, the product-mix may change very fast. This point clearly comes out in the following analysis of the input-structures of the specified dye-groups.

5.2 Inputs and Outputs of Dyestuffs

Organic chemicals such as dyestuffs, pharmaceuticals, etc. are produced by synthesis of basic organic products that are derived from coal, petroleum or natural gas. The basic materials are first converted into hydrocarbons (acetylene, propylene, benzene, etc.) and carbon monoxide. Through diverse processes and complicated synthesis series that pass through many stages and cross one another, higher organic compounds are built up. The number and diversity of these are too large for the structure of input and output

for each specific category to be established. This problem we have already discussed at some length in Chapter III while discussing the nature of the dyestuff industry.

For the same reason statistics on specific products cannot be aggregated by simple addition. Because of the complexity of production and the cross-linkages of different stages of synthesis, double counting cannot be avoided. To illustrate the point, a detailed chart obtained from a large-scale dyestuff unit is presented on the following page which shows the different complex reactions involved in obtaining the different individual dyes within the same product group viz. Vat dyes. Again, it is evident from the chart that many permutations and combinations of product-mix are possible.

Explanation of the Chart in the Language of a Dye Chemist⁵: The following chart shows that Benzene and Phthalic Anhydride in the presence of Aluminium Chloride (Friedelcraft Reaction) give Orthobenzoyl Benzoic Acid (OBB). This is a dye intermediate. This (a) on cyclization with sulphuric acid gives anthraquinone or (b) on condensation with Glycerine gives Benzanthrone both of which are primary intermediates for the manufacture of the Vat Dyes.

⁵ The author is grateful to Shri R. A. Powar, B.Sc.(Tech) in Dye Chemistry for the Chart and the explanation.

Anthraquinone on sulphonation gives various sulpho-nated products and for each sulphonated product, there is a different process. The input-mix of each sulphonated product will also differ. For example, 1-sulphonate and AQ 1:5 Disulphonate require mercury while AQ 2-sulphonate and AQ 2:6 Disulphonate do not require the same. These two products AQ 2 sulphonate and 2:6 Disulphonate on amination give respectively amino compounds viz. 2-amino AQ and 2:6 Diamino AQ. These compounds on alkali fusion give intermediates for respective dyes shown in the chart as Blue BC and Yellow GCN.

The other two sulphonated products viz. 1-Sulphonate and 1:5 Sulphonate can either be Chlorinated or Aminated to get the respective amino or chloro compounds shown in the chart. For example, 1-sulphonate can either be converted to 1-amino 1-chloro or 1-amino 5-chloro Anthraquinone. These compounds are used for the Anthrimides of various dyes such as Olive Green B, Olive P, Brown BR, Brown R and Olive R shown in the chart.

AQ 1:5 Sulphonate in the same way is converted into chloro and amino compounds. For example, 1:5 Dichloro and 1:5 Diamino Anthraquinone. 1:5 Dichloro compound is used for Disperse Dyes only while 1:5 Diamino Anthraquinone is used for the Anthrimides or Orange 3G and Brown R dyes.

Bensanthrone, on bromination gives either (1) Bromo-

benzanthrone or (ii) Di-bromobenzanthrone. Bromobenzanthrone is converted into Violet 4R or Violet 3B dyes by alkali fusion reaction or can be condensed with 1-Amino anthraquinone to get Anthrimide for Olive Green B which on cyclization gives Olive Green B dye. On the other hand, Di-Bromobenzanthrone on condensation with 1-Amino Anthraquinone gives Anthrimide for Olive T which on cyclization gives Olive T Dye.

Benzanthrone on Alkali Fusion gives either (a) Di-Benzanthronyl or (b) Di-Benzanthrone. Di-Benzanthronyl on Oxidation and Methylation gives various green dyes, e.g., Green FFB, Green 2G and Green IB. Di-Benzanthrone on Nitration and Chlorosulphonation gives Black CR, Black BB or Blue BR.

The various final dyes and intermediates and indigosols mentioned at the left hand side of the chart at the bottom are the final products coming from the various reactions shown in the chart. These are the marketable products of the Company.

The complexity of production and the cross-linkages of different stages of synthesis, impose severe constraints on the extent to which we can reasonably go towards disaggregation. The second and the still greater difficulty is the limitations to accurate data. Even if a country had at its disposal a highly refined statistical mechanism,

certain limits would be set to the statistical exploration of the Chemical Industry, if realistic and reasonable description is preferred to a theoretically perfect approach. Such limits, as explained earlier, are due to the technical and economic peculiarities of the complex pattern of chemical production. They may be either narrow or wide, depending on the individual country. In the United States, for instance, the breadth of the market and the resultant strong specialization of technical and economic activities seem to have had the effect of promoting statistical refinement. Another factor, which is not to be under-estimated, the open-mindedness of enterprises in regard to statistics and their interest in statistical results, attitudes which have gradually developed in the United States industries. The improvements achieved during the last 50 years seem to confirm the importance of this attitude.

In India the people in the chemical industry are very secretive as has been already stated in Chapter I. Data could not be had at a more disaggregative level than a dye-group. Some of the people in the industry, though helpful felt that such an exercise of going beyond a product group towards disaggregation would not be worthwhile nor possible because of the endless chain of permutations and combinations theoretically possible and where one often tended to commit the error of double counting.

In fact M/s. Atul Products Ltd., the largest Dyestuffs and Intermediates unit in the country, have now installed a computer to work out the different permutations and combinations possible to enable them to achieve optimum plant utilization and returns.

To illustrate the point, the Technical Manager of a Dyestuff Plant gave the example of the input structure of ten different individual dyes belonging to the Vat Group manufactured in his plant. The example is presented in Table 5.1. Since the market values of final products could not be available, gross input coefficients have been presented against the total value of raw materials consumed. In this Table, input coefficients of ten individual dyes are given in columns 1 to 10 while column 11 gives the input-structure for the entire product range of 10 dyes. At the bottom of the Table, weightages of individual dyes are given. These weights change with any change in the quantities of individual dyes produced and consequently, the input-structure is affected. By looking at the Table, one would be surprised to see that while such an important basic chemical as soda ash figures as an input in Green FB, it is not seen in any other colour. When the author inquired about this with the Technical Manager, it was revealed that soda ash is already figuring as one of the inputs in the intermediates that are used as inputs in other colours and

Table 5.1 : Input Structures of Ten Different Dyes Belonging to the Group Vat Dyes Manufactured by the Same Firm

| Inputs (1) | Blue BC (2) | Green FB (3) | Orange 3G (4) | Green 2G (5) | Brown R (6) | Olive R (7) | Yellow GCN (8) | Magenta B (9) | Black CH (10) | Violet 4 R (11) | Input structure for all Vat dye group (12) |
|---|-------------------|--------------------|---------------------|--------------------|-------------------|-------------------|----------------------|---------------------|---------------------|-----------------------|---|
| 1. Indanthrone | .5576559 | | | | | | | | | | .0373985 |
| 2. 98% H ₂ SO ₄ | .3189981 | .1136112 | .1079169 | .0238329 | .0783110 | .1126760 | .0591299 | | | .0511415 | .07477020 |
| 3. Manganese Dioxide | .0022054 | | | | | | | | | | .0001479 |
| 4. Chlorine | .0055135 | | | | | | | | | | .0003697 |
| 5. 20% Oleum | .0866989 | | .0181398 | .0158863 | | | | | .0168929 | | .0108392 |
| 6. Aluminium | .0103969 | | | | | | | | | | .0006972 |
| 7. Tricresol | .0151228 | | | | | | | | | | .0010141 |
| 8. Tamol | .0031505 | | | | | | | | | | .0002112 |
| 9. Crude Green | | .8852821 | | .49493813 | | | | | | | .1757944 |
| 10. Soda Ash | | .0001844 | | | | | | | | | .0000211 |
| 11. Idet | | .0009221 | | | | | | | | | .0001056 |
| 12. Anthrimide | | | .5073020 | | .814680 | | | | | | .0871577 |
| 13. Sodium Dichromate | | | .3681781 | | | | | | | | .0251965 |
| 14. Sodium Chlorate | | | | | .1069782 | .2615694 | | | | | .0089270 |
| 15. Sodium Bisulphite | | | | .0002812 | | | | | | | .0000422 |
| 16. Sodium Nitrite | | | | .1898200 | | | | | | | .0002825 |
| 17. Bromine | | | | .4631608 | | | | .0341813 | | | .0728215 |
| 18. Dibenzyl Diamthrimide | | | | | | .8611670 | | | | | .0678245 |
| 19. Sodium Hypochlorate | | | | | | | .6742215 | | | | .1011980 |
| 20. NaOH | | | | | | | .0004927 | .0026896 | | | .0003275 |
| 21. Chloro Sulphonic Acid | | | | | | | | .1226045 | .3227895 | | .0389410 |
| 22. Dibenzanthrone | | | | | | | | | .6410958 | | .0543864 |
| 23. 2:5 Dimethyl-4-Chloro Thioglycolic Acid | | | | | | | | .8405244 | | | .0792342 |
| 24. Intermediate for Yellow GCN | | | | | | | .2660847 | | | | .0399340 |
| 25. HNO ₃ | | | | | | | | | .0197775 | | .0016903 |
| 26. Isoviolanthrone | | | | | | | | | | .26567040 | .0338066 |
| 27. Sulphurlyl Chloride | | | | | | | | | | .6294728 | .0801005 |
| 28. Pyridine | | | | | | | | | | .0537152 | .0068352 |
| Weights | .0670639 | .1145622 | .0687225 | .1502704 | .0641903 | .0787588 | .1500802 | .0942676 | .0848335 | .1272502 | |

Source : Case Study Data.

that at so stage, soda ash has entered in the inputs of each dye. He however agreed that even after taking into account such factors, there is variability in the input structures even within the same product-group depending upon the product range manufactured at a point of time.

To illustrate this point, the input-structures of four different groups of dyes are studied with the help of the field survey data collected from nine different firms of varying sizes. The dye-groups studied are :

- (1) Azo Dyes - for 3 firms (F-1, F-2, F-3)
- (2) Organic Pigment Colours - for 2 firms (F-4 and F-5)
- (3) Reactive Dyes - for 2 firms (F-6 and F-7)
- (4) Fast Colour Bases- for 2 firms (F-8 and F-9)

The raw material inputs have been suitably aggregated in consultation with a chemist into 26 groups to bring them to manageable proportions.

The inter-firm comparisons of flow-coefficients are presented in the Tables 5.2 to 5.5.

It is obvious from these Tables that even for the same groups of dyes produced by different firms, there is considerable variation in the flow-coefficients. This is apparently because of all the causes enumerated above such as differences in product range, substitutability of inputs, linkages and cross-linkages, etc. Perhaps a better

Table 5.2 : Azo Dyes

| | Inputs per rupee worth of final product | | |
|-------------------------------------|--|-----------|-----------|
| | Firm F-1 | Firm F-2 | Firm F-3 |
| <u>ORGANIC CHEMICALS</u> | | | |
| <u>(i) Aliphatics</u> | | | |
| 1. Organic Acids | .0039036 | .0009837 | .0008395 |
| 2. Aldehydes | .0003867 | .0003443 | .0005066 |
| 3. Ketones | .0003317 | .0002387 | - |
| 4. Solvents | .0010288 | .0001171 | .0032110 |
| 5. Esters | - | - | - |
| 6. Amines | .0000428 | - | - |
| 7. Others | .0095660 | .0053350 | .0405194 |
| <u>(ii) Aromatics</u> | | | |
| 8. Benzene Derivatives | .2394760 | .1763242 | .2781751 |
| 9. Naphthalene " | .2338500 | .1045335 | .0973618 |
| 10. Anthracene " | - | - | - |
| <u>(iii) Heterocyclics</u> | | | |
| 11. Pyrazolones | .0031404 | .0103052 | .0018627 |
| <u>INORGANIC CHEMICALS</u> | | | |
| 12. Inorganic Acids | .0023537 | .0088117 | .00286731 |
| 13. Sodium Hydroxide) | .0122440 | .0183586 | .0147648 |
| " Carbonate) | | | |
| " Bicarbonate) | | | |
| 14. Potassium Hydroxide) | .0012945 | .0075391 | .0019187 |
| " Carbonate) | | | |
| 15. Calcium Carbonate | - | - | - |
| 16. Sodium Chloride) | .0106214 | .0162981 | .0149851 |
| Vacuum salt) | | | |
| Sodium Sulphate) | | | |
| 17. Potassium Chloride) | .0001886 | .00102399 | - |
| " Sulphate) | | | |
| 18. Ammonium Chloride) | .0000028 | - | - |
| " Sulphate) | | | |
| 19. Copper Sulphate | .0002079 | .0002790 | - |
| 20. Chlorine, Bromine and Iodine | .0004248 | .0027401 | - |
| 21. Zinc Chloride, Metals, etc. | - | .0005866 | - |
| 22. Sodium Bisulphite) | .0006154 | .0001370 | - |
| Sodium Bisulphate) | | | |
| 23. Sodium Nitrite | .0020401 | .0196887 | .0024449 |
| 24. Other inorganic chemicals | .0181364 | .0356503 | .0068609 |
| <u>OTHERS</u> | | | |
| 25. Binders, Dispersing Agents | .0008486 | .0025488 | .0009550 |
| 26. Final Products | .0566302 | .0008496 | .0004099 |

Table 5.3 : Organic Pigment Colours

| | Inputs per rupee worth of final product | |
|--|--|----------|
| | Firm F-4 | Firm F-5 |
| <u>ORGANIC CHEMICALS</u> | | |
| <u>(i) Aliphatics</u> | | |
| 1. Organic Acids | .0277289 | .0230684 |
| 2. Aldehydes | - | - |
| 3. Ketones | - | - |
| 4. Solvents | - | - |
| 5. Esters | - | - |
| 6. Amines | - | - |
| 7. Others | - | .0003358 |
| <u>(ii) Aromatics</u> | | |
| 8. Benzene Derivatives | .3358360 | .2454820 |
| 9. Naphthalene Derivatives | .0682788 | .0445554 |
| 10. Anthracene Derivatives | - | - |
| <u>(iii) Heterocyclics</u> | | |
| 11. Pyrazolones | .0109959 | .0092121 |
| <u>INORGANIC CHEMICALS</u> | | |
| 12. Inorganic Acids | .0309488 | .0227404 |
| 13. Sodium Hydroxide) Sodium Carbonate) Sodium Bicarbonate) | .0124869 | .0103154 |
| 14. Potassium Hydroxide) Potassium Carbonate) | - | - |
| 15. Calcium Carbonate | .0020997 | .0002531 |
| 16. Sodium Chloride) Vacuum Salt) Sodium Sulphate) | .0051850 | .0023333 |
| 17. Potassium Chloride) Potassium Sulphate) | - | - |
| 18. Ammonium Chloride) Ammonium Sulphate) | - | - |
| 19. Copper Sulphate | - | - |
| 20. Chlorine, Bromine, Iodine | .0006156 | .0003964 |
| 21. Zinc Chloride, Metals, etc. | - | - |
| 22. Sodium Bisulphite) Sodium Bisulphate) | .0011210 | .0008274 |
| 23. Sodium Nitrite | .0185731 | .0201354 |
| 24. Other inorganic chemicals | .0515660 | .0459869 |
| <u>OTHERS</u> | | |
| 25. Binders, Dispersing Agents | .0148869 | .0091358 |
| 26. Final Products | .0440352 | .0383945 |

Table 5.4 : Reactive Dyes

| | Inputs per rupee worth of final product | |
|---------------------------------|--|----------|
| | Firm F-6 | Firm F-7 |
| <u>ORGANIC CHEMICALS</u> | | |
| <u>(i) Aliphatics</u> | | |
| 1. Organic Acids | - | .0004627 |
| 2. Aldehydes | - | - |
| 3. Ketones | - | - |
| 4. Solvents | - | - |
| 5. Esters | .2357880 | - |
| 6. Amines | - | - |
| 7. Others | .0152387 | .1423108 |
| <u>(ii) Aromatics</u> | | |
| 8. Benzene Derivatives | - | .1203013 |
| 9. Naphthalene Derivatives | .0846747 | .0013476 |
| 10. Anthracene Derivatives | - | - |
| <u>(iii) Heterocyclics</u> | | |
| 11. Pyrazolones | .01264388 | .0094946 |
| <u>INORGANIC CHEMICALS</u> | | |
| 12. Inorganic Acids | .0004227 | .0030891 |
| 13. Sodium Hydroxide) | .0027325 | .0181328 |
| " Carbonate) | | |
| " Bicarbonate) | - | - |
| 14. Potassium Hydroxide) | | |
| " Carbonate) | | |
| 15. Calcium Carbonate | - | - |
| 16. Sodium Chloride) | .0129836 | .0097144 |
| Vacuum Salt) | | |
| Sodium Sulphate) | - | .0051877 |
| 17. Potassium Chloride) | | |
| " Sulphate) | | |
| 18. Ammonium Chloride) | - | - |
| " Sulphate) | | |
| 19. Copper Sulphate | - | .0071727 |
| 20. Chlorine, Bromine, Iodine | - | - |
| 21. Zinc Chloride, Metals, etc. | - | - |
| 22. Sodium Bisulphite) | - | .0017495 |
| " Bisulphate) | | |
| 23. Sodium Nitrite | .0043458 | .0017982 |
| 24. Other inorganic chemicals | .00389404 | .0072580 |
| <u>OTHERS</u> | | |
| 25. Binders, Dispersing Agents | - | .0001136 |
| 26. Final Products | - | .0922678 |

Table 5.5 : Fast Colour Bases

| | Inputs per rupee worth of final product | |
|---------------------------------|--|----------|
| | Firm F-8 | Firm F-9 |
| ORGANIC CHEMICALS | | |
| (i) Aliphatics | | |
| 1. Organic Acids | .0128034 | .0985126 |
| 2. Aldehydes | - | - |
| 3. Ketones | .0022595 | .0023524 |
| 4. Solvents | .0068469 | .0072044 |
| 5. Esters | - | .0000499 |
| 6. Amines | .0014111 | .0013002 |
| 7. Others | .0314724 | - |
| (ii) Aromatics | | |
| 8. Benzene Derivatives | .2887758 | .2312130 |
| 9. Naphthalene Derivatives | .0042553 | .0061538 |
| 10. Anthracene Derivatives | - | - |
| (iii) Heterocyclics | | |
| 11. Pyrozolones | - | - |
| INORGANIC CHEMICALS | | |
| 12. Inorganic Acids | .0414964 | .0407638 |
| 13. Sodium Hydroxide) | .0201290 | .0197709 |
| " Carbonate) | | |
| " Bicarbonate) | | |
| 14. Potassium Hydroxide) | .0004589 | .0003988 |
| " Carbonate) | | |
| 15. Calcium Carbonate | .0000108 | .0005347 |
| 16. Sodium Chloride) | .0038389 | .0032946 |
| " Sulphate) | | |
| Vacuum Salt) | | |
| 17. Potassium Chloride) | - | - |
| " Sulphate) | | |
| 18. Ammonium Chloride) | - | - |
| " Sulphate) | | |
| 19. Copper Sulphate | - | .0000299 |
| 20. Chlorine, Bromine, Iodine | .0006695 | .0006622 |
| 21. Zinc Chloride, Metals, etc. | - | - |
| 22. Sodium Bisulphite) | .0010830 | .0005347 |
| " Bisulphate) | | |
| 23. Sodium Nitrite | .0072463 | .0067530 |
| 24. Other inorganic chemicals | .0170463 | .0170433 |
| OTHERS | | |
| 25. Binders, Dispersing Agents | .0004040 | .0004750 |
| 26. Final Products | .0009111 | .0012232 |

approximation of the input coefficients of different dye groups can be arrived at by giving the average results by combining the data of a number of firms.

We find however that at a greater level of aggregation for the industry as a whole, we get fairly stable input coefficients as we shall see in Chapter VI.

In the Appendix to this chapter, the flow coefficients for some important groups of dyes are presented at a detailed disaggregative level which are computed from the field survey data.

The detailed disaggregative flow-coefficients presented in the appendix to this chapter will give some idea of the variability of coefficients between different product-groups. With such variability and interdependability, the disaggregated input coefficients become very much dependent on the product-mix of a particular moment. And as the product-mix is changing very fast, even in the same firm, it is not possible to find fairly stable disaggregative input coefficients. Further, it cannot be maintained that you can reach more stability by further disaggregation because of highly inter-connected joint production, as exemplified in the chart earlier. We therefore are led to two conclusions: (1) There is a limit to meaningful disaggregation in chemical industries beyond which it starts becoming counterproductive. (2) Even with those

disaggregated industries, unless and until their product-mix is fairly constant, it is not possible to get stable input structure in a very disaggregative way.

5.3 Variations in Value Added

This can be partly explained by the fact that there is a considerable diversity in the degree to which the various components of the chemical industry add value by manufacturing. The relatively simple processes employed in the basic chemical division implies that value added is low compared to the total value of the commodity. On the other hand, the fine chemical group, e.g., pharmaceuticals, add considerable value to the raw material through many complex operations.⁶

With a change in the product-mix, the value added by manufacture by each group as a percentage of total value added changes not only between firms but also within the same firm for different dye groups. This in fact is an extension of what we have said above viz. value added differs between basic chemicals, fine chemicals, etc. This is because, the processes involved in the manufacture of some dyes are relatively simple while for others, they are more complex involving more stages of reactions. This is amply illustrated in Table 5.6 which gives the groupwise

⁶ See Stanley Vance, Industrial Structure and Policy. Englewood Cliffs, N.J.: Prentice Hall, Inc., 1961. p. 266.

Table 5.6 : Value Added by Manufacturing — Groupwise and Firmwise Comparisons

| Firm | Product Group | Value of Production (Rs.) | Value of Raw Materials* Consumed (Rs.) | Value Added (Rs.) | Value added as % of value of production | Average % value added for the total produc- tion of the firm |
|------|--------------------------------|------------------------------|--|------------------------|---|--|
| 1 | 2 | 3 | 4 | 5 = (3 - 4) | 6 = 5/3 x 100 | |
| X-1 | Azo Dyes | 2,49,37,238 | 1,87,71,772 | 61,65,466 | 24.72 | 39.32 |
| | Fast Colour Bases | 92,18,659 | 66,77,092 | 25,41,567 | 27.57 | |
| | Sulphur Black | 83,85,644 (92687994) | 26,80,272 (5623686) | 57,05,372 (36451133) | 68.04 | |
| | Naphthols | 1,30,64,213 | 68,03,273 | 62,60,940 | 47.92 | |
| | Intermediates | 3,70,82,240 | 2,13,04,452 | 1,57,77,788 | 42.55 | |
| X-2 | Vat Dyes | 8,72,00,102 | 2,03,08,422 | 6,68,91,680 | 76.71 | 74.90 |
| | Disperse Dyes | 33,16,482 (173475564) | 6,83,357 (43529871) | 26,32,915 (129945713) | 79.39 | |
| | Intermediates | 8,29,59,000 | 2,25,37,882 | 6,04,21,118 | 72.83 | |
| X-3 | Organic Pigments | 1,22,96,000 | 82,55,897 | 40,40,103 | 32.85 | 50.39 |
| | Pigment Emulsions | 2,58,76,000 | 1,07,55,426 | 1,51,20,574 | 58.43 | |
| | Synthetic Resin Binders | 2,07,53,000 (60480000) | 1,05,69,208 (30004586) | 1,01,83,792 (30475414) | 49.07 | |
| | Synthetic Organic Dyestuffs | 15,55,000 | 4,24,055 | 11,30,945 | 72.73 | |
| X-4 | Sulphur Black | 27,07,000 | 14,89,173 | 12,17,827 | 44.98 | 44.94 |
| | Food Colours | 12,33,000 (9945000) | 5,31,138 (547555) | 7,01,862 (4469449) | 56.92 | |
| | Optical Bleaching Agents | 21,12,000 | 8,57,250 | 12,54,750 | 59.41 | |
| | Intermediates | 38,93,000 | 25,97,990 | 12,95,010 | 33.26 | |
| X-5 | Organic Pigments | 1,35,36,272 | 1,00,99,741 | 34,36,531 | 25.39 | 27.66 |
| | Inorganic Pigments | 1,09,14,315 (24450587) | 75,88,000 (17687741) | 33,26,315 (6762846) | 30.47 | |

* Exclusive of fuels, power and labour.

Figures in brackets give the totals for all the groups.

Source : Field Survey Data.

and firmwise comparisons of value added by manufacture for the selected firms. It will be seen that the proportion of value added in the different groups studied varies very much even within the same firm, e.g., in firm X-1, the range is between 24 and 68 per cent. This clearly demonstrates the different importance of current inputs, labour inputs and capital services for different dye groups. To take them in one group would thus be subject to very large unexplained error due to the changing composition of production of various dye groups in the same firm year after year. Incidentally, the Table indicates that the percentage value added for firm X-2 is much higher to the other firms. This is because, it is the largest firm specializing in the manufacture of Vat and Disperse dyes which are more complex involving greater number of processes. Naturally, these are also the costlier dyes compared to other groups.

Table A_{5.1} : Flow-Coefficients for Azo Dyes

| Sr. No. | Name of the Raw Materials | Input per Rupee worth of final products |
|---------|-------------------------------------|---|
| 1. | Aceto Acetanilide | .000838 |
| 2. | Alpha Naphthylamine | .001533 |
| 3. | Ortho Amino Phenol 4 sul. Acid | .000585 |
| 4. | Benzidine dilter | .085259 |
| 5. | Beta Naphthal | .010646 |
| 6. | Benzol Sulfochloride | .000024 |
| 7. | Benzoyl Chloride | .001145 |
| 8. | 1:6 Cleveis Acid | .000032 |
| 9. | 1:7 Cleveis Acid | .000642 |
| 10. | Chromium Fluoride | .001118 |
| 11. | Dihydrothio paratol sul. acid | .004666 |
| 12. | Disnisidine Base | .014266 |
| 13. | Diphenylamine | .014481 |
| 14. | Ethyl oxy ethyl aniline | .0002391 |
| 15. | Metaxylylidine o.sul. acid | .001751 |
| 16. | Mono Ethynalamine | .000810 |
| 17. | 2-Naphthalene 4:8 Disul. acid | .002275 |
| 18. | 1:8 Naphthalene | .00443 |
| 19. | 4 Nitro 2 Amino Phenol 6 sul. acid | .006792 |
| 20. | O-Amino Phenol 6 sul. acid | .001698 |
| 21. | Ortho Toluidine Oil | .000066 |
| 22. | Ortho anisidine | .001591 |
| 23. | Para Amino Acetanilide | .001034 |
| 24. | Para Cresidine | .001597 |
| 25. | Para Xylidine | .000810 |
| 26. | Pyrazolone | .001376 |
| 27. | Phenyl Gamma Acid | .000322 |
| 28. | Para Anisidine | .012876 |
| 29. | Phosgene | .001467 |
| 30. | Para Toly Peri Acid | .000467 |
| 31. | Para Amino Azo Benzene | .002847 |
| 32. | Rosocinol | .000266 |
| 33. | Sulphuric Acid | .000202 |
| 34. | Triethanolamine | .000051 |
| 35. | 1:6 + 1:7 Cleve's Acid | .000284 |
| 36. | Red 3 GL (4 chloro 2 nitro anidine) | .001334 |
| 37. | 1:6 Cleve's Acid | .000122 |
| 38. | Chicago Acid | .024366 |
| 39. | 1-Diazo 2-Naph, 4-Sul. acid | .012112 |
| 40. | G. Salt | .004913 |
| 41. | Gamma Acid | .039055 |
| 42. | H. Acid | .086017 |
| 43. | J. Acid Urea | .017389 |
| 44. | J. Acid | .005099 |

(continued)

Table A_{5.1} : (continued)

| Sr. No. | Name of the Raw Material | Input per Rupee worth of final products |
|---------|----------------------------------|---|
| 45. | Lawrents Acid | .000141 |
| 46. | Metanilic Acid | .004734 |
| 47. | 6 Nitro 1:2:4 Acid Diazo | .000585 |
| 48. | Naphthalene Mono Sulfuric acid | .000025 |
| 49. | N. & W. Acid | .002612 |
| 50. | Para Tolyli Peri Acid | .003462 |
| 51. | Phenyl J. Acid | .008102 |
| 52. | Phenyl Peri Acid | .008626 |
| 53. | Rhocluline Acid | .006268 |
| 54. | Schafferls Acid | .000051 |
| 55. | D.N.S. D.S. Acid | .025130 |
| 56. | D.A.S. D.S. Acid | .027785 |
| 57. | D.A.S.D.S. Sodium Salt | .018480 |
| 58. | 2 Chloro-4-Nitro Aniline | .000674 |
| 59. | Sodium Naphthionate | .036202 |
| 60. | M.P.D. Solution | .004139 |
| 61. | M.T.D. Solution | .002420 |
| 62. | Sulfanilic acid | .007874 |
| 63. | 4 Chloro 2-nitro phenol | .005386 |
| 64. | Aceto Acetanilide | .000248 |
| 65. | Sulphuric Acid 98% | .000793 |
| 66. | Caustic Soda Solution | .005860 |
| 67. | Caustic Potash Flakes | .001534 |
| 68. | Sodium Sulfide Sol. | .000304 |
| 69. | Chlorine Liquid | .000503 |
| 70. | Hydrochloric acid | .001996 |
| 71. | P.A.A.B. | .000818 |
| 72. | P.A.P.A.S. Acid | .006307 |
| 73. | Product No. 452 (due) | .006174 |
| 74. | Product No. 453 (due) | .009304 |
| 75. | Brilliant Yellow | .048717 |
| 76. | Acid Yellow R. | .002906 |
| 77. | Basic Chromium Sulfate Solution | .002805 |
| 78. | Benzoyl. J. Acid | .005563 |
| 79. | 2:4 Dichloro Phenol | .004985 |
| 80. | Aniline W, Methyne Sulfuric acid | .003537 |
| 81. | R. Salt | .001530 |
| 82. | Brine Sol. | .001360 |
| 83. | Hypochloride Sol. | .000048 |
| 84. | Finiline Oil | .004271 |
| 85. | Ammonia | .000057 |
| 86. | Alcohol | .001219 |
| 87. | Acetone | .000393 |
| 88. | Activated Carbon | .000086 |

(continued)

Table A_{5.1} : (continued)

| Sr. No. | Name of the Raw Material | Input per Rupee worth of final products |
|---------|-------------------------------------|---|
| 89. | Ammonium Sulfate | .000003 |
| 90. | Antimony Trisulfide | .000024 |
| 91. | Berol | .000095 |
| 92. | Borax Powder | .002204 |
| 93. | Burnt lime | .000097 |
| 94. | Cyanuric Chloride | .011811 |
| 95. | Copper Sulfate | .900246 |
| 96. | Caloline Oil | .000044 |
| 97. | Chlorol Tech. | .006641 |
| 98. | Dentrine | .002004 |
| 99. | D.T.E. Oil | .000004 |
| 100. | Diethylene | .000023 |
| 101. | Dedanol DT | .000032 |
| 102. | Erkantol BX | .000054 |
| 103. | Ethyl Chloride | .003713 |
| 104. | Formaldehyde | .000458 |
| 105. | G. Salt Crystals | .005033 |
| 106. | G. Salt Powder | .002229 |
| 107. | Glue Animal | .000013 |
| 108. | Hexamine | .007599 |
| 109. | Hyflosupercel | .000501 |
| 110. | Hydrated Lime | .000004 |
| 111. | Iron Filings | .000139 |
| 112. | Kieselguhr | .000009 |
| 113. | Leonil DB Powder | .000015 |
| 114. | Linseed Oil | .000025 |
| 115. | Metanilic Acid | .000496 |
| 116. | Methanol | .002293 |
| 117. | Manochloro acetic acid | .003723 |
| 118. | M.P.D. | .008725 |
| 119. | Meta Cresol | .000142 |
| 120. | Oxalic Acid | .000027 |
| 121. | Oleic Acid | .000002 |
| 122. | Para Nitro Aniline | .008806 |
| 123. | Phenol | .005942 |
| 124. | Para Sulfo phenol Methyl Pyrazolone | .002345 |
| 125. | Potassium Chloride | .000223 |
| 126. | Para Cresol | .000236 |
| 127. | Sodium Nitrite | .024174 |
| 128. | Salicylic Acid | .004423 |

(continued)

Table A5.1 : (continued)

| Sr. No. | Name of the Raw Material | Input per Rupee worth of final products |
|------------|---------------------------|--|
| 129. | Salt Vacuum | .000956 |
| 130. | Soda Ash | .008647 |
| 131. | Sodium Bicarbonate | .000203 |
| 132. | Sodium Bisulfite | .000735 |
| 133. | Salt Common | .004366 |
| 134. | Sodium Acetate Crystal | .003641 |
| 135. | Sodium Bicbromate | .001034 |
| 136. | Sodium Hydrosulfite | .000589 |
| 137. | Sodium Cynide | .000245 |
| 138. | Sodium Lignosulfate | .000088 |
| 139. | Sodium Sulfite | .000017 |
| 140. | Sodium Loryl Sulfate | .000005 |
| 141. | Sodium Formate | .000065 |
| 142. | Sodium Acetate Solution | .000653 |
| 143. | T.R.O. | .000428 |
| 144. | Tetra Sodium Pyrosulphate | .000496 |
| 145. | Tumol MIO | .000285 |
| 146. | Urea | .000015 |

Table A_{5.2} : Flow-Coefficients for Vat Dyes

| Sr. No. | Name of the Raw Material | Input per Rupee worth of final product |
|---------|-------------------------------|--|
| 1. | 2-Acetyl Amino-3-Chloro aq. | .002972 |
| 2. | Bromine | .001028 |
| 3. | Bromine Acid | .001044 |
| 4. | Benzoyl Chloride | .004864 |
| 5. | 2-Chloro-4-Nitro Aniline | .000319 |
| 6. | D.M.S. | .006756 |
| 7. | 2:6 Dihydroxy Anthraquinone | .001986 |
| 8. | 3-Ethoxy Propylamine Pure | .000061 |
| 9. | Isobutanol | .003549 |
| 10. | Kieselguhr | .000105 |
| 11. | Monomethylamine | .000008 |
| 12. | N.Ethyl-Hydro-Ethyl Aniline | .000122 |
| 13. | N. Dimethyl Sulphamine Acid | .000098 |
| 14. | N.N. Dimethyl ethyl M-Toluene | .000404 |
| 15. | Pyridine base | .004138 |
| 16. | Para Chlorophenol | .002926 |
| 17. | Para Amino Phenol | .000405 |
| 18. | Pyridine Pure | .001598 |
| 19. | Sulphur Loose | .024724 |
| 20. | Aluminium Powder | .000060 |
| 21. | Acetone | .000029 |
| 22. | Acetic Acid | .000694 |
| 23. | Acetic Anhydride | .000001 |
| 24. | Acinol OTID | .000051 |
| 25. | Acinol Sul. | .000548 |
| 26. | Arosil 1504 Defoamer | .000315 |
| 27. | Aro Salt | .000074 |
| 28. | Ahura ST | .000246 |
| 29. | Ammonium Lignosulphate | .000001 |
| 30. | Ahuramina MNES | .000001 |
| 31. | Boric Acid | .000698 |
| 32. | Benzo-Tri-Chloride | .003524 |
| 33. | Benzene | .000061 |
| 34. | Caustic Potash Flakes | .040559 |
| 35. | Caustic Soda Solid | .000471 |
| 36. | Caustic Soda Flakes | .006227 |
| 37. | Caustic Soda Sol. | .005131 |
| 38. | Cryselic Acid | .000092 |
| 39. | Copper Powder | .000598 |
| 40. | Cupric Oxide | .000112 |
| 41. | Chloro Sulphuric Acid | .005385 |
| 42. | Cuprous Chloride | .000027 |

(continued)

Table A₅.2 : (continued)

| Sr. No. | Name of the Raw Material | Input per Rupee worth of final product |
|---------|---------------------------------------|--|
| 43. | Calcium Carbonate | .000002 |
| 44. | Cupric Chloride | .000049 |
| 45. | 2:5 Dimethyl-4-Chlorophenyl | .010850 |
| 46. | 2:4 Dinitro Chloro Benzene | .000201 |
| 47. | Dedanol OT | .000031 |
| 48. | Dissolvent Hu | .000545 |
| 49. | Dedanol S.T.S. | .000148 |
| 50. | Dispersing Agent Type I | .002904 |
| 51. | Dispersing Agent Type II | .009401 |
| 52. | Dispersing Agent Type III | .003905 |
| 53. | Dedanol BX | .000088 |
| 54. | Dinaha's Acid | .000020 |
| 55. | Ethylene Glycol | .000410 |
| 56. | Formaldehyde | .000007 |
| 57. | G. Salt | .000398 |
| 58. | Glycerine | .000008 |
| 59. | Hydrochloric Acid | .000082 |
| 60. | Hydrated Lime | .000137 |
| 61. | Iron Pdr. Elec. | .000152 |
| 62. | Idet 10 | .000321 |
| 63. | Iodine | .000042 |
| 64. | Ice | .002418 |
| 65. | Jakolite | .000007 |
| 66. | Kelestrene | .000322 |
| 67. | Lead Acetate | .000385 |
| 68. | Manganese Dioxide (MnO ₂) | .001217 |
| 69. | Methanol | .001401 |
| 70. | Mono Chlorobenzene | .000001 |
| 71. | Meta Nitro benzene | .000162 |
| 72. | Magnesium Chloride | .000039 |
| 73. | Magnesium Sulphate | .000013 |
| 74. | Metapera Cresol | .000001 |
| 75. | Nitric Acid Commercial 70% | .000014 |
| 76. | Nitric Acid Fuming | .001653 |
| 77. | Nitrobenzene | .014631 |
| 78. | Naphthalene | .001917 |
| 79. | Nitrogen Gas | .000175 |
| 80. | Nitric Acid 60% | .000153 |
| 81. | Naphthalene H.P. | .000651 |
| 82. | Oxalic Acid | .000237 |
| 83. | Olive Oil | .000004 |
| 84. | Potassium Carbonate | .004073 |
| 85. | Potassium Chloride Crystals | .000267 |

(continued)

Table A_{5.2} : (continued)

| Sr. No. | Name of the Raw Material | Input per Rupee worth of final product |
|---------|---|--|
| 86. | Phthalic Anhydride | .000764 |
| 87. | Paraffin | .000087 |
| 88. | Para Ethoxy Aniline | .000406 |
| 89. | Phenol | .000126 |
| 90. | Potassium Chloride Powder | .000002 |
| 91. | 1-Para-Sulphophenyl 3 Methyl 5 Pyrosalene | .000001 |
| 92. | Para Toluyyl Sulphonamide | .000145 |
| 93. | Sulphur Packed | .000032 |
| 94. | Sulphuryl Chloride | .005376 |
| 95. | Sodium Acetate | .005010 |
| 96. | Sodium Acetate | .005010 |
| 97. | Soda Ash (light) | .001702 |
| 98. | Sodium Bicarbonate | .000031 |
| 99. | Sodium Sulphite | .001254 |
| 100. | Sodium Chlorate | .002473 |
| 101. | Sodium Chloride | .000153 |
| 102. | Sodium Hydrosulphite | .022121 |
| 103. | Sodium Nitrite | .000017 |
| 104. | Sodium Sulphide | .001983 |
| 105. | Sodium Tripoly Phosphate | .000351 |
| 106. | Sodium Phenate | .004152 |
| 107. | Sodium Alignate | .000024 |
| 108. | Sodium Sulphamic Acid | .000012 |
| 109. | Sugar | .000021 |
| 110. | Sodium Ligno Sulphate | .000803 |
| 111. | Toluene | .000394 |
| 112. | Turkey Red Oil | .000023 |
| 113. | Thionyl Chloride | .000257 |
| 114. | Thioglycolic Acid | .000009 |
| 115. | Urea | .000009 |
| 116. | Vacuum Salt | .000032 |
| 117. | Uniphenol | .000001 |
| 118. | Sulphuric Acid 98% | .002894 |
| 119. | Dyes | .000443 |

Table A_{5.3} : Flow-Coefficients for Disperse Dyes

| Sr. No. | Name of the Raw Material | Input per Rupee worth of final product |
|---------|-----------------------------|--|
| 1. | Isobutanol | .006144 |
| 2. | Mono Methylamine | .001612 |
| 3. | Mono Ethylamine | .000980 |
| 4. | Bromine | .011759 |
| 5. | Kiesulguhr | .000170 |
| 6. | 2:4 Dinitro-6-Bromo Aniline | .006799 |
| 7. | Hexandial | .003926 |
| 8. | Sodium Phenate | .006061 |
| 9. | Ortho Dichlorobenzene | .001509 |
| 10. | G. Salt | .000129 |
| 11. | Sodium Bisulphite | .001900 |
| 12. | Soda Ash | .009802 |
| 13. | Vacuum Salt | .004079 |
| 14. | Caustic Soda Solution | .005428 |
| 15. | Sodium Nitrite | .002168 |
| 16. | Chlorine | .000146 |
| 17. | Dimethyl Sulphate | .003116 |
| 18. | Methanol | .026645 |
| 19. | Hydrochloric Acid | .001123 |
| 20. | Sodium Acetate | .012341 |
| 21. | Para Amino Azo Benzene | .104571 |
| 22. | Ortho Cresol | .002095 |
| 23. | Aniline Oil | .003665 |
| 24. | Para Nitro Aniline | .007325 |
| 25. | Formaldehyde | .001104 |
| 26. | Sodium Bicarbonate | .000481 |
| 27. | Caustic Potash Flakes | .008141 |
| 28. | Oleic Acid | .005753 |
| 29. | Potassium Carbonate | .001197 |
| 30. | Phenol | .009786 |
| 31. | Acetic Acid | .000348 |
| 32. | Boric Acid | .001502 |
| 33. | Nitric Acid Fuming | .011475 |
| 34. | Sodium Sulphide | .005362 |
| 35. | Vacuum Salt | .000252 |
| 36. | Alpha Naphthylamine | .007042 |
| 37. | Copper Powder | .000528 |
| 38. | Para Toluyyl Sulphonamide | .003831 |
| 39. | Sulphuric Acid 98% | .012694 |
| 40. | Oleum 20% | .003119 |

Table A_{5.4} : Flow-Coefficients for Fast Colour Bases

| Sr. No. | Name of the Raw Material | Input per Rupee worth of final product |
|---------|----------------------------|--|
| 1. | Beta Naphthol | .006862 |
| 2. | Benzoyl Chloride | .001864 |
| 3. | 2:5 Diethoxy aniline | .016909 |
| 4. | D.N.C.B. | .016682 |
| 5. | Mono Ethanolamine | .002254 |
| 6. | Metachloro Nitro benzene | .020929 |
| 7. | Ortho Chloro Aniline | .000273 |
| 8. | Ortho Toluidine Moist | .001057 |
| 9. | Ortho Toluidine oil | .033019 |
| 10. | Ortho Nitro Chloro Benzene | .002450 |
| 11. | Ortho Anisidine | .047308 |
| 12. | Para Toluidine | .029966 |
| 13. | Para Anisidine | .095148 |
| 14. | Para Amino Phenol | .000555 |
| 15. | Triethanolamine | .000021 |
| 16. | N. Acetyl O.Toluidine | .060771 |
| 17. | D.N.S.D.S. Acid | .071642 |
| 18. | D.A.S.D.S.A. Sod. Sald | .017808 |
| 19. | Sodium Sulfanilate | .002886 |
| 20. | Sulfanilic acid | .001232 |
| 21. | 2.5 D.C.N.B. | .027286 |
| 22. | Sulphuric Acid 98% | .009721 |
| 23. | Oleum 60% | .000037 |
| 24. | Chloro Sulfuric Acid | .000823 |
| 25. | Caustic Soda 50% | .027969 |
| 26. | Caustic Soda flakes | .001322 |
| 27. | Caustic Potaash flakes | .000740 |
| 28. | Sodium Sulfide | .011771 |
| 29. | Chlorine Liquid | .001079 |
| 30. | HCl 30% | .003586 |
| 31. | Benzoyl Sulfo Red KB | .001469 |
| 32. | Mixed Acid 45% | .015438 |
| 33. | Aniline Oil | .000729 |
| 34. | Acetic Anhydride | .042624 |
| 35. | Ammonia | .000162 |
| 36. | Alcohol | .000012 |
| 37. | Acetic Acid | .019371 |
| 38. | Acetone | .003644 |
| 39. | Activated Carbon | .003965 |
| 40. | Borax Powder | .000624 |

(continued)

Table A₅.4 : (continued)

| Sr. No. | Name of the Raw Material | Input per Rupee worth of final product |
|---------|--------------------------|--|
| 41. | Burnt Lime | .000092 |
| 42. | Benzyl Chloride | .010491 |
| 43. | Copper Oxide | .001297 |
| 44. | Calcium Carbonate | .000018 |
| 45. | Calsolene Oil | .000028 |
| 46. | Disodium EDTA | .000063 |
| 47. | Dedanol DT | .000008 |
| 48. | Ethyl Chloride | .002855 |
| 49. | Ethylene Dichloride | .003716 |
| 50. | Formic Acid | .001070 |
| 51. | Ferrous Sulfate | .000006 |
| 52. | Glauber Salt Powder | .000043 |
| 53. | Hydro Sulphone | .005094 |
| 54. | Hyflosupercel | .000928 |
| 55. | Hydrated Lime | .000339 |
| 56. | Iron filings | .001010 |
| 57. | Kieselghur | .000241 |
| 58. | Monochlorobenzene | .005129 |
| 59. | Methanol | .011029 |
| 60. | Magnesium Oxide | .000016 |
| 61. | Magnesium Sulfate | .000428 |
| 62. | Nitric Acid 60% | .014554 |
| 63. | Nitric Acid 90% | .020754 |
| 64. | Pyridine | .004983 |
| 65. | Sodium Nitrite | .011685 |
| 66. | Sulfur | .002952 |
| 67. | Salt Vacuum | .006148 |
| 68. | Soda Ash | .003089 |
| 69. | Sodium Bicarbonate | .000078 |
| 70. | Sodium Bisulfite | .001746 |
| 71. | Sodium Acetate crystal | .003371 |
| 72. | Sodium Hydrosulfite | .000244 |
| 73. | Sodium Sulfite | .000004 |
| 74. | Sodium Sulfide flakes | .003749 |
| 75. | Sulphuric Acid 98% | .002038 |
| 76. | T.R.O. | .000523 |
| 77. | Trichloro Ethylene | .001554 |
| 78. | Tumol MNO | .000029 |
| 79. | Tartaric Acid | .000206 |
| 80. | Zinc Dust | .000673 |

Table A₅.5 : Flow-Coefficients for Naphthols

| Sr. No. | Name of the Raw Material | Input per Rupee worth of final product |
|---------|--|--|
| 1. | Aceto Acetic Ester | .002338 |
| 2. | Alpha Naphthylamine | .006802 |
| 3. | Azoic Acid | .027087 |
| 4. | Aceto Acetic Methyl Ester | .016647 |
| 5. | Benzoyl Chloride | .000551 |
| 6. | 4-Chloro 2:5 Dimethoxy aniline | .003644 |
| 7. | 2:5 Dimethoxy aniline | .004967 |
| 8. | 2-Hydroxy Dioenzafuran Carboxylic Acid | .021437 |
| 9. | Ortho Toluidine Moist | .050703 |
| 10. | Ortho Toluidine oil | .000895 |
| 11. | Ortho Anisidine | .005943 |
| 12. | Para Chloro aniline | .010715 |
| 13. | Triethanolamine | .000111 |
| 14. | Tabias Acid | .023846 |
| 15. | Beta Oxy Naphthoic Acid | .183380 |
| 16. | Phosphorous Trichloride | .013825 |
| 17. | Meta Nitro Aniline | .066079 |
| 18. | 5-Chloro-O-Toluidine | .023585 |
| 19. | Caustic Soda Sol. | .004819 |
| 20. | Hydrochloric Acid | .000027 |
| 21. | Aniline Oil | .019364 |
| 22. | Alcohol | .000035 |
| 23. | Acetic Acid | .000676 |
| 24. | Activated Carbon | .000010 |
| 25. | Calcium Carbonate | .000036 |
| 26. | Glauber Salt Powder | .000425 |
| 27. | Hyflosupercel | .000028 |
| 28. | Leonil DB Powder | .000017 |
| 29. | Monochloro Benzene | .025854 |
| 30. | Phosphorous Trichloride | .001016 |
| 31. | Soda Ash | .003896 |
| 32. | Sodium Bicarbonate | .000040 |
| 33. | Sodium Acetate Crystals | .000149 |
| 34. | T.R.O. | .000050 |
| 35. | Urea | .000443 |

Table A_{5.6} : Flow-Coefficients for Sulphur Black

| Sr. No. | Name of the Raw Material | Input per Rupee worth of final products |
|---------|--------------------------|---|
| 1. | D.N.C.B. | .115709 |
| 2. | Caustic Soda Sol. | .038413 |
| 3. | Sodium Sulfide | .102065 |
| 4. | Calsolene Oil | .004627 |
| 5. | D.T.E. Oil | .002998 |
| 6. | Diethylene | .000166 |
| 7. | Glauber Salt Crystals | .000276 |
| 8. | Sulfur | .044284 |
| 9. | Sodium hydro sulfide | .001854 |
| 10. | Soda Ash | .002384 |
| 11. | Sodium Sulfide Flakes | .006507 |
| 12. | Sulphuric Acid 98% | .000341 |

Table A_{5.7} : Flow-Coefficients for Organic Pigments

| Sr. No. | Name of the Raw Material | Input per Rupee worth of final products |
|---------|--|---|
| 1. | Acetoacetanilide | .017051 |
| 2. | Acetoacet-o-Anisidide | .005004 |
| 3. | Acetoacet-o-Toluidide | .013799 |
| 4. | Acetoacet-o-Chloranilide | .031618 |
| 5. | Amino Anisic Acid Anilide | .006668 |
| 6. | Beta Naphthol | .019893 |
| 7. | 2-Chloro-5-Toluidine-4-Sulfonic Acid | .011811 |
| 8. | p-chloro-o-Nitroaniline | .010054 |
| 9. | O-chloro-p-Nitroaniline | .017238 |
| 10. | 3,3 Dichlorobenzidine/3,3 Dichloro benzidine Dihydrochloride | .051476 |
| 11. | 5-Nitro-2-Toluidine | .007262 |
| 12. | Naphthol AS-LC | .015492 |
| 13. | Phthalic Anhydride | .012656 |
| 14. | p-Methyl-Phenyl-Methyl-Pyrazolone | .005009 |
| 15. | 1-phenyl-5-Pyrazolone-3-carboxylic Acid Ethyl Ester | .005986 |
| 16. | Tobias Acid | .000747 |
| 17. | 4-Toluidine-3-sulfonic Acid | .010791 |
| 18. | 2,4,5, Trichloroaniline | .001805 |
| 19. | Ortho Sulfanilic Acid | .004262 |
| 20. | 2-oxy Naphthalene-3-Carbonic Acid (4 Sulpho) Anilide | .011301 |
| 21. | Amixio Sulfonic Acid | .000392 |
| 22. | Ammonium Molybdate | .001621 |
| 23. | Hyflosupercel | .000348 |
| 24. | Sodium Nitrite | .018573 |
| 25. | Acetoacetacet-o-chloranilide | .011773 |
| 26. | 2-chloro-5-Toluidine-4-Sulfonic Acid | .001053 |
| 27. | 4-Toluidine-3-Sulfonic Acid | .009889 |
| 28. | Acetic Acid Glacial | .027729 |
| 29. | Acinol LTA | .005815 |
| 30. | Bon Acid | .008801 |
| 31. | Bordeaux G.P. Base | .000955 |
| 32. | 2,5, Dichloroaniline | .000685 |
| 33. | 3-Nitro-4-Toluidine | .087990 |
| 34. | 5-Nitro-2-Toluidine | .001743 |
| 35. | 4-Nitro-2-Toluidine | .005903 |
| 36. | Nitrobenzene | .011275 |
| 37. | Urea | .016219 |
| 38. | Activated Carbon | .001134 |

(continued)

Table A₅.7 : (continued)

| Sr. No. | Name of the Raw Material | Input per Rupee worth of final products |
|---------|-----------------------------|---|
| 39. | Dispersing Agent H265 | .002451 |
| 40. | Naphthol AS | .001055 |
| 41. | Naphthol AS-E | .026532 |
| 42. | Noigen ET 180 | .003765 |
| 43. | Rosin | .001626 |
| 44. | Sendale A Paste | .001050 |
| 45. | Xylene | .000487 |
| 46. | Dispersing Agent H 273 | .000179 |
| 47. | Ammonium Chloride | .000868 |
| 48. | Aluminium Chloride | .008826 |
| 49. | Boric Acid | .000529 |
| 50. | Borium Chloride | .001971 |
| 51. | Caustic Soda 100% | .01060 |
| 52. | Calcium Carbonate | .002099 |
| 53. | Calcium Chloride | .000794 |
| 54. | Cuprous Chloride | .018582 |
| 55. | Ferrous Sulphate Crystals | .000125 |
| 56. | Glauber's Salt | .002795 |
| 57. | Hydrochloric Acid 30% | .002331 |
| 58. | Liquid Chlorine | .000615 |
| 59. | Common Salt | .000290 |
| 60. | Soda Ash | .001887 |
| 61. | Sodium Bisulphate | .001122 |
| 62. | Sulphuric Acid (Commercial) | .028088 |
| 63. | Ammonia | .001075 |
| 64. | Dry Ice | .000458 |

CHAPTER VI

SIZE-STRUCTURE AND INPUT-OUTPUT RATIOS

(A CASE STUDY OF THE DYES AND
INTERMEDIATES INDUSTRY IN INDIA)

6.1 Input-Output Ratios for the Growing Firm Size

The study of the behaviour of various input-output ratios such as Capital-Output, Capital-Value added, Capital-Labour, Wages-Output for the varying sizes of firms in an industry is very useful to find out the factor proportions, possible substitution between different factors of production if any. Such an exercise could be of much help in the long-term planning of the development of any industry.

With respect to the chemical industry, it is the general belief that this industry is subject to increasing returns to scale. But as we have discussed earlier, there are many branches in the chemical industry employing hundreds of different processes. What is true for continuous processes, may not always be true for batch processes. Since one of the basic assumptions of input-output analysis is the constant returns to scale, it is sometimes suggested that input-output analysis cannot be used for chemical industry. It is also suggested that because of large number of alternative possible combinations of inputs in this multi-product and multi-process industry, flow-coefficients may not remain stable for changing sizes of the firms.

In this chapter an attempt has been made to examine the hypothesis of increasing returns to scale with the help of the behaviour of input-output ratios in the Dyestuffs and

Intermediates Industry in India. For the purpose of this analysis, A.S.I. data for the years 1960-1966 has been used. Unfortunately, the data for a longer time-series could not be available. A.S.I. data comes out with 8 to 9 years lag while in the CMI series, Dyestuff Industry has not been separately classified. Wherever possible, the results obtained from A.S.I. data have been verified with the firm-wise observations.

6.2 Adjustment of Capital for Depreciation

For the purpose of our analysis of capital-output ratios, figures for capital available from A.S.I. data have been adjusted to arrive at a more realistic estimate of capital value. The Annual Survey of Industries data provides information on fixed and working capital of large-scale manufacturing by different categories. The A.S.I. Reports write down (depreciated) book value of the fixed assets. In order to obtain their 'gross' or 'purchase' value, an appreciation of the reported figures of fixed assets is required.

Gross-net value adjustment is a complicated problem since it is dependent on the age-structure of capital assets, maintenance, rate of depreciation, etc. Obviously, a common ratio for all the categories of assets and all the industries would not serve the purpose. In the absence of complete information on the age-structure of fixed assets in different industries, the best that could be done would be to assess

for a particular year the average gross-net ratio for each industry from a good sample of the firms giving information about the purchase value of the assets and the written down value of the assets. In order to appreciate the capital data to a fair approximation, the gross-net ratios available from the Reserve Bank of India's Company Finance data relating to chemical companies has been used in this study for the relative years.

6.3 Price Adjustments

Even after the capital is adjusted for depreciation, the problem of price adjustment remains. One way of adjusting for price changes would be to take the wholesale price index for machinery and adjust. The Government of India's Economic Adviser's wholesale price index which is also given by the Reserve Bank of India is for machinery as a whole. Since separate price index is not available for chemical machinery, an assumption is made that the price index of chemical machinery is the same as that of all machinery. However, in order to obtain a consistent value of capital for a given year t what we require is to express all the past additions to the capital in terms of the t^{th} year's (current) prices. The year to year index cannot be applied to all the capital which is the result of cumulative accumulation over the years. The adjustment therefore must be only with respect to the incremental capital and not for all the capital stock. To

overcome this difficulty here, the author has used the method given by Hashim and Dadi¹ who have done this exercise for the years 1946 to 1964 with respect to Indian Manufacturing. They have used CMI and ASI data. Since CMI series start from 1946, they have taken into account the year to year differences in values with some adjustments to annual retirements of assets to arrive at the additions during the two consecutive years. These additions are in that year's prices in which the additions were made. They thus express the value of accumulated capital assets in t^{th} year in t^{th} year's prices (K_t) as :

$$K_t = \sum_{i=1}^n A_i \left\{ \frac{P_t}{P_i} \right\}$$

where A_i is the addition in the i^{th} year ($i = 1, \dots, 19$, A_1 being the stock existing in 1946) and p_i and p_t are price indices in i^{th} and t^{th} years respectively. To tackle the problem of obtaining an estimate of assets which were acquired before 1946, they have made an assumption that the assets existing in 1946 would not be generally older than about 25 years. They argue that most of these assets must have been acquired after the First World War. In fact it was this period which registered a marked rise in industrial activity, except the depression period of thirties when

1 S. R. Hashim and M. M. Dadi, Capital-Output Relations in Indian Manufacturing (1946-64), The M. S. University, Baroda, 1973.

not much capital was added. Further, it was during and after the Second World War that there was a fresh spurt in industrial activity in India. Hence they have taken a simple average of the price indices of manufacturing goods during 1919 to 1929 and 1940 to 1945 so as to use it as a price inflator for all the assets acquired before 1946.

In the present study, our problem has been made relatively simpler because of the fact that the Dyestuff Industry is a new industry which has come into existence after 1950 and grew rapidly only in the 1960's. Hence we have taken a simple average of price indices published by the Economic Adviser's Office with 1952-53 as a base, for the years 1952 to 1960, converting the indices to 1960 base to adjust the value of assets existing in 1960. And for the years 1961 to 1966, we have adjusted with those years' price indices (with 1960=100) for incremental capital using the above formula given by messrs. Hashim and Dadi.

6.4 Capital Per Firm

The A.S.I. data for the dyestuff industry presented in Table 6.1 indicates that over the years, the capital per firm has been increasing indicating that the expansion of the industry is dictated towards bigger size rather than towards more number of firms. This might have been due to the better profitability of larger size.

Table 6.1 : Capital Per Firm Over the Years

| Year | No. of factories | Total Fixed Capital * (Rs. Lakhs) | Average Fixed Capital Per Factory (Rs. Lakhs) |
|------|------------------|-----------------------------------|---|
| 1960 | 19 | 1213.96 | 63.89 |
| 1961 | 20 | 1421.85 | 71.09 |
| 1962 | 20 | 1683.22 | 84.16 |
| 1963 | 24 | 2087.67 | 86.98 |
| 1964 | 29 | 3205.28 | 110.52 |
| 1965 | 32 | 4378.28 | 136.82 |
| 1966 | 34 | 4481.81 | 131.81 |

* Adjusted for depreciation and prices.

Source : Computed from Annual Survey of Industries' data.

6.5 Capital Per Worker

Over the same period, it is also observed that the capital employed per worker has been increasing significantly as can be seen from Table 6.2 below.

Table 6.2 : Capital Employed Per Worker

| Year | Total Fixed Capital * (Rs. Lakhs) | Total No. of Workers | Average Fixed Capital Employed per Worker (Rs. Lakhs) |
|------|-----------------------------------|----------------------|---|
| 1960 | 1213.96 | 3,720 | 0.3263 |
| 1961 | 1421.85 | 4,003 | 0.3551 |
| 1962 | 1683.22 | 3,734 | 0.4507 |
| 1963 | 2087.67 | 4,147 | 0.5034 |
| 1964 | 3205.28 | 4,790 | 0.6691 |
| 1965 | 4378.28 | 6,954 | 0.6296 |
| 1966 | 4481.81 | 5,575 | 0.8039 |

* Adjusted for depreciation and prices.

Source : Computed from A.S.I. data.

Both the above Tables indicate the trend of increasing capital intensity of the industry over the years with the growth in the size of the firm.

Increasing returns can be achieved either by saving on raw materials with the increasing size of the firm or by saving on factor inputs or changing the factor input proportions in such a way that with the growth of the firm size, the relatively cheaper factor input is utilized more abundantly.

6.6 Behaviour of Flow Coefficients

For the seven years of A.S.I. data (1960-66), it is seen that with the growing size of the firm, the input structure with regard to the flow coefficients is not changing significantly as can be seen from Table 6.3. Some variations that are observed could be attributed partly to the changing product-mix over the years and partly to the substitutability between inputs. The changes in the product-mix have been considerable as can be seen from Table 6.4 and 6.5. Table 6.4 gives the quantities and values of products and by-products manufactured and Table 6.5 gives the value proportions of different products at 1966 prices. Naturally, some element of instability could be attributed to this changing product-mix.

In order to mitigate the effect of substitutable raw material inputs, the various inputs have been suitably aggregated into 12 broad groups in consultation with a dye chemist

Table 6.3 : Behaviour of Flow Coefficients

| Name of the input | Value of input per rupee worth of final product (at 1966 prices) | | | | | | |
|---------------------------------------|--|---------|---------|---------|----------|---------|---------|
| | 1960 | 1961 | 1962 | 1963 | 1964 | 1965 | 1966 |
| 1. Sulphur | - | .004569 | .006791 | .006577 | .008043 | .008936 | .007644 |
| 2. Sulphuric Acid | .013193 | .006621 | .013230 | .010759 | .012973 | .011847 | .010818 |
| 3. Oleum | .000471 | .000723 | .001296 | .002607 | .002541 | .001978 | .001331 |
| 4. Hydrochloric Acid | .001627 | .001425 | .001309 | .001464 | .001075 | .001121 | .001134 |
| 5. Nitric acid | .002194 | .002022 | .001987 | .002378 | .001769 | .001741 | .001294 |
| 6. Chlorosulphonic acid | .006080 | .000395 | .000491 | .000137 | .000704 | .000999 | .001166 |
| 7. Caustic Soda | .010556 | .008320 | .010961 | .009981 | .007559 | .007334 | .008352 |
| 8. Soda Ash | - | .002585 | .003993 | .003465 | .0004072 | .003808 | .003561 |
| 9. Common Salt | .000341 | .001125 | .001572 | .001556 | .003232 | .001689 | .003046 |
| 10. Chemical lime | .000053 | .000100 | .000136 | .000014 | .000015 | .000110 | .000272 |
| 11. Sodium Nitrite | .000705 | .001404 | .001567 | .001430 | .001458 | .001295 | .001518 |
| 12. Sodium Sulphide | .000625 | .005416 | .007011 | .008724 | .004174 | .002746 | .002927 |
| 13. Sodium bisulphite | .000704 | .000592 | .000679 | .000434 | .000626 | .000619 | .000775 |
| 14. Manganese dioxide | .000349 | .000474 | .000882 | .000355 | .000464 | .000562 | .000408 |
| 15. Phosgene | - | - | - | .000004 | - | .000001 | .000175 |
| 16. Alum | .000365 | .000247 | .000234 | .000407 | - | .000221 | .000236 |
| 17. Benzene | .004945 | .000005 | .000026 | .000006 | .000014 | .000034 | .000029 |
| 18. Benzidine | .005811 | .005795 | .006132 | .003073 | .000502 | .003112 | .002670 |
| 19. Benzaldehyde | - | - | - | .000537 | .000549 | .000305 | .000385 |
| 20. Aniline | .003647 | .003318 | .003953 | .004024 | .004076 | .004411 | .004043 |
| 21. Para-amino-azobenzene | - | .000422 | .000935 | .000130 | .000487 | .000289 | .000121 |
| 22. Metanilic acid | .000679 | .001651 | .001148 | .001352 | .002400 | .002292 | .002227 |
| 23. Sulphanilic acid | .000319 | .000412 | .000170 | .000019 | .000047 | .000116 | .000279 |
| 24. Naphthalene | .000162 | .000123 | .000170 | .000361 | .000396 | .000674 | .001079 |
| 25. Beta naphthol | .007780 | .007316 | .007939 | .007172 | .009714 | .012417 | .012604 |
| 26. Alpha-naphthylamine | .000270 | .001189 | .001748 | .001363 | .002043 | .002166 | .001504 |
| 27. Beta-naphthylamine | - | .001289 | .001183 | - | - | - | .000017 |
| 28. Sodium Naphthionate | .004003 | .002740 | .000674 | .000556 | .000467 | .000509 | .000343 |
| 29. Para-nitroaniline | .000068 | .000232 | .000283 | .000197 | .000105 | .000164 | .000033 |
| 30. Beta-hydroxi naphthoic acid | .002846 | .004427 | .003311 | .003109 | .002715 | .000589 | .000553 |
| 31. Phthalic anhydride | .000298 | .000173 | .000140 | .000627 | .001320 | .001541 | .001427 |
| 32. Dianisidine | .002792 | .001053 | .000724 | .000973 | .000694 | .000569 | .000554 |
| 33. Diphenylamine | .000584 | .000626 | .000817 | .000309 | .000541 | .000738 | .000721 |
| 34. Ortho-nitro-chlorobenzene | .000329 | .000238 | .000510 | .000128 | .000267 | .000231 | .000183 |
| 35. Para-nitro-chlorobenzene | - | - | - | - | - | .000061 | .000072 |
| 36. Metaphenylamine diamine | .000002 | .000146 | .000177 | .000020 | .000016 | .000033 | .000035 |
| 37. Michler's Ketone | - | - | - | - | - | .000067 | .000246 |
| 38. Toluene | .001428 | .001587 | .001220 | .000997 | .000761 | .002103 | .001525 |
| 39. Quinizarine | - | .000291 | .000355 | .000659 | .000255 | .000208 | .000180 |
| 40. Pyridine | .001528 | .002091 | .003012 | .002943 | .002711 | .002738 | .002551 |
| 41. Toluidine (ortho,para,meta) | .000641 | - | .000550 | .003404 | .001911 | .012154 | .007816 |
| 42. Dimethyl aniline | .001154 | .001608 | .001253 | .003170 | .004013 | .003601 | .003180 |
| 43. Dimethyl sulphate | .002224 | .002183 | .002656 | .002778 | .002316 | .002537 | .001934 |
| 44. Orthonitro toluene | .000962 | .000360 | .000458 | .000389 | .002889 | .000234 | .000247 |
| 45. Dinitrochlorobenzene | .000344 | .004922 | .006129 | .007537 | .006742 | .005018 | .005502 |
| 46. Anthraquinone | .015127 | .012178 | .015259 | .012790 | .029149 | .022587 | .025751 |
| 47. Alcohol | .001856 | .001042 | .000661 | .000261 | .000281 | .000880 | .001566 |
| 48. Acetic acid | .000848 | .000561 | .001041 | .001382 | .001315 | .001171 | .001235 |
| 49. Acetic anhydride | .002701 | .002034 | .003057 | .002733 | .001773 | .002128 | .001205 |
| 50. Vat dyes | .045123 | .020044 | .029165 | .028544 | .055279 | .020468 | .024591 |
| 51. Other dyes and colours | .148942 | .040384 | .047214 | .047565 | .004077 | .047084 | .071648 |
| 52. Other acids | .012334 | .011629 | .008875 | .008269 | .006539 | .007822 | .009265 |
| 53. Caustic potash | - | .012437 | .015335 | .012045 | .009426 | .010809 | .011266 |
| 54. Cyanuric chloride | - | - | - | - | - | .005635 | .005024 |
| 55. Amino Anthraquinone | - | - | - | - | - | .005203 | .000413 |
| 56. Diamino Stilbene disulphonic acid | - | - | - | - | - | .009096 | .007522 |
| 57. Litharge | - | - | - | - | - | .004392 | .004140 |
| 58. Acrylic acid butyl ester | - | - | - | - | - | .012301 | .010649 |
| 59. Emulsifier | - | - | - | - | - | .007865 | .011327 |
| 60. Glycerine | - | - | - | - | - | - | .003481 |
| 61. Nitrobenzene | - | - | - | - | - | - | .002969 |
| 62. Anisidine | - | - | - | - | - | - | .004614 |
| 63. Acrylic resin & compounds | - | - | - | - | - | - | .005993 |
| 64. Others | .215972 | .139937 | .167787 | .185495 | .190880 | .158464 | .162236 |
| 65. Packing materials | .038275 | .038095 | .043172 | .049338 | .042366 | .053604 | .049769 |
| 66. Repairs and Maintenance | .008633 | .008561 | .010791 | .009613 | .013942 | .010905 | .010182 |

Table 6.4 : Products and By-products Manufactured (1960-66) Excluding Intermediates

| | | 1960 | 1961 | 1962 | 1963 | 1964 | 1965 | 1966 |
|-------------------------------------|---------------|----------------------|----------------------|--------------------|--------------------|--------------------|----------------------|----------------------|
| 1. Acid Azo Dyes | Tonnes Rs. | 336 34,08,384 | 601 60,96,544 | 657 66,64,608 | 184 18,66,496 | 226 22,92,544 | 396 40,17,024 | 367 37,22,816 |
| 2. Basic Azo Dyes | Tonnes Rs. | 7 1,41,470 | 3 60,630 | 3 60,630 | 15 3,03,150 | 9 1,81,890 | 14 2,82,940 | 8 1,61,685 |
| 3. Direct dyes other than Congo Red | Tonnes Rs. | 1,334 2,70,73,530 | 1,330 2,69,92,350 | 954 1,93,61,430 | 811 1,64,59,245 | 739 1,49,98,005 | 792 1,60,73,640 | 1,185 2,40,50,267 |
| 4. Congo Red | Tonnes Rs. | 57 6,90,270 | 257 31,12,270 | 315 38,14,650 | 156 18,89,160 | 161 19,49,710 | 249 30,15,390 | 153 18,52,910 |
| 5. Naphthols | Tonnes Rs. | 843 55,21,842 | 977 2,94,79,998 | 857 2,58,59,118 | 611 1,84,36,314 | 646 1,94,92,404 | 1,039 3,13,50,786 | 1,070 3,22,86,079 |
| 6. Fast Colour Bases | Tonnes Rs. | 469 1,24,69,303 | 382 1,01,48,594 | 357 94,91,559 | 346 91,99,102 | 393 1,04,48,691 | 514 1,36,65,718 | 470 1,24,95,944 |
| 7. Fast Colour Salts | Tonnes Rs. | 69 9,09,834 | 72 9,49,392 | 26 3,42,836 | 27 3,56,022 | 41 5,40,626 | 44 5,80,184 | 36 4,74,718 |
| 8. Rapid Fast Dyes | Tonnes Rs. | 76 16,96,092 | 78 17,40,726 | 96 21,42,432 | 70 15,62,190 | 95 21,20,115 | 83 18,52,311 | 115 25,66,507 |
| 9. Rapidogen Dyes | Tonnes Rs. | 67 18,10,161 | 60 16,20,000 | 86 23,22,000 | 48 12,96,000 | 50 13,50,000 | 46 12,43,242 | 44 11,80,326 |
| 10. Ink Blue | Tonnes Rs. | 0.24 21,315 | 19 16,53,000 | 23 20,01,000 | 24 20,88,000 | 28 24,36,000 | 31 27,52,419 | 24 21,01,726 |
| 11. Methylene blue | Tonnes Rs. | 0.5 12,875 | 77 19,25,000 | 31 7,75,000 | 67 16,75,000 | 67 16,75,000 | 45 11,36,300 | 71 17,78,900 |
| 12. Myrobalan extract | Tonnes Rs. | 365 3,65,000 | 490 4,90,000 | - - | 258 2,58,000 | 93 93,000 | 244 2,44,400 | 559 6,23,844 |
| 13. Stabilised azoics | Tonnes Rs. | 20 4,74,903 | - - | 20 4,68,000 | - - | 14 3,27,600 | 20 4,77,992 | 27 6,43,632 |
| 14. Indigo Vat dyes | Tonnes Rs. | 4 2,89,057 | 1 72,500 | 236 1,71,10,000 | 1 72,500 | 2 1,45,000 | 20 14,69,068 | 37 27,11,549 |
| 15. Other Vat Dyes | Tonnes Rs. | 571 5,05,77,750 | 578 5,11,53,000 | 356 3,15,06,000 | 577 5,10,64,500 | 817 7,23,04,500 | 792 7,00,57,397 | 992 8,77,57,885 |
| 16. Solubilised Vat Dyes | Tonnes Rs. | 103 1,13,41,833 | 83 91,63,200 | 89 98,25,600 | 100 1,10,40,000 | 124 1,36,89,600 | 144 1,59,93,758 | 151 1,67,25,678 |

(continued)

Table 6.4 : (continued)

| | | 1960 | 1961 | 1962 | 1963 | 1964 | 1965 | 1966 |
|---|--------|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|
| 17. Sulphur black | Tonnes | 1,086 | 1,225 | 1,230 | 1,615 | 1,619 | 1,417 | 1,136 |
| | Rs. | 73,84,800 | 83,30,000 | 83,64,000 | 1,09,82,000 | 1,10,09,200 | 96,35,036 | 78,08,686 |
| 18. Sulphur dyes other than sulphur black | Tonnes | 7 | 32 | 20 | 53 | 43 | 23 | 643 |
| | Rs. | 43,604 | 1,85,600 | 1,16,000 | 3,07,400 | 2,49,400 | 1,35,082 | 37,29,466 |
| 19. Acid dyes other than acid azo dyes | Tonnes | 83 | 130 | 93 | 109 | 125 | 209 | 123 |
| | Rs. | 14,58,817 | 22,75,000 | 16,27,500 | 19,07,500 | 21,89,500 | 36,49,800 | 21,56,122 |
| 20. Basic dyes other than basic azo dyes | Tonnes | 108 | 60 | 61 | 183 | 261 | 309 | 274 |
| | Rs. | 26,36,225 | 14,64,000 | 14,88,400 | 44,65,200 | 63,68,400 | 75,46,578 | 66,69,417 |
| 21. Mordant dyes including elizarine | Tonnes | - | - | - | - | - | - | 9 |
| | Rs. | - | - | - | - | - | - | 2,31,784 |
| 22. Chrome dyes | Tonnes | 13 | 14 | 5 | Neg. | 3 | 1 | 1 |
| | Rs. | 3,13,295 | 32,37,600 | 1,17,000 | 1,704 | 70,200 | 12,753 | 21,189 |
| 23. Acetate rayon dyes | Tonnes | 4 | 5 | 3 | Neg. | 2 | 1 | 2 |
| | Rs. | 1,38,358 | 1,79,500 | 1,07,700 | 10,216 | 71,800 | 5,62,553 | 54,073 |
| 24. Lakes, Pigments, Toners and Spirit soluble dyes | Tonnes | 632 | 1,148 | 1,162 | 1,578 | 1,911 | 2,237 | 2,526 |
| | Rs. | 1,41,00,780 | 2,56,00,400 | 2,59,12,600 | 3,51,89,400 | 4,26,15,300 | 4,98,83,428 | 5,62,44,055 |
| 25. Other Dyes | Tonnes | 540 | 795 | 11 | 193 | 296 | 214 | 236 |
| | Rs. | 2,11,29,923 | 3,10,96,425 | 4,30,265 | 75,49,195 | 1,15,78,040 | 83,70,610 | 92,31,223 |
| 26. Optical Whitening Agents | Tonnes | - | 154 | 133 | 193 | 289 | 382 | 624 |
| | Rs. | - | 83,70,516 | 72,29,082 | 1,04,90,322 | 1,57,08,306 | 2,07,63,228 | 3,39,16,946 |
| 27. Synthetic Resin Binders | Tonnes | - | - | 1,225 | 1,552 | 1,969 | 3,687 | 3,374 |
| | Rs. | - | - | 1,00,90,325 | 1,27,83,824 | 1,62,18,653 | 3,03,69,819 | 2,77,92,326 |
| 28. Pigment Emulsions | Tonnes | - | - | - | - | - | - | 106 |
| | Rs. | - | - | - | - | - | - | 28,71,644 |
| 29. Drugs and Pharmaceuticals | Rs. | 1,59,49,022 | 2,10,10,739 | 1,53,43,534 | 1,14,43,773 | 2,15,66,883 | 2,23,63,239 | 1,15,12,598 |
| 30. Electricity Sold | Kwh | 34,71,201 | 46,12,041 | 49,20,811 | 58,87,340 | 61,40,757 | 69,76,102 | 64,45,612 |
| | Rs. | | | | | | | |
| 31. Others | Rs. | 1,75,86,603 | 1,56,98,393 | 1,01,82,675 | 1,64,20,763 | 1,41,36,716 | 1,43,76,640 | 1,86,82,272 |
| 32. Electricity Produced | Kwh | - | - | - | - | 1,58,43,953 | 1,69,87,979 | 1,92,44,830 |
| | Rs. | | | | | | | |
| Total | | 19,82,73,998 | 26,01,63,905 | 21,37,87,314 | 23,03,53,317 | 28,71,14,642 | 33,23,23,617 | 37,34,13,257 |

Table 6.5 : Value Proportions of Different Dye-Groups in the Total Production (1960-1966) at 1966 Prices

| | 1960 | 1961 | 1962 | 1963 | 1964 | 1965 | 1966 |
|--|---------|---------|---------|---------|---------|---------|---------|
| 1. Acid Azo Dyes | .017190 | .023433 | .031174 | .008103 | .007985 | .012087 | .009969 |
| 2. Basic Azo Dyes | .000713 | .000233 | .000283 | .001316 | .000633 | .000851 | .000433 |
| 3. Direct Dyes other than Congo Red | .136546 | .103751 | .090564 | .071452 | .052236 | .048367 | .064406 |
| 4. Congo Red | .003481 | .011962 | .017843 | .008201 | .006790 | .009073 | .004962 |
| 5. Naphthols | .027849 | .113313 | .120957 | .080035 | .067891 | .094338 | .086462 |
| 6. Fast Colour Bases | .062889 | .039008 | .044397 | .039935 | .036392 | .041122 | .033464 |
| 7. Fast Colour Salts | .004588 | .003649 | .001603 | .001545 | .001883 | .001746 | .001271 |
| 8. Rapid Fast Dyes | .008554 | .066908 | .010021 | .006782 | .007515 | .005574 | .006873 |
| 9. Rapidogen Dyes | .009129 | .006227 | .010861 | .005626 | .004702 | .003741 | .003161 |
| 10. Ink Blue | .000107 | .006354 | .009359 | .009064 | .008484 | .008282 | .005628 |
| 11. Methylene Blue | .000065 | .007399 | .003625 | .007271 | .005834 | .003419 | .004764 |
| 12. Myrobalan extract | .001840 | .001883 | - | .001120 | .000324 | .000735 | .001671 |
| 13. Stabilised Azoics | .002395 | - | .002189 | - | .001141 | .001438 | .001724 |
| 14. Indigo Vat Dyes | .001457 | .000278 | .080033 | .000314 | .000505 | .004420 | .007261 |
| 15. Other Vat Dyes | .255090 | .196618 | .147371 | .221679 | .251831 | .210811 | .235015 |
| 16. Solubilised Vat Dyes | .057203 | .035221 | .045959 | .047926 | .047679 | .048127 | .044791 |
| 17. Sulphur black | .037245 | .032018 | .039123 | .047674 | .038344 | .028993 | .020912 |
| 18. Sulphur Dyes other than Sulphur black | .000219 | .000713 | .000542 | .001334 | .000868 | .000406 | .009987 |
| 19. Acid dyes other than acid azo dyes | .007357 | .008744 | .007613 | .008281 | .007619 | .010983 | .005774 |
| 20. Basic dyes other than basic azo | .013296 | .005627 | .006962 | .019384 | .022181 | .022708 | .017861 |
| 21. Modern Dyes incl. alizeriul | - | - | - | - | - | - | .000621 |
| 22. Chrome Dyes | .001580 | .012444 | .000547 | .000007 | .000244 | .000038 | .000057 |
| 23. Acetate rayon Dyes | .000697 | .000689 | .000504 | .000044 | .000250 | .001693 | .000145 |
| 24. Lakes, Pigments, Toners and Spirit Sol. Dyes | .071117 | .098401 | .121207 | .152763 | .148426 | .150105 | .150621 |
| 25. Other Dyes | .106569 | .195262 | .002012 | .032772 | .040325 | .025188 | .024721 |
| 26. Optical Whitening Agents | - | .032174 | .033814 | .045540 | .054711 | .062479 | .090829 |
| 27. Synthetic Resin Binders | - | - | .047198 | .055496 | .056488 | .091386 | .074427 |
| 28. Pigment Emulsions | - | - | - | - | - | - | .007690 |
| 29. Drugs and Pharmaceuticals | .080439 | .080759 | .071770 | .049679 | .077889 | .067293 | .030831 |
| 30. Others | .088698 | .060340 | .047629 | .071285 | .050073 | .043261 | .050031 |

Table 6.6 : Behaviour of Flow Coefficients at a More Aggregative Level at 1966 Prices (A.S.I. data)

| Sr. No. | Name of the Input Group | Value of input per rupee worth of final product (at 1966 prices) | | | | | | |
|---------|---|---|---------|---------|---------|----------|---------|---------|
| | | 1960 | 1961 | 1962 | 1963 | 1964 | 1965 | 1966 |
| I. | Acetylating, Methalating products | .019605 | .022892 | .023011 | .026406 | .023247 | .022582 | .022706 |
| II. | Inorganic Acids and their raw materials | .023565 | .015755 | .025104 | .023922 | .027105 | .026622 | .023387 |
| III. | Alkalies | .010556 | .023342 | .030289 | .025491 | .0174282 | .021951 | .023179 |
| IV. | Inorganic chemicals other than alkalies | .003142 | .009358 | .012081 | .012924 | .009969 | .011635 | .013497 |
| V. | Di-amino Stilbene Disulphonic acid | - | - | - | - | - | .009096 | .007522 |
| VI. | Cynuric chloride | - | - | - | - | - | .005635 | .005024 |
| VII. | Solvents | .009782 | .003733 | .003045 | .002142 | .004102 | .004217 | .007670 |
| VIII. | Anthraquinone based products | .015425 | .012642 | .015754 | .014414 | .030724 | .029539 | .027771 |
| IX. | Phenols and Amino compounds | .028799 | .030616 | .029194 | .022297 | .023807 | .027405 | .026783 |
| X. | Polymers and Resins | - | - | - | - | - | .020166 | .032583 |
| XI. | Final Dyes | .194065 | .060428 | .076379 | .076109 | .059356 | .067552 | .096239 |
| XII. | Others | .262880 | .186593 | .221750 | .244446 | .247188 | .223009 | .222187 |

and the flow coefficients have been computed for these groups of raw material inputs. These coefficients have been separately presented in Table 6.6. It is seen that despite the changing product-mix, these coefficients are fairly stable over the years. For the three inputs viz. Diamino Stilbene Disulphonic Acid, Cynuric Chloride and Polymers and Resins, the inputs are zero upto 1964 and are fairly stable for the last two years. This is because of the Pigment Emulsions and Synthetic Resin Binders introduced in the product-mix in the later years. These products are not actually dyes but products that are used along with pigments as catalysts. In order to find out the extent of variation in the coefficients in this aggregated Table, Standard Deviations and Coefficients of Variations were computed and these have been presented in Table 6.7. It can be seen that out of the 12 observations, significant variation is seen in only two of them, which could be attributed to a great jump in the production of synthetic resin binders, pigment emulsions and pigments in later years, or partly due to some error in aggregation. But for the two observations, the coefficients are stable. Thus it is evident that at a more aggregative level, we can get stable flow-coefficients for the dyestuff industry. This means that the flow coefficients remain the same irrespective of the size of the firm. This finding has also been confirmed by the author's field investigations by means of personal interviews of managers, chemists and other concerned

Table 6.7 : Standard Deviations and Coefficients of Variations with respect to Flow Coefficients at an Aggregative Level

| | No. of Observations | Mean | Standard Deviation | Coefficient of Variation |
|----|---------------------|--------|--------------------|--------------------------|
| 1 | 7.0000 | 0.0229 | 0.0018 | 0.0798 |
| 2 | 7.0000 | 0.0236 | 0.0035 | 0.1477 |
| 3 | 7.0000 | 0.0217 | 0.0058 | 0.2667 |
| 4 | 7.0000 | 0.0253 | 0.0373 | 1.4724 |
| 5 | 2.0000 | 0.0083 | 0.0008 | 0.0947 |
| 6 | 2.0000 | 0.0053 | 0.0003 | 0.0573 |
| 7 | 7.0000 | 0.0050 | 0.0025 | 0.5116 |
| 8 | 7.0000 | 0.0209 | 0.0074 | 0.3550 |
| 9 | 7.0000 | 0.0270 | 0.0028 | 0.1026 |
| 10 | 2.0000 | 0.0264 | 0.0062 | 0.2354 |
| 11 | 7.0000 | 0.0900 | 0.0440 | 0.4890 |
| 12 | 7.0000 | 0.2297 | 0.0228 | 0.0994 |

experts in the industry. The differences in individual firms' inputs as seen by us in Chapter V are primarily accounted for by the changing output pattern in response to the current market and technical situation.

6.7 Capital Per Unit of Output

However, if we look at the capital per unit of output, we find that it increases at a faster rate with the growth in the size of the firm as may be seen from Table 6.8.

Table 6.8 : Capital-Output Ratios

| Year | Fixed Capital* (Rs. Lakhs) | Value of Output at Constant Prices (Rs. Lakhs) | Capital-Output Ratio at Constant Prices |
|------|-------------------------------|---|--|
| 1960 | 1213.96 | 1899.62 | 0.6390 |
| 1961 | 1421.85 | 1999.99 | 0.7109 |
| 1962 | 1683.22 | 1699.16 | 0.9906 |
| 1963 | 2087.67 | 1803.04 | 1.1578 |
| 1964 | 3205.28 | 2280.21 | 1.4056 |
| 1965 | 4378.28 | 2268.98 | 1.9296 |
| 1966 | 4481.81 | 2535.60 | 1.7675 |

*Adjusted for depreciation and prices.

Source : Computed from A.S.I. data.

6.8 Wages Per Unit of Capital and Per Unit of Output

During the same period it is seen that there is a declining trend in the wages per unit of capital as also wages per unit of output as can be seen from Tables 6.9 and 6.10.

Table 6.9 : Wages Per Unit of Capital

| Year | Fixed Capital Employed* (Rs. Lakhs) | Wages ** (Rs. Lakhs) | Wages per Unit of Capital |
|------|---|-------------------------|---------------------------------|
| 1960 | 1213.96 | 72.68 | 0.0599 |
| 1961 | 1421.85 | 82.82 | 0.0582 |
| 1962 | 1683.22 | 62.39 | 0.0371 |
| 1963 | 2087.67 | 76.23 | 0.0365 |
| 1964 | 3205.28 | 72.20 | 0.0225 |
| 1965 | 4378.28 | 88.97 | 0.0203 |
| 1966 | 4481.8 | 82.51 | 0.0184 |

*Adjusted for depreciation and prices.

**Converted to constant prices by adjusting with the Cost of Living Index for Industrial Workers.

Source : Computed from A.S.I. data.

Table 6.10 : Wages Per Unit of Output

| Year | Value of Output at Constant Prices (Rs. Lakhs) | Wages at Constant Prices (Rs. Lakhs) | Wages per Unit of Output |
|------|---|---|--------------------------------|
| 1960 | 1899.62 | 72.68 | 0.0382 |
| 1961 | 1999.99 | 82.82 | 0.0414 |
| 1962 | 1699.16 | 62.39 | 0.0367 |
| 1963 | 1803.04 | 76.23 | 0.0422 |
| 1964 | 2280.21 | 72.20 | 0.0316 |
| 1965 | 2268.98 | 88.97 | 0.0392 |
| 1966 | 2535.60 | 82.51 | 0.0325 |

Source : Computed from A.S.I. data.

From the above Tables it could be inferred that Capital per unit of output as a function of time has been increasing while wages per unit of capital as also per unit of output show a declining trend despite fluctuations in some years. Of course, the time series data available is only for 7 years. If the data could be available for a longer period, definite trends could be established. Because of the data limitation, it is difficult to ascertain the trend.

6.9 Capital-Output and Capital-Value Added Ratios

Apparently one would be inclined to infer from the above data that with the growing size of the firm, there is a substitution between capital and labour because of the

higher capital-output ratio for the growing size of the firm and also a much higher capital-value added ratio as can be seen from the Table 6.11.

Table 6.11 : Capital-Value Added Ratios

| Year | Capital Employed* (Rs. Lakhs) | Value Added (Rs. Lakhs) | Capital/ Value Added |
|------|----------------------------------|----------------------------|-------------------------|
| 1960 | 1213.96 | 673.36 | 1.8028 |
| 1961 | 1421.85 | 925.23 | 1.5367 |
| 1962 | 1683.22 | 741.74 | 2.2692 |
| 1963 | 2087.67 | 717.13 | 2.9111 |
| 1964 | 3205.28 | 812.44 | 3.9452 |
| 1965 | 4378.28 | 940.08 | 4.6572 |
| 1966 | 4481.81 | 1171.79 | 3.8247 |

* Adjusted for depreciation and prices.

Source : Computed from A. S. I. data.

The increasing capital-output ratio and capital-value added ratio with a growing size of the firm is also observed for the firm-wise study made by the author, the results of which are presented in Table 6.12.

6.10 Relation between Output and Capital Employed

To investigate the relation between output and the capital employed, a case study of a leading firm was undertaken. Data for the growth of capital employed and output for the ten years upto 1972 for this firm are presented in Table 6.13.

Table 6.12 : Capital-Output and Capital-Value Added Ratios for the Individual Firms Studied

| Firm | Capital* Employed (Rs.) | Value of Output (Rs.) | Value Added (Rs.) | Capital/ Output | Capital/ Value Added |
|----------------|-------------------------------|-----------------------------|-------------------------|--------------------|----------------------------|
| F ₁ | 1,49,08,390 | 6,04,81,000 | 3,04,75,414 | 0.2464 | 0.4892 |
| F ₂ | 2,83,92,544 | 6,88,16,360 | 3,44,93,478 | 0.4126 | 0.8231 |
| F ₃ | 6,62,27,000 | 11,34,75,584 | 4,99,45,713 | 0.5836 | 1.3254 |
| F ₄ | 8,92,78,537 | 12,26,87,994 | 3,64,51,133 | 0.7276 | 2.4492 |

*Capital here refers only to plant and machinery.

Source: Field survey data.

Table 6.13 : Capital Employed and Output for the Years 1963 to 1972 for a Single Firm

| Year | Capital Employed* (Rs. Crores) | Value of Output (Rs. Crores) |
|------|-----------------------------------|---------------------------------|
| 1963 | 2.5941 | 2.6272 |
| 1964 | 4.3186 | 2.9059 |
| 1965 | 4.6651 | 4.3857 |
| 1966 | 5.2749 | 5.7968 |
| 1967 | 5.7906 | 7.2357 |
| 1968 | 6.2853 | 8.5270 |
| 1969 | 6.3521 | 10.5949 |
| 1970 | 6.5010 | 13.2699 |
| 1971 | 7.0945 | 14.8916 |
| 1972 | 9.0657 | 14.8070 |

*Capital refers only to value of plant and machinery.

Source : Case study data.

An exponential function relating the output to capital was fitted to the data presented in Table 6.13. The exponential relationship of the form $A = KB^X$ shows that the rate of return can be taken as 14 per cent per unit of capital employed. The statistical test of significance shows that there is a significant positive correlation between capital and output at 1 per cent level.

6.11 Behaviour of Factor Proportions for the Growing Size of Aggregate of Firms (A.S.I. Data)

To investigate the behaviour of capital and labour coefficients for the growing size of the firm, the Annual Survey of Industries Data for the years 1960-66 with respect to fixed capital, wages and output has been analysed. Annual Survey of Industries' capital figures are adjusted for depreciation and prices as explained earlier in this chapter. Figures of output and wages have been deflated by wholesale price index for dyeing materials and cost of living index for industrial workers, respectively. The adjusted data on capital, wages and output with respect to the Annual Survey of Industries and the individual industries are presented in Table 6.14.

To the data presented in Table 6.14, regression was fitted for $\log \left(\frac{K}{W} \right)_t = \alpha + \beta \log O_t$ where K is capital, W is wages and O is output. The results are given below :

Table 6.14 : Behaviour of Capital, Wages and Output in the Dyestuff Industry (1960-66)

| Year | Capital Employed (Rs. lakhs) | Wages (Rs. lakhs) | Value of Output (Rs. lakhs) |
|------|---------------------------------|----------------------|--------------------------------|
| 1960 | 1213.96 | 72.68 | 1899.62 |
| 1961 | 1421.85 | 82.82 | 1999.99 |
| 1962 | 1683.22 | 62.39 | 1699.16 |
| 1963 | 2087.67 | 76.23 | 1803.04 |
| 1964 | 3205.28 | 72.20 | 2280.21 |
| 1965 | 4378.28 | 88.97 | 2668.98 |
| 1966 | 4481.81 | 82.51 | 2535.60 |

Source : Government of India, Annual Survey of Industries, Central Statistical Organisation, New Delhi.

| Intercept (α) | Slope (β) | R ² | F (ratio) | D. W. Statistic |
|---------------------------|----------------------|----------------|--------------|--------------------|
| -12.91903 | 2.13616 | .5786 | 6.86 | 1.37 |

Standard Errors of β Coefficients: 0.81530

The elasticity of $\left(\frac{K}{W}\right)$ with respect to output is derived from the original equation $\frac{K}{W} = aO^\beta$. That is $\log\left(\frac{K}{W}\right) = \alpha + \beta \log O$ and denoting $Y = \log\left(\frac{K}{W}\right)$, $\alpha = \log a$ and $X = \log O$.

Elasticity of $Y = aX^\beta$ is computed as follows:

$$\text{Elasticity} = \frac{dy}{dx} \times \frac{X}{Y} = \beta a x^{\beta-1} \times \frac{1}{a} \cdot x^{1-\beta} = \beta.$$

Therefore β is the coefficient of elasticity. Where this is negative, it means that the ratio of (K/W) declines as output increases. Output here is taken to represent the

size of the firm. Thus a growing output indicates the growing size of the firm. Therefore, the above function has been fitted to find out the elasticity of (K/W) with respect to the growing size of the firm/industry.

The results presented above therefore indicate that there is a substitution between capital and labour, with either increasing size or the coming of new firms.

6.12 Behaviour of Factor Proportions for the Individual Firms (Balance Sheet Data)

The same function was fitted to the Balance Sheet data of six leading firms for ten years (1965 to 1974). The data on gross fixed capital, wages and salaries and value of output have been adjusted with the help of index of capital, cost of living index for industrial workers and wholesale price index for dyeing materials respectively. Instead of physical labour, wages at constant prices have been taken to take care of the highly paid workers in bigger firms in this industry. The adjusted data for the six firms in Appendix Tables at the end of this chapter.

The regression results are presented in Table 6.15.

Since auto-correlation was high for firms II to V, necessary adjustments were made and the adjusted results are presented in Table 6.16.

It is seen that R^2 is not significant excepting for firm VI. As such no conclusions can be drawn for firms I to V. The data for firm VI indicates a substitution of labour for capital.

Table 6.15 : Regression Results for Six Firms Data for the Years 1965 to 1974

| Regression | Intercept α | Slope β | R^2 | F (ratio) | D. W. Statistic | Auto Correlation |
|------------|-----------------------|-----------------------|-------|--------------|--------------------|---------------------|
| Firm I | 6.29846 | -0.41503 (0.18958) | .3746 | 4.79 | 1.39 | 0.30588 |
| Firm II | 4.32301 | -0.31024 (0.14108) | .3767 | 4.38 | 0.65 | 0.67579 |
| Firm III | 6.16399 | -0.47255 (0.14637) | .5658 | 10.42 | 0.66 | 0.66864 |
| Firm IV | 3.14669 | -0.04540 (0.10819) | .0215 | 0.18 | 0.97 | 0.51425 |
| Firm V | 5.08784 | -0.52238 (0.18567) | .4974 | 7.92 | 0.64 | 0.68103 |
| Firm VI | 3.72007 | -0.19789 (0.05461) | .6170 | 12.89 | 2.16 | -0.07761 |

Note: Figures in brackets are standard errors of β coefficients.

Table 6.16 : Regression Results Adjusted for Auto-Correlation for Firms II to V

| Regression | Intercept α | Slope β | R ² | Auto correlation |
|------------|-----------------------|-----------------------|----------------|------------------|
| Firm II | 0.55370 | -0.01250 (0.02019) | .0519 | 0.09998 |
| Firm III | 0.79575 | 0.00441 (0.02107) | .0623 | 0.21973 |
| Firm IV | 0.92381 | -0.44449 (0.08612) | .0367 | 0.38696 |
| Firm V | 0.31651 | -0.03849 (0.08527) | .0283 | 0.82875 |

Note: Figures in brackets are standard errors of β coefficients.

The results for the pooled data of six firms for 10 years (60 observations) and aggregated data of firms I to VI by fitting the same function are presented in Table 6.17.

Table 6.17 : Regression Results for Six Firms Pooled Data and Aggregated Data for the Years 1965 to 1974

| Regression | Intercept α | Slope β | R ² | F (ratio) | D. W. Sta- tistic | Auto- corre- lation |
|------------------------------------|-----------------------|-----------------------|----------------|--------------|-------------------------|---------------------------|
| Pooled (60 obser- vations) | 3.12605 | -0.07215 (0.05144) | .0328 | 1.97 | 0.24 | 0.88136 |
| Aggregated for firms I to VI | 6.55158 | -0.47170 (0.1352) | .6034 | 12.17 | 0.69 | 0.65715 |

Note: Figures in brackets are standard errors of β coefficients.

After adjusting for auto-correlation, the results are presented in Table 6.18.

Table 6.18 : Regression Results for Six Firms Pooled and Aggregated Data After Adjusting for Auto-Correlation

| Regression | Intercept α | Slope β | R^2 | Auto-correlation |
|-----------------|-----------------------|-----------------------|-------|------------------|
| Pooled data | 0.14500 | 0.16976 (0.10758) | .0419 | 0.42655 |
| Aggregated data | 0.90541 | -0.06962 (0.11993) | .4593 | 0.65613 |

Note: Figures in brackets are standard errors of β coefficients.

It is seen that for pooled data, when the auto-correlation is almost removed, R^2 becomes not significant. Even to begin with it was not significant. Therefore, these results can give no conclusion. In the aggregated data of six firms we get R^2 or F significant, though an evidence of auto-correlation is there. This auto-correlation is not removed in the first iteration though significance of R^2 is removed. Therefore no conclusion can be drawn from this.

6.13 Elasticity of Substitution between Capital and Labour

From the above results, it is seen that for A.S.I. data, there is a tendency of substitution between capital and labour, but for firm VI (the only case where R^2 is significant),

there is a substitution of labour for capital. Hence no conclusions can be drawn about the substitution between capital and labour as the size of the firm grows.

Table A_{6.1} : Behaviour of Capital, Wages and Output for Firm I (1965-74)

| Year | Capital Employed (Rs. lakhs) | Wages (Rs. lakhs) | Value of Output (Rs. lakhs) |
|------|------------------------------|-------------------|-----------------------------|
| 1965 | 1271.07 | 34.90 | 718.70 |
| 1966 | 1460.63 | 35.44 | 655.47 |
| 1967 | 1522.60 | 47.02 | 611.01 |
| 1968 | 1554.75 | 42.93 | 820.86 |
| 1969 | 1607.61 | 43.31 | 955.41 |
| 1970 | 1670.99 | 47.01 | 976.65 |
| 1971 | 1717.43 | 55.13 | 1008.38 |
| 1972 | 1742.01 | 64.02 | 1296.31 |
| 1973 | 1798.75 | 70.27 | 1131.11 |
| 1974 | 1861.56 | 69.89 | 880.54 |

Source : Computed from Balance Sheet Data.

Table A_{6.2} : Behaviour of Capital Wages and Output for Firm II (1965-74)

| Year | Capital Employed (Rs. lakhs) | Wages (Rs. lakhs) | Value of Output (Rs. lakhs) |
|------|------------------------------|-------------------|-----------------------------|
| 1965 | 193.87 | 20.36 | 522.46 |
| 1966 | 213.51 | 20.43 | 486.10 |
| 1967 | 235.59 | 21.04 | 481.11 |
| 1968 | 288.33 | 22.84 | 436.01 |
| 1969 | 334.31 | 29.83 | 535.87 |
| 1970 | 441.69 | 37.50 | 547.49 |
| 1971 | 490.88 | 46.86 | 697.19 |
| 1972 | 531.79 | 53.67 | 729.67 |
| 1973 | 605.27 | 66.01 | 768.94 |
| 1974 | 695.44 | 69.39 | 497.47 |

Source : Computed from Balance Sheet Data.

Table A_{6.3} : Behaviour of Capital, Wages and Output for Firm III (1965-74)

| Year | Capital Employed (Rs. lakhs) | Wages (Rs. lakhs) | Value of Output (Rs. lakhs) |
|------|------------------------------|-------------------|-----------------------------|
| 1965 | 830.17 | 27.60 | 367.17 |
| 1966 | 877.34 | 30.53 | 429.34 |
| 1967 | 944.07 | 34.46 | 509.71 |
| 1968 | 983.15 | 38.72 | 594.76 |
| 1969 | 990.40 | 43.06 | 717.87 |
| 1970 | 1004.40 | 51.52 | 796.44 |
| 1971 | 1076.69 | 51.85 | 859.69 |
| 1972 | 1193.47 | 56.33 | 740.84 |
| 1973 | 1238.00 | 67.62 | 846.70 |
| 1974 | 1281.08 | 70.85 | 517.85 |

Source : Computed from Balance Sheet Data.

Table A_{6.4} : Behaviour of Capital, Wages and Output for Firm IV (1965-74)

| Year | Capital Employed (Rs. lakhs) | Wages (Rs. lakhs) | Value of Output (Rs. lakhs) |
|------|------------------------------|-------------------|-----------------------------|
| 1965 | 27.77 | 1.47 | 1.56 |
| 1966 | 37.50 | 1.72 | 3.47 |
| 1967 | 41.15 | 2.39 | 12.47 |
| 1968 | 42.79 | 2.80 | 21.02 |
| 1969 | 42.69 | 1.34 | 14.62 |
| 1970 | 42.89 | 1.28 | 22.20 |
| 1971 | 43.04 | 1.43 | 13.10 |
| 1972 | 47.03 | 2.85 | 31.22 |
| 1973 | 50.08 | 3.35 | 45.51 |
| 1974 | 51.75 | 3.12 | 22.82 |

Source : Computed from Balance Sheet Data.

Table A_{6.5} : Behaviour of Capital, Wages and Output for Firm V (1965-74)

| Year | Capital Employed (Rs. lakhs) | Wages (Rs.lakhs) | Value of Output (Rs. lakhs) |
|------|------------------------------|------------------|-----------------------------|
| 1965 | 389.41 | 65.76 | 485.67 |
| 1966 | 425.22 | 65.48 | 484.72 |
| 1967 | 457.79 | 68.99 | 512.74 |
| 1968 | 475.01 | 72.35 | 577.93 |
| 1969 | 480.68 | 75.22 | 629.27 |
| 1970 | 493.53 | 82.97 | 590.33 |
| 1971 | 511.39 | 96.77 | 725.96 |
| 1972 | 534.71 | 113.76 | 785.91 |
| 1973 | 562.29 | 118.13 | 790.41 |
| 1974 | 607.44 | 122.67 | 545.87 |

Source : Computed from Balance Sheet Data.

Table A_{6.6} : Behaviour of Capital, Wages and Output for Firm VI (1965-74)

| Year | Capital Employed (Rs. lakhs) | Wages (Rs.lakhs) | Value of Output (Rs. lakhs) |
|------|------------------------------|------------------|-----------------------------|
| 1965 | 358.05 | 27.87 | 266.52 |
| 1966 | 382.99 | 28.92 | 322.57 |
| 1967 | 409.13 | 30.95 | 324.14 |
| 1968 | 452.02 | 31.36 | 396.14 |
| 1969 | 483.82 | 41.28 | 470.02 |
| 1970 | 553.44 | 48.67 | 615.28 |
| 1971 | 608.71 | 52.55 | 605.70 |
| 1972 | 646.16 | 55.89 | 649.49 |
| 1973 | 690.63 | 60.84 | 647.17 |
| 1974 | 732.43 | 62.49 | 523.55 |

Source : Computed from Balance Sheet Data.

CHAPTER VII

CONCLUSION

The main findings that emerge from this study are with respect to the stability of flow-coefficients, limitations to aggregations and disaggregations and the behaviour of input-output ratios in the Dyestuff Industry.

Because of the variability and interdependability, the disaggregated input coefficients become very much dependent on the product-mix of a particular moment. As the product-mix is changing very fast in this multi-product and multi-process industry, even in the same firm, it is not possible to find fairly stable input coefficients at a very disaggregative level. With a change in the product-mix, the value added by manufacture as a percentage of the total value added changes not only between firms but also within the same firm for different dye-groups. This is because, the processes involved in the manufacture of some dyes are relatively simple while for others, they are more complex involving more stages of reactions, more sets of capital equipments, etc. However, for the industry as a whole and at a more aggregative level, the flow coefficients are fairly stable.

Thus, for this industry it cannot be maintained that you can reach more stability by further disaggregation because of :

- (1) Highly inter-connected joint products;
- (2) Linkages and cross-linkages;
- (3) Different process-routes and
- (4) By-products associated with certain processes.

We therefore arrive at two conclusions in this respect :

- (a) There is a limit to meaningful disaggregation in chemical industries beyond which it starts becoming counter productive, and
- (b) Even with the disaggregated industries, unless and until their product-mix is fairly constant, it is not possible to get stable input-structure in a disaggregative way.

As regards the behaviour of capital and labour coefficients, it is seen that A.S.I. data gives support to the hypothesis that there is a substitution between capital and labour, with either increasing size or the coming of new industries. From A.S.I. data it seems that with the increase in output, the capital intensity increases in dye-stuff industry. However, this may be due to either real technological substitution or new techniques being introduced over time, as within these 7 years the capital employed increased almost three-and-a-half times. Further, these results are suspect because of an assumption of no unutilized capacity, which is a bit far-fetched in view of the fact that the total output itself decreased 2 or 3 times during these 7 years. However, the data for firm VI gives a substitution of labour for capital, which seems contrary to expectations, and might be due to the fact that big capital investments were going on and not producing the results immediately. However, the paucity and idiosyncracies of the data do not give any firm conclusion. Thus, with the available data and

results, we cannot disprove the Leontief type hypothesis of constancy of capital and labour coefficients.

The growth of the industry is dictated by increasing capital intensity rather than the number of firms. Although a large number of small scale units have come up in this industry in India, the largest five firms account for more than 60 per cent of the output. Because of the high capital intensity, research and development in new areas can be undertaken only by larger firms. The industry has reached a saturation point excepting in the field of new sophisticated dyes and intermediates required for synthetics, plastics, etc.

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