This paper examines the influence of structural changes in manufacturing activity which occur during the industrialization process, on the relative size and composition of inventory, by the stages of fabrication. The manufacturing activity is divided into four pairs of industrial groups, according to the durability of products, end use of products, origin of supply of purchased materials, and the manufacturing process. A simple accelerator model is used to test several hypotheses. The data, annual and mostly undeflated, relate to the large scale manufacturing sector of India, 1946 (or 1950) -1963.

Value added is found to be a good proxy for output in forecasting inventory investment for a long-term plan where detailed output targets are not available. The industrial groupings help to explain the almost unchanging composition of total inventory for the entire manufacturing sector. A negative trend is evident in the purchased materials inventory relations of fast growing industrial groups, which also possess higher inventory-output coefficients.

This paper indicates the significance of planning for inventories in medium- and long-term development plans.

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Summary and Conclusions

1. Several structural changes in the manufacturing activity of a developing economy occur during the industrialization process. The manufacturing sector is classified here into four pairs of industrial groups, according to the durability of products, end use of products, origin of supply of purchased materials, and the manufacturing process. A simple accelerator model is used to determine the influence of various factors on the relative size and composition of inventory by the stages of fabrication. Several hypotheses are tested using the annual, mostly undeflated, data relating to large scale manufacturing sector of India, 1946 (or 1950) - 1963. The time-dependence of errors, multicollinearity, and heteroscedasticity are considered; and the simultaneity and errors in variables are bypassed.

ii. The present analysis leads to many interesting results though at times their implications challenge comprehension. Output and sales are found to be most important determinants of inventory level, as could be expected. They are closely followed by value added. Thus value added is likely to be a good proxy for output in forecasting inventory investment for a long-term plan where detailed output targets are not available. Of the two long-term factors -- secular trend, and average establishment size -- the former was found much more effective. This contrast may be somewhat deceptive due to the limitations of data. Among the two short-term factors -- interest rate, and price index -- the former obtained only a few significant coefficients but with a perverse positive sign. The coefficients of the latter were usually insignificant, and the sign of significant coefficients were positive for the finished products and negative for the purchased materials inventories.

iii. Analysis of four types of industrial groups shows that the fast growing groups -- durables, capital goods, mineral-based, and continuous process industries -- possess higher marginal total inventory-output coefficients than the slow growing ones -- non-durables, consumer goods, agro-based, and discontinuous process industries. Consequently, we are inclined to infer that relatively more resources for inventory investment will be needed by the Indian manufacturing sector, if industrial priorities remain unchanged. The industrial groupings also help to explain the almost unchanging composition of the total inventory for the entire manufacturing sector.

iv. The inventory composition of the groups differs widely by inventory components. Purchased materials inventory, generally the largest component, is considerably higher in the fast growing groups than in the others. A strong negative trend in the purchased materials inventory relations is evident in the durables and mineral-based industry. The capital goods industry, otherwise sharing the common characteristics of the fast growing groups, for some reason does not show such a trend in the purchased materials inventory relations in the fourteen year period, though the
negative trend is evident from the eighteen year period. The coefficients of finished products inventory relations generally support the hypothesis of a negative trend. Similarly, the work-in-process inventory-output coefficients and components validate the hypotheses, although the extent of observed distinctions among the industrial groups was not fully anticipated.
I. Introduction

1. The industrialization process is characterized by various structural changes in manufacturing activity of a developing economy. Some of these changes are revealed by the changing composition of four types of industrial product groups derived on the basis of:

(a) the durability of products; durables versus non-durables,
(b) the end-use of products; capital versus consumer goods,
(c) the origin of purchased materials; mineral-based versus agro-based, and
(d) the process of manufacture; continuous versus discontinuous. 1/

The influence of the structural changes on the inventory-output (or inventory-value added) relationships in manufacturing industry is analyzed here. Further, manufacturers' inventories are distinguished by the three stages of fabrication, that is, purchased materials, work-in-process, and finished products; and the influence of these structural changes on the composition of manufacturers' inventories is analyzed in this paper. This study, however, does not consider inventories of manufactured products or industrial raw materials in the distributive or any other sectors of an economy except manufacturing.

2. Several scholars have worked on these aspects of the Indian economy. 3/ Several scholars have worked on these aspects of the Indian economy /5, 14, 17, 19/. Sen's study, which is probably the most comprehensive, estimates working capital requirements in India during the Third Five Year Plan. It also discusses many conceptual problems involved in the identification and measurement of inventory investment. The study conducted by Krishnamurty and Sastry is the most recent and detailed. It is basically a disaggregated study of the Census of Manufacturing Industries, 1956-1958, but it is often supplemented by the Reserve Bank of India's statements on finances of public limited companies, 1950-1962. Since the findings were generally inconclusive, the authors emphasized the necessity of further research.

3. The present study is macro-economic, intertemporal, and related to the large scale manufacturing sector of India, 1950 (or 1946) to

1/ We can visualize many more types of industrial groups; and in any type we can have more than two groups. Practical considerations led to the selection of the abovementioned classification. Any such grouping of industries will, however, represent the reality only approximately, especially when the original industrial classification has aggregated industries like chemicals and chemical products, general and electrical engineering. Nonetheless, the changing composition of the manufacturing sector is empirically discernible, and many interesting inferences can be drawn, though at times on weak statistical bases.
1963. 1/ Even the annual and undated data for this short period involved meshing the two sources: first, supplying data for 29 industries for the period 1946-1958, and second, supplying data for more than 200 industries covering the period 1959-1963. This analysis uses the simple accelerator hypotheses, 2/ where inventory total or anyone of its three components by the stages of fabrication is a dependent variable, and there are seven explanatory variables (though seldom more than three in any single hypothesis). The manufacturing sector is disaggregated into the above-mentioned four pairs of industrial groups, and the data were usually undated.

1/ The first four years (1946-1949) representing the pre-planning period were often relegated due to more frequent failures in the homogeneity tests, non-availability of work-in-process inventory data, and high non-response in the first two years. The loss of precious four degrees of freedom was the main consideration in going back to 1940.

2/ Flexible accelerator hypotheses and ratio hypotheses, used by the present author in an earlier study [18], do not generally lead to more statistically significant results.
and procedures /3, 4, 9, 13/, including a rule of thumb, have been rigorously followed, though it should be recognized that econometric theory is still not well advanced to treat these statistical problems simultaneously, particularly when there are only a few time-series observations.

Hypotheses

5. The acceleration principle in its simplest form in the present context postulates that the manufacturers succeed in maintaining their inventory total or its components, at an equilibrium level $Y^*$ which is linearly related to actual output level $X_1$ or sales $X_0$ in an industry.

\[ Y^* = b_0 + b_1 (X_0 \text{ or } X_1) + e, \quad b_1 > 0 \]

\[ Y^* = b_0 + b_1 X_{1t} + e, \quad b_1 > 0 \]

6. In the present study several other factors are also considered within the framework of the simple acceleration principle. The time, $T$, is one of them. It is considered as a proxy variable representing the influence of numerous secular changes. Standardization and specialization in production, improvements in transportation and communications, economies of scale, change from a single to multiple shifts operation, horizontal or vertical integration of firms, integration of markets from local to regional to national, and substitution of capital-intensive modern technology for labor-intensive traditional technology, together with the introduction of modern techniques of inventory management will possibly tend to reduce the relative size of inventories in the long run during the industrialization process of an economy. On the other hand, the uncertainty in supply often created by chronic foreign exchange scarcity, higher returns resulting from persistent inflation, diversification of products without standardization, greater dispersion of consumer markets, increasing proportion of durables or capital goods or mineral based manufactured goods, teething troubles in newly established industrial plants, and so on are liable to increase the relative size of inventory holdings. /1/ We presume that the secular trend should be negative in general, unless we have supporting evidence to the contrary.

\[ Y^* = b_0 + b_1 (X_0 \text{ or } X_1) + b_2 T + e, \quad b_1 > 0, \quad b_2 < 0 \]

7. A scanning of the inventory management and operations research literature reinforces the contention of economies of scale in inventory holdings /1, 207/. A widely known Indian materials management expert, consultant to numerous large manufacturing corporations in India, told me that he "strongly recommends the well known 'square root' formula as a rule of thumb to his clients and to trainees in the management seminars". The

/1/ Initially, we experimented with an index of foreign exchange reserves that assumed to represent the foreign exchange scarcity. All the coefficients were statistically insignificant and had mixed signs. The related conceptual and methodological problems, and limitations are discussed in /187/.
II. Formulation of the Hypotheses

Symbols

A. Dependent Variables

\( Y_1 = \text{materials and products inventory} = Y_3 + Y_4 \)
\( Y_2 = \text{total inventory} = Y_3 + Y_4 + Y_5 \)
\( Y_3 = \text{purchased materials inventory} \)
\( Y_4 = \text{finished products inventory} \)
\( Y_5 = \text{work-in-process inventory} \)

B. Explanatory Variables

\( X_{0t} = \text{sales} = X_1 t + Y_{4t-1} - Y_{4t} \)
\( X_1 = \text{ex-factory value of output} \)
\( X_4 = \text{value added (gross of depreciation)} \)
\( E = \text{average establishment size (output or value added per establishment)} \)
\( I = \text{short-term interest rate at the end of a year} \)
\( P_1 = \text{average annual wholesale price index} \)
\( T = \text{time or secular trend} \)

Econometric Problems

4. Econometric methods available to analyze small samples of observations are fairly restrictive, and their limitations become all the more stringent if one has to deal with time-dependent variables when any one or more of the standard assumptions of the linear estimation theory may not be valid or applicable. As expected, the study encounters the statistical problems arising from serial correlation, heteroscedasticity, multicollinearity, observational errors, and simultaneity bias. Standard statistical tests

1/ All the stock variables presumably refer to December 31 of a year, observations are annual, and money values are in rupees (million), suffix 't' represents current period, but is generally omitted; Y may refer to inventory, total or any of its components; and '*' represents the desired value.
same formula has been found "to have adequate practical value" by another expert in India (27). Since this rule is based on fairly restrictive assumptions, we used the average establishment size as a surrogate measure of the economies of scale. Hence, a priori negative sign of coefficient of average establishment size (S) is assumed.

\[ Y = b_0 + b_1 X + b_2 S + e, \quad b_1 > 0, \quad b_2 < 0. \]

The monetary variables -- interest rate, and money supply -- may influence the inventory not so much directly as indirectly through real variables like the national product, prices, unfilled orders, output. If so, their influence is underestimated and poses a serious problem in the measurement. However, the interest rate is likely to be more significant in a developing economy than in a developed one. In the former, capital markets are much less organized, imperfections are usually more widespread, investment funds are more scarce, and free market (non-institutional) interest rates are relatively high. Further, interest as a component of the cost of holding inventory is expected to be higher in a developing economy due to comparatively low costs of rent and depreciation in storage and warehousing, and less risk of obsolescence. The interest rate used in this study is represented by the State Bank of India's prime rate. Its coefficient is assumed to be negative, since interest is an element of cost.

\[ Y = b_0 + b_1 X + b_2 I + e, \quad b_1 > 0, \quad b_2 < 0. \]

Most manufacturers are not likely to hoard inventories with a view to reselling at an anticipated higher price at some future date; but are likely to hoard for the sake of minimizing their future cost of production whenever a rise in the price of inputs is expected. As we have no anticipation data, we cannot adequately test the influence of price speculation. Moreover, speculation is basically a short-run phenomenon, and monthly or quarterly data, instead of annual data that is used here, would

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1/ For instance, in Monhollon's study the coefficients of money supply were insignificant and had perverse sign (27). In initial computer runs we used money supply, but abandoned it later due to insignificant coefficients. Since the large scale manufacturing sector constitutes only 10-15 percent of the monetized Indian economy, the results were not surprising. Moreover, the sophistication of the working of Indian monetary policy, that is, two-three-four tier system of lending rates, to the scheduled banks, and selective credit control, etc., might have invalidated the significant results.
be more appropriate. Nonetheless, we attempted to examine the influence of the speculative motive on inventory holding, by using the current year's ex-post price index (PI), since inflation has been a common feature on the Indian economy. We assume that a positive sign of the coefficient of the price index indicates correct price anticipation and a negative sign implies perverse anticipation.

\[(7) \ y^* = b_0 + b_1 (X_1 \ or \ X_4) + b_2 \ PI + e, \ b_1 > 0, \ b_2 > 0.\]

III. Significance and Limitations of Industrial Groups

10. It is customary to study inventory relationships not only for the total output of manufacturing sector but also for its sub-divisions by the durability of products. The product-mix of a manufacturing sector tends to change in favor of durable goods as a concomitant of the industrialization process. Another classification with similar implications subdivides the manufacturing output by the end use of products. This product-mix changes

1/ Nonavailability of monthly or quarterly data was the main reason for not using a lagged price index. The time-lags, however, may be longer in developing than in a developed economy due to more imperfections in product and capital and other factor markets, more barriers in communications and transportation, greater scarcity of capital, smaller and fragmented markets, and so on.

2/ Inflation may lead to a frequent revaluation of inventories, but no consideration has been given to this problem due to a complete absence of the information.

3/ The speculative holding of inventories does not depend solely on the expected higher price level or rate of price rise of a particular input or product, but on the excess of anticipated price rise over the cost of holding inventory. As long as the cost is constant, it does not create any problem in applying a linear model. But if cost is a nonlinear function of price, we cannot easily adhere to the assumptions of linear estimation theory. In a developing economy like India with continuous all round inflation, cost of inventory holding just cannot remain constant. This may be a general limitation of macroeconomic inventory models.

4/ There are many reasons for the rising share of durable goods in the manufacturing activity of a developing economy. They stem both from the demand as well as supply considerations. In the context of Indian industrialization, a special reason, viz., the strategy of economic planning adopted by the Planning Commission in favor of the heavy industry, can also be advanced.
in favor of capital goods. The significance of these two classifications may be viewed from various angles.

11. First, manufactured goods may be either made to order or to stock. The durable or capital goods comprise a much larger share of goods made to order than to stock as compared to the nondurable or consumer goods industries. The finished products inventory, ceteris paribus, must be relatively more for goods made to stock than to order. But the purchased materials inventory may be considerably more in a developing economy than in a developed one, where materials are not available on tap as in the latter. Tangible and intangible losses due to the delay in execution or cancellation of customer's orders may exceed the gain, if any, in not holding purchased materials inventories until a customer's order is received. The work-in-process inventory on the other hand, may be governed mainly by the extent of technological sophistication involved in manufacturing, continuous versus discontinuous manufacturing process, uncertainty in future orders, and efficiency of internal organization of an enterprise. Consequently, the relative size of the work-in-process inventory is likely to be more for goods made to order.

12. Any direct or precise estimate of the relative volumes of manufactured goods made to order and to stock is extremely difficult. Two qualifications must be made here. The product-mix of the made to order group is a fluid one, and a manufacturing concern is usually a multi-product firm with its output partly made to order and partly made to stock. Further, some products may change their category, especially in a seller's market that usually prevails in India.

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1/ Usually products are classified into capital, intermediate, and consumer goods. The aggregative nature of the data limited our classification to two categories, capital and consumer goods. Intermediate industries have been classified by their anticipated end use.

2/ One can list predominantly 'made to order' industries. These include industrial machinery for cement, sugar, or tea manufacturing, boilers, haulages, railways' rolling stock, ships, airplanes, and machine tools. The products of public sector projects such as Heavy Engineering, and Heavy Electricals, are also usually made to order. All these products are of recent origin in India.

2/ New industries may enter and old may exit. In the developing phase of an industry, when its market may be small or it may lack a reputation among prospective customers, entrepreneurs may produce 'to order' only. But as the industry establishes and its market expands, it may start manufacturing 'to stock'. The experience of the Indian cotton textile machinery industry supports this contention.
13. Second, industrialization also implies use of more sophisticated technology. Changeovers from simple industries like flour or rice milling to sophisticated industries like preservation or canning of food, from boat building to shipbuilding, from light electrical goods to heavy electrical equipment, and from steel making to heavy machine building, illustrate the point. Moreover, during industrialization the product-mix diversifies, design and production become more complex, the variety of purchased materials increases, and customers require delivery more promptly. As a result, both the production period, and the cost of production smoothing tend to rise. Consequently, the relative size of total inventory, in general, and that of the work-in-process, in particular, may rise.

14. Third, and this is implied by the second point, there is an increasing reliance on multiple production stages or on a discontinuous manufacturing process. Even though the most modern technology may be adopted in establishing these plants, the capital-intensity (incremental fixed capital-labor ratio) tends to decline, since the processing involves relatively more supervision, operation, and handling by technologists, operatives, and skilled labor. The work-in-process inventory to output ratio tends to rise, since when a production process involves successive stages, buffer-stocks may be kept 'between stages' besides 'within stages'.

15. Finally, an implication of rapid industrial development, often overlooked, is the increased under-utilization of installed capacity. The under-utilization may arise for two main reasons. New industries are often believed to have considerable economies of scale and so a plant is installed with the realization that it may remain partially idle for some years to come. Moreover, the introduction of modern plants, embodying new and sophisticated technology and operating on a large scale, usually face 'teething troubles'. Both these factors may increase the purchased materials and work-in-process inventories relative to the low output levels.

16. In contrast to the abovementioned two classifications based primarily on the economic considerations, our next two classifications are derived mainly from technological considerations. The first classification is according to the industrial origin of principal purchased materials which may be either agricultural or mining. However, many manufacturing industries do not process a primary produce, and heavily rely for their inputs on manufacturing industries. In fact, this is an essence of industrialization where adaption of more and more round-about methods of production and distribution generally leads to a more and more

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1/ This dichotomy refers to mainly indigenous materials, which constitute more than 90 percent of manufactures' inputs in India. Moreover, it ignores the substitution between natural and manufactured materials.
However, little information is available on the breakup of purchased materials inventory by indigenous and imported, and/or by agriculture, animal husbandry, fishery, forestry, mining, and manufacturing sectors as the sources of supply. Hence, the distinction adopted here is large, though analytically significant.

17. The supply response to an increased rate of usage of agro- and mineral-based materials may vary for a number of reasons. Agriculture crops are largely seasonal, whereas mineral production is basically perennial. Agriculture is a decentralized activity using mainly traditional production methods, whereas mining is largely organized and relies heavily on modern techniques. Moreover, agriculture supply is subject to weather hazards, whereas mineral output is generally not. Consequently, raising agricultural supplies may have a longer gestation lag than raising mineral supplies. Supply adjustments in agriculture in the short- or medium-run are extremely arduous and indefinite, and those in mining are relatively easy and definite. The purchased materials inventory, however, may be relatively small in agro-based industry for the following reasons.

(i) The larger safety margins necessitated by more uncertain supply and longer time-lags have to be maintained at a higher inventory carrying cost of agriculture materials resulting from their higher perishability, pilferage, and warehousing cost.

(ii) The trading sector plays a vital role in the supply of agro-based materials owing to their decentralized production. Thus, the bulk of inventory may be kept by traders instead of manufacturers. The former may be acting as 'buffer stock' holders for the latter, and may also be absorbing variations in inventory due to the vagaries of weather.

(iii) In contrast to mines whose location is governed by the natural resource endowment, agricultural traders may have warehouses around the consuming centers thereby reducing the delivery lag.

(iv) Institutional considerations such as price control and quota systems have a tendency to depress the relative volume of the purchased materials inventory. Agricultural commercial crops in India have been subject to these regulations to a greater extent than the minerals.

(v) Manufacturers may form a buffer stock association, and the inventory held by it is not counted in the manufacturing sector. The jute industry is an important example in India.

As a result, the proportion of manufactured products used as inputs in the manufacturing activity tends to increase over time. My computations indicate that this share has increased from 39 percent to 46 percent in the 1970s in the Indian economy.
18. The last industrial grouping is according to the nature of a manufacturing process which may be continuous, discontinuous, or mixed.1/ A continuous process industry either covers only a single stage production, or if it covers more than one stage, it does not hold buffer stock between stages. The sequential production stages in a discontinuous process industry offers choice in selecting points for holding inventories. The more such inventories are carried between stages, the less coordination is required for running the process smoothly. Hence, an enterprise's efficient internal organization can be a partial substitute for its work-in-process inventory in a discontinuous process industry. Since acute scarcity of organizational skills and their ineffective utilization may be a cause as well as an effect of underdevelopment, the work-in-process inventory may rise more with the usage of discontinuous process.2/

19. Output can be increased either by installing new plant and equipment, or by operating existing plant and equipment more intensively, for example, more days per week, more shifts (or hours) per day. The former is a capital-intensive device relative to the latter. Potential savings in fixed capital by its more intensive use have been recognized by the 'Indian planning body', but not the possible savings in inventory stocks. The installation of new plant and equipment involves, pari passu, an increase in work-in-process inventory. But with a more effective utilization of fixed capital, the work-in-process inventory-output ratio also tends to fall, though more significantly in the discontinuous process industries.

20. The distinction between continuous and discontinuous process can also be viewed from the points of 'indivisibilities' and 'fixed proportions'. A continuous process is basically indivisible, and the input-mix is relatively fixed due to its single production stage. Consequently, the work-in-process inventory-output ratio may be small and inflexible, ceteris paribus, relative to discontinuous process, where 'between stages' inventory may allow flexibility. On the other hand, the characteristics, that are instrumental in keeping the work-in-process inventory down, may raise the optimal level of purchased materials inventory. For instance, the inflexibility of the input-mix in continuous process industry may necessitate

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1/ The industries with 'mixed' manufacturing process are classified into the 'continuous' or 'discontinuous' groups according to the assumed importance of each.

2/ Actually, the significance of internal organization in a factory and efficiency of external distribution system may be more important for the inventories of purchased materials and finished products than the work-in-process inventory, since the latter is more directly affected by production process than the former. Perhaps these might be the two important reasons for the higher inventory to value added ratios obtained in a developing economy as compared to a developed one.
higher safety margins, and hence, may tend to increase the relative volume of purchased materials inventory.

IV. Results 1/

Determiants

21. The output was found to be the single most important determinant. It was invariably significant at 0.1 percent level. Even though the output appeared to have a slight edge over the sales -- in terms of 'Di', 'R2', or 't' and also in degrees of freedom -- the choice between them was arbitrary. 2/ An important weakness of the output (or sales), nonetheless, was the time-dependence of the error term, particularly in the purchased materials inventory relations. Even the high values of R2 (greater than 0.95) were of little comfort because of a high time-dependence among the errors. 3/ To circumvent this difficulty, the proxy variable time was introduced, which led to the time-independence of the error term in most cases. Alternatively, we wanted to use the average establishment size, representing the economies of scale in the long run, and thereby reducing the time dependence of the errors. But the results were not encouraging. The change in source of data in 1959, which resulted in almost 100 percent or more jump in the average establishment size, probably nullified its influence.

22. The replacement of output by the gross value added achieved little in respect to 'D0' or 'R2', and lost in 't'. These findings support the contention that it may be the output (or sales) and not the value added that enters into the inventory decisions. The value added is essentially a macroeconomist's construct, and it is instrumental neither in maximizing producers' revenue nor in minimizing their cost. The output is behavioral in the manufacturers' inventory decisions and operational in the detailed national economic planning, whereas the value added is important only in the macroeconomic long-term planning.

1/ The results of homogeneity tests are summarized in the Appendix.

2/ Lovell (17) used the output as explaining the purchased materials and work-in-process inventories, and the sales for explaining the finished products inventory. The implication is obvious, but was not discernible from our results.

3/ The latter may be indicative of some flaw in a model. In particular, a model may require an explicit recognition of some omitted variables. Often the influence of these individual variables may be too small, they may be too numerous to be accounted for in the model using a very short time-series, the data may not be available for them, or they may not be quantifiable at the present.
23. The interest rate had mostly insignificant, and a few significant coefficients, but with a perverse positive sign. The reasons seem to be the indirect and delayed effects, lack of anticipatory data, external financing through institutions other than banks at a higher interest rate, use of internal funds, variations in terms of credit availability, insensitivity to cost consideration, lack of representativeness of the interest rate, and confinement of the study to only the manufacturing sector.1/ Further, the work-in-process inventory may be less responsive to a change in the interest rate, since an enterprise may command little maneuverability over it, at least in the short-run, due to fixed factors such as plant and equipment, organization, and technology. The commitment for this inventory is often of a long-term nature, especially in the capital goods or durables, where the production lag is longer and more important in a developing economy than in a developed one.

24. The interest cost is a small fraction of the unit cost of production, though it is a major element of the inventory carrying cost. But the latter is often a hidden cost in the sense that there may be no specific account for it and its various constituents may be embedded in different accounts. This is a general feature of the Indian industry and exceptions to this rule may not be numerous.2/ Finally, such small incremental changes in the bank interest rate, one quarter or one half percent per annum -- as have occurred in India -- would hardly be influential in inventory decisions of most manufacturers, for at least three reasons:

(i) Since the changes in the interest rate have been only unidirectional, the entrepreneurs would have considered these changes as permanent rather than temporary, and as an increase in the cost of production.

(ii) Since the cost of borrowing money from banks constitutes roughly one third of the total inventory carrying cost, a change of half percentage point in the interest rate would affect the inventory carrying cost by 2½ percent (if the latter is taken at 20 percent per annum). But

1/ This study relied on a single interest rate, which was the highest rate charged by the State Bank of India on short-term loans outstanding at the end of a financial year. Hence, it was neither representative for a year nor did it represent the interest rate charged by commercial banks. These interest rates depend on a variety of considerations including nature of the security offered; age, size, and prospects of the borrowing firm as well as of industry; a borrower's reputation in financial circles; foreign collaboration; and the size of lending bank.

2/ Inventory control is still in its infancy in India, and business enterprises are not often cost conscious. It is an irony of underdevelopment that most investors are not conscious of the opportunity cost of capital.
the optimum-order quantity is relatively insensitive to small changes in
the inventory carrying cost.1/

(iii) What matters probably is the influence of a change in the
interest rate on the marginal cost of production (including inventory
carrying cost) and that would generally be too small to initiate any serious
rethinking about inventory policy.

25. Only crude price indices were used as the precise indices are not
available.2/ The coefficient of the price index was often insignificant,
and the sign of significant coefficients was usually positive for finished
products but negative for the purchased materials inventory. This means
that a manufacturer generally had correct expectations regarding the price
behavior of his finished products, but not for the purchased materials.
The prerequisites essential for successful anticipations are seldom pos-
sessed by an Indian manufacturer.3/ But why have the Indian manufacturers
more often succeeded in predicting the price movements in the finished
products than in the purchased materials? We argue as follows:

(i) A manufacturer generally keeps in touch with relatively
few markets in finished products. Hence, his knowledge, comprehension,
and analysis should be far better for his products than for the materials.

(ii) A manufacturer on the average purchases almost half of the
materials that are agricultural crops. He is in a weaker position to

1/ Both Magee 127 and Holt 167 emphasize the point that a good answer
to the problem of lot size of purchase or production order can be
obtained even with fairly crude cost data.

2/ The price indices of industrial raw materials and manufactured articles
were used in the equations of purchased materials inventory and finish-
ed products inventory respectively. These indices were combined
according to their relative weights in the Index Number of Wholesale
Prices in India (Revised Series), and the combined index was used in
the equation of total inventory. The weights were 35:65 for the in-
dustrial raw materials and manufactured articles.

3/ He faces all around market imperfections, great communication barriers,
inadequate transport facilities, and often indiscriminate government
interventions. Moreover, he may not be cost conscious either because
of his preoccupation with primitive business techniques, or because of
the protection received in a sheltered, or sellers market. Further,
he may not obtain short-term loans from banks for speculative purposes
due to legal barriers. Hence, he may be a poor forecaster, and may not
indulge in speculation. Thus, the insignificance of coefficients may
not be surprising.
anticipate prices of materials correctly, due to the vagaries of weather and speculative role of intermediaries.

(iii) His capability for influencing the product market is greater than influencing the materials market, since monopolies are more pervasive than monopsonies in the commodity markets of India.

(iv) Several major agro-based materials (particularly raw cotton, raw jute, raw silk, sugar cane) and also coal, crude oil, etc., have often been subject to government price and/or distribution controls in India. The extent of controlled commodities was possibly more among the industrial raw materials than among the finished products. Hence, the prices of finished products were more exposed to market forces, competitive or monopolistic, than those of the purchased materials. The outcome of market forces may be more predictable than that of public regulations due to their ad hoc nature.

(v) If the proportion of goods made to order is higher among the finished products than among the industrial raw materials, then the prices of finished products may be more predictable than those of the raw materials, since the former offers a greater opportunity for direct negotiations, bargaining, and adjustments.

Industrial Groups

26. The tables 1, 2 and 3 indicate many interesting characteristics of the industrial groupings. A distinction between the durables, capital goods, mineral-based, and continuous process industries on the one hand; and nondurables, consumer goods, agro-based, and discontinuous process industries on the other is apparent. The former set has grown more rapidly than the latter in terms of gross value added, output, and total inventory. (Table 1). The growth rate differentials in each pair of groups, resulting largely from the priorities assigned to them during the industrialization drive in India, are most in total inventory and least in value added. These differentials are more in the eighteen-year than in the fourteen-year period. The distinction is also visible in the relatively high marginal total inventory-output coefficients for the fast growing groups. (Table 2). Consequently, we are inclined to infer that relatively more resources for inventory investment will be needed by the Indian manufacturing sector, if industrial priorities remain unchanged. It follows that there will be a growing need for a widespread use of inventory management techniques, and the Indian plans should be more realistic in resource allocation for inventory investment.2/

1/ The output data are not presented due to similarity of results.

2/ The under-allocation of resources for inventory investment in the Indian Plans will be discussed in a separate paper.
Table 1: Growth Rates and Percentage Shares of Industrial Groups in Value Added and Total Inventory

<table>
<thead>
<tr>
<th>Industrial Groups</th>
<th>Average Annual Growth Rates</th>
<th>Percentage Shares in Total Inventory</th>
</tr>
</thead>
<tbody>
<tr>
<td>All industry</td>
<td>2.70</td>
<td>2.92</td>
</tr>
<tr>
<td>1a. Durables</td>
<td>4.40</td>
<td>6.16</td>
</tr>
<tr>
<td>1b. Nondurables</td>
<td>2.22</td>
<td>2.22</td>
</tr>
<tr>
<td>2a. Capital goods</td>
<td>3.10</td>
<td>4.04</td>
</tr>
<tr>
<td>2b. Consumer goods</td>
<td>2.46</td>
<td>2.40</td>
</tr>
<tr>
<td>3a. Mineral-based</td>
<td>4.54</td>
<td>5.88</td>
</tr>
<tr>
<td>3b. Agro-based</td>
<td>1.99</td>
<td>2.02</td>
</tr>
<tr>
<td>4a. Continuous process</td>
<td>3.83</td>
<td>4.91</td>
</tr>
<tr>
<td>4b. Discontinuous process</td>
<td>2.21</td>
<td>2.17</td>
</tr>
</tbody>
</table>

Note: Figures in brackets are deflated average annual absolute levels in rupees million.

27. The almost unchanging composition of the total inventory of 'all industry' seems intriguing, unless we look at the industrial groupings. (Table 3). As expected, the share of work-in-process inventory in 'all industry' rose by 1.2 percentage point, and that of finished products inventory fell by 1.4 percentage point, leaving thereby the share of purchased materials inventory practically unchanged. The composition remained unchanged despite a rising share of purchased materials inventory (gaining 5.0 to 8.2 percentage points), and a falling share of finished products inventory (losing 2.5 to 6.9 percentage points) among the fast growing industrial groups. The compensating changes that have occurred in the slow growing counterparts seem difficult to comprehend.

28. A special feature of the purchased materials inventory relations is a highly significant negative trend among the durables and mineral-based

\footnote{These changes are more varied. The purchased materials inventory component lost 1.1 to 7.3 percentage points, and the finished products component changed from -1.3 to +6.7 percentage points.}
Table 2. Selected Regression results: Hypothesis \( T^2 = b_0 + b_1(T1) + b_2(T1)^2 \), Data: 1950-1965

<table>
<thead>
<tr>
<th>Industry</th>
<th>( b_1 )</th>
<th>( b_2 )</th>
<th>( T )</th>
<th>( R^2 )</th>
<th>( \bar{y} )</th>
<th>( \bar{y} ) (( \bar{y} ) of Dur. Goods)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Durable Goods Industry</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.66</td>
<td>.99</td>
<td>21.0</td>
<td>.500</td>
<td>.014</td>
<td>1.97**</td>
<td>-18.9, .207**</td>
</tr>
<tr>
<td>1.51</td>
<td>.99</td>
<td>7.5</td>
<td>.139</td>
<td>-1.26**</td>
<td>1.68**</td>
<td>30.4, .186**</td>
</tr>
<tr>
<td>2.06</td>
<td>.97</td>
<td>100.1</td>
<td>.107</td>
<td>-1.57*</td>
<td>1.81**</td>
<td>-219.5, 12.4</td>
</tr>
<tr>
<td>1.63</td>
<td>.99</td>
<td>12.4</td>
<td>.107</td>
<td>-2.13*</td>
<td>1.60**</td>
<td>-0.3, .019**</td>
</tr>
<tr>
<td><strong>Capital Goods Industry</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.62</td>
<td>.99</td>
<td>23.3</td>
<td>.665</td>
<td>-5.59**</td>
<td>2.09**</td>
<td>-357.4, 1.53**</td>
</tr>
<tr>
<td>1.61</td>
<td>.99</td>
<td>24.8</td>
<td>.500</td>
<td>-3.19**</td>
<td>1.69**</td>
<td>39.1, .186**</td>
</tr>
<tr>
<td>2.03</td>
<td>.97</td>
<td>155.1</td>
<td>.107</td>
<td>-1.72*</td>
<td>1.83**</td>
<td>-300.3, 1.55*</td>
</tr>
<tr>
<td>1.82</td>
<td>.95</td>
<td>29.2</td>
<td>.056</td>
<td>-7.28**</td>
<td>1.30**</td>
<td>8.9, .019**</td>
</tr>
<tr>
<td><strong>Continuous Process Industry</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.96</td>
<td>.98</td>
<td>-29.0</td>
<td>.397</td>
<td>-0.81</td>
<td>1.08**</td>
<td>427.0, .355**</td>
</tr>
<tr>
<td>1.77</td>
<td>.96</td>
<td>-15.5</td>
<td>.750</td>
<td>-2.25**</td>
<td>2.05**</td>
<td>-112.2, .498**</td>
</tr>
<tr>
<td>1.65</td>
<td>.91</td>
<td>3.9</td>
<td>.115</td>
<td>-0.43</td>
<td>2.18**</td>
<td>78.4, .275**</td>
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<tr>
<td>1.41</td>
<td>.96</td>
<td>-15.4</td>
<td>.027**</td>
<td>-1.71</td>
<td>1.25**</td>
<td>-100.8, .618**</td>
</tr>
<tr>
<td><strong>All Industry</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.73</td>
<td>.99</td>
<td>-57.7</td>
<td>.385</td>
<td>-0.51</td>
<td>1.78**</td>
<td>489.3, 1.141**</td>
</tr>
<tr>
<td>1.76</td>
<td>.969</td>
<td>-487.3</td>
<td>.385</td>
<td>-0.51</td>
<td>1.68**</td>
<td>399.8, .098**</td>
</tr>
<tr>
<td>1.70</td>
<td>.97</td>
<td>-56.0</td>
<td>.100**</td>
<td>-0.83</td>
<td>1.85**</td>
<td>25.0, .217*</td>
</tr>
<tr>
<td>1.38</td>
<td>.958</td>
<td>-71.3</td>
<td>.235**</td>
<td>-0.71</td>
<td>1.46**</td>
<td>159.3, .525**</td>
</tr>
<tr>
<td><strong>All Industry (1966-1965)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.69</td>
<td>.99</td>
<td>-19.4</td>
<td>.166**</td>
<td>-0.97</td>
<td>1.73**</td>
<td>-171.7, 1.145**</td>
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<tr>
<td>1.56</td>
<td>.998</td>
<td>-552.2</td>
<td>.285**</td>
<td>-1.19**</td>
<td>1.60**</td>
<td>-473.8, .825**</td>
</tr>
<tr>
<td>1.51</td>
<td>.951</td>
<td>3.7</td>
<td>.107**</td>
<td>0.14</td>
<td>1.69**</td>
<td>-17.9, .100**</td>
</tr>
</tbody>
</table>

Significance Levels: Durbin-Watson Statistic (D) 0.5 percent, + 1 percent.

Notes: The tests of homogeneity were not conducted in the work-in-process inventory relations. In all other cases, except in models with \( T \), they were conducted and an affirmative result shown by \( T \). Figures in parentheses are the value of \( \bar{y} \). The basic data were in thousands of units.
Table 3: Inventory-Output/Value Added Ratios and Inventory Composition

<table>
<thead>
<tr>
<th>Industrial Groups</th>
<th>Year</th>
<th>Y2</th>
<th>Y3</th>
<th>Y4</th>
<th>as percent of Y2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>X1</td>
<td>X2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>All Industry</td>
<td>1950-1952</td>
<td>.377</td>
<td>1.074</td>
<td>54.9</td>
<td>37.0</td>
</tr>
<tr>
<td></td>
<td>1961-1963</td>
<td>.336</td>
<td>1.113</td>
<td>55.0</td>
<td>35.6</td>
</tr>
<tr>
<td>1a. Durables</td>
<td>1950-1952</td>
<td>.391</td>
<td>0.924</td>
<td>57.2</td>
<td>28.7</td>
</tr>
<tr>
<td></td>
<td>1961-1963</td>
<td>.408</td>
<td>1.183</td>
<td>65.4</td>
<td>22.5</td>
</tr>
<tr>
<td>b. Nondurables</td>
<td>1950-1952</td>
<td>.293</td>
<td>1.114</td>
<td>58.4</td>
<td>38.8</td>
</tr>
<tr>
<td></td>
<td>1961-1963</td>
<td>.304</td>
<td>1.073</td>
<td>48.9</td>
<td>43.4</td>
</tr>
<tr>
<td>2a. Capital goods</td>
<td>1950-1952</td>
<td>.305</td>
<td>0.882</td>
<td>62.0</td>
<td>27.4</td>
</tr>
<tr>
<td></td>
<td>1961-1963</td>
<td>.377</td>
<td>1.128</td>
<td>67.5</td>
<td>21.5</td>
</tr>
<tr>
<td>b. Consumer goods</td>
<td>1950-1952</td>
<td>.307</td>
<td>1.192</td>
<td>51.8</td>
<td>41.2</td>
</tr>
<tr>
<td></td>
<td>1961-1963</td>
<td>.309</td>
<td>1.101</td>
<td>45.4</td>
<td>46.5</td>
</tr>
<tr>
<td>3a. Mineral-based</td>
<td>1950-1952</td>
<td>.387</td>
<td>0.926</td>
<td>60.6</td>
<td>27.3</td>
</tr>
<tr>
<td></td>
<td>1961-1963</td>
<td>.385</td>
<td>1.124</td>
<td>65.6</td>
<td>22.8</td>
</tr>
<tr>
<td>b. Agro-based</td>
<td>1950-1952</td>
<td>.287</td>
<td>1.133</td>
<td>53.0</td>
<td>40.2</td>
</tr>
<tr>
<td></td>
<td>1961-1963</td>
<td>.301</td>
<td>1.102</td>
<td>45.7</td>
<td>46.9</td>
</tr>
<tr>
<td>4a. Continuous process</td>
<td>1950-1952</td>
<td>.378</td>
<td>1.041</td>
<td>47.2</td>
<td>48.0</td>
</tr>
<tr>
<td></td>
<td>1961-1963</td>
<td>.390</td>
<td>1.208</td>
<td>52.6</td>
<td>41.1</td>
</tr>
<tr>
<td>b. Discontinuous process</td>
<td>1950-1952</td>
<td>.281</td>
<td>1.090</td>
<td>58.3</td>
<td>32.1</td>
</tr>
<tr>
<td></td>
<td>1961-1963</td>
<td>.304</td>
<td>1.045</td>
<td>57.2</td>
<td>30.8</td>
</tr>
</tbody>
</table>
industries and a weak negative trend in their counterparts as well as in the remaining pairs. The 'all industry', however, always share a strong negative trend. Some arguments are adduced to elucidate these trends:

(i) Scattered empirical studies of the Indian manufacturing enterprises, especially in cement and fertilizer industries and large public sector industrial undertakings, show that the 'stores and spares' usually constitute 75 percent or more of the purchased materials inventory, and are subject to a considerable reduction through the adoption of inventory management.

(ii) The number of establishments increased most rapidly in those two groups that show a strong negative trend in the total (or purchased materials) inventory. New enterprises are more modern than the older ones, and probably contribute a negative trend to the industry soon after overcoming their teething troubles.

(iii) These two groups -- durables, and mineral-based -- have relatively more engineering industries than their counterparts -- non-durables and agro-based industries. They offer more scope for a better plant utilization through multiple shifts, and henceforth, more possibilities of savings in inventory investment.

29. The dichotomy of capital versus consumer goods should logically fall in the category of the above two groupings, but the results for the capital goods industry for the eighteen-year series only, shown below, corroborate our hypotheses. 2/

\[
Y_1 = -173.9^{**} + 1.407 x_1^{***} - 3.388 T^{***}, \quad R^2 = .99, \quad DW = 1.86^{**}, \quad h. \\
(3.39) \quad (22.6) \quad (3.67)
\]

\[
Y_2 = -201.0^{***} + .312 x_1^{***} - 2.60 T^{***}, \quad R^2 = .99, \quad DW = 1.59^{**}, \quad h. \\
(1.88) \quad (21.4) \quad (3.13)
\]

\[
Y_3 = 72.0 + .0949 x_1^{***} - 1.30 T^{***}, \quad R^2 = .98, \quad DW = 2.07^{**}. \\
(1.53) \quad (15.2) \quad (3.30)
\]

An interesting common feature of the above three groupings, dominated by a negative trend in inventory holdings, is that they are fast growing and will possibly continue to grow fast in India.

1/ The number rose by 74 to 77 percent in each of these two groups against 3 to 11 percent in their counterparts, and 34 percent in the 'all industry'.

2/ We are puzzled to see the sharp distinction between the fourteen and eighteen year series with respect to the significance of the secular trend. The instability of coefficients may be indicating multicollinearity. No such instability is apparent in any other industrial grouping.
30. As envisaged in Section III, the four dichotomies clearly reveal the wide differences in the inventory-output coefficients by the stages of fabrication. For instance, the purchase materials inventory coefficient in the durables is twice that of the nondurables. In the work-in-process inventory-output coefficient the contrast is even sharper. All the pairs also draw a sharp distinction in the finished products inventory-output coefficient where it is almost two-thirds in the groups likely to produce relatively more 'made to order'. The distinction, however, is not as sharp as we had envisioned in the durables versus nondurables. Our hypothesis regarding the sharpest distinction in the work-in-process industry is validated, although the distinction between the two marginal coefficients is not as large as we had conceived.1/ The dichotomy by the origin of purchased materials clearly dispels the notion that the purchased materials inventory in the agro-based industry may be relatively more than in the mineral-based industry due to seasonality or greater uncertainty in the output of agricultural crops.2/

31. In the 'all industry' two additional variants -- replacing output by gross value added and current values by deflated values -- have been attempted.3/ In replacing the output by the value added, 'R^2' remained almost the same, and 'DF' and 't' invariably fell, though only slightly. In a way, this finding is rewarding since at the aggregate level value added can be taken as a second best determinant for estimating inventory investment in a long-term plan where detailed output targets are not worked out. The results of the deflated series are mixed, and no unqualified judgment can be made. Without any crucial loss in 't' or 'R^2', the relations generally showed a gain in 'DF', particularly in the purchased materials inventory relation with output as the only determinant. But when the trend is incorporated, deflation appeared futile.4/ If one has to

1/ The sharpest distinction in these coefficients is drawn among the durables versus nondurables dichotomy, being 3:1 against 3:2 among the discontinuous process versus continuous process industry.

2/ It is possible that one may arrive at a different conclusion if one had access to detailed data pertaining to the commodity composition of the purchased materials inventory.

3/ The output, sales, and finished products inventory were deflated by the wholesale price index of all manufactured articles. The purchased materials inventory was deflated by the wholesale price index of industrial raw materials. These indices were obtained from different sources. The problem of deflating the work-in-process inventory was circumvented by inflating the undeflated total inventory by the ratio of the sum of deflated finished products and purchased materials inventories to the sum of undeflated finished products and purchased materials inventories.

4/ This may not be surprising since the wholesale prices of all the manufactured articles or the industrial raw materials had a high positive correlation with the trend.
choose between the average establishment size or secular trend, the choice seems clear. The results unambiguously indicate the superiority of the secular trend in every respect (including 'Δt' and 't'). This superiority remains unchallenged despite the deflation or different time periods. The hypothesis of a gradual and systematic change in the relative size and composition of inventories appears to be confirmed.
APPENDIX

Results of Homogeneity Tests

1. Two statistical texts were applied to total inventory (Y2) and the two major components (Y3 and Y4) in hypotheses (1), (3), and (4). The first was the test of equality of the full set of coefficients in the two regressions, namely, for 1950-1953 (or 1950-1958) and 1959-1963. This test assumes homoscedasticity. The validity of this assumption was tested by applying the second, F-test for the equality of variances.

2. Several important conclusions emerge from the homogeneity tests. Firstly, we must prefer the fourteen year period, 1950-1963 over the eighteen year period, 1946-1963. Secondly, we should generally prefer hypothesis using output (X1) and proxy variable (T) over other hypotheses. Thirdly, the choice between the secular trend (T) and average establishment size (E) may often be arbitrary. Finally, the purchased materials inventory seems to meet the first test with only rare violations of the second test. On the other hand, the finished products inventory rejected the first test only rarely, but it was most frequent in rejecting the second test. This apparently curious phenomenon reinforces the statistical theory that both the tests must be conducted to ascertain the homogeneity of any time-series.

3. The contrast between the durable and nondurable goods was sharp in the first test but not in the second. The nondurables passed the first test in all hypotheses in 1950-1963, but failed frequently in the second. The durables rejected the first test in half the cases even in 1950-1953. No such contrast was visible between the capital and consumer goods industries. Both passed the first test in all the hypotheses in 1950-1963, but the consumer goods failed very often in the second. The capital goods industry in a way was singularly well behaved. In the agro-based industry the purchased materials inventory failed to meet the first test in all the hypotheses in 1950-1963, but posed no problem in 1950-1963. The finished products inventory, on the other hand, violated the second test, though it passed the first. The purchased materials inventory of mineral-based industry had an easy time in hypotheses (3) and (4) in both the time-periods. The finished products inventory failed in the second, whereas it passed the first. The continuous and discontinuous process industries performed similar to each other in all the models in the first test, except for the purchased materials inventory of the latter. In the second test, the roles of these two industrial groups were interchanged. Finally, in all industry the total inventory had smooth sailing in all the hypotheses in the first test, but it had no success in validating the second. Very often the purchased materials inventory failed in the first test, whereas the finished products inventory failed in the second.
We had many failures in ascertaining the homogeneity even in the simple hypotheses tested here. As the power of these tests is weak due to few degrees of freedom, it was not advisable to discard the hypotheses mechanically on the basis of these tests. Nonetheless, one should be fully aware of the limitations posed by the heterogeneity of data and keep them in mind while interpreting the results.
SELECTED REFERENCES


2. Chadda, R.S., Inventory Management in India, New Delhi, Allied Publishers, 1964.


