3.1 The Present Study

The methodology in this study is to fit alternate functions, with investment as the dependent variable, and several alternate independent variables, defined by the alternate theories of investment behaviour, and to make the choice of an equation a function of the evidence provided by ex post factors.

The starting point of the study is the flexible accelerator model of investment behaviour, as originated by Chenery. Denoting the actual level of capital in period $t$ by $K_t$, and the desired level by $K^*_t$, capital is adjusted towards its desired level by a certain proportion of the discrepancy between desired and actual capital in each period i.e.

$$I_t = \lambda (K^*_t - K_{t-1})$$

where $I_t$ is the net investment, and $\lambda$ is the speed of adjustment, i.e., the speed at which the gap between the desired and the actual level of capital stock is met.

Total investment is defined in terms of its two components, namely, (i) plant and machinery investment, and (ii) construction investment.

Capital formation can be measured in gross or net terms.

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At the component level, the above distinction between gross and net investment is not possible. While all data sources give estimates of gross capital formation for the components; construction, and plant and machinery, estimates of depreciation are available only at the aggregate level. It therefore becomes necessary to make value judgements regarding the estimates of depreciation. In the present study, replacement is assumed to be a constant proportion \( \delta \) of the actual capital stock. This assumption implies that a constant proportion of the capital stock is replaced each year, irrespective of the age of the existing equipment, and the current economic conditions. Poot and Feldstein\(^2\) have questioned the proportionality theorem, but they also conclude that constant proportional replacement may be true on the average in the long run, but it is not true on a year to year basis.

Under this assumption the specification takes the following form,

\[
NI_t + \delta K_{t-1} = \lambda (K^*_t - K_{t-1}) + \delta K_{t-1}
\]

Or

\[
GI_t = \lambda (K^*_t - K_{t-1}) + \delta K_{t-1}
\]

where \( GI_t \) represents gross investment in plant and machinery, and \( K_{t-1} \) represents replacement investment. Underlying the above

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specification is the assumption that the speed of adjustment remains constant over the period of the study.

The unobservable nature of $K^*$ suggests that empirical estimation of $K^*$ is possible only if the determinants of $K^*$ are known apriori. It is at this point that the alternate theories of investment behaviour diverge.

In this study, the desired level of capital stock is assumed to be proportional to sales, under the accelerator theory. Retained earnings is assumed to determine desired capital stock under the liquidity theory. The basic premise of the corresponding theory of investment behaviour is that the supply of funds schedule rises sharply at the point where internal funds are exhausted. For the neo-classical theory, the definition used by Jorgenson in his studies, to define the neo-classical variable, is followed in this study too. Both version of the neo-classical theory are considered, i.e. the theory of investment behaviour incorporating capital gains, namely Neo-classical I, and the theory excluding capital gains, namely Neo-classical II. These two theories of investment behaviour, differing in their treatment of the cost of capital, but based on capital accumulation, complete the list of the four alternative explanations of investment behaviour to be included in this study.
3.2 The Functional Relationships

By substituting alternative variables defined by the alternate theories of investment, in the definition of \( k_t^* \), (the desired level of capital stock), in the flexible accelerator specification, a set of relationships are obtained. These relationships are used in the present study, for empirical analysis.

The assumption of the accelerator theory is that optimum capital stock is a function of expected sales. Empirical studies require expectations be accounted for. The general approach is to assume that expectations are extrapolations of the past and the present behaviour. In the present study, two kinds of expectation models are assumed, namely, static expectations, and constant expected change.

Assuming the accelerator theory, and static expectations, \( k_t^* \), the desired level of capital stock is defined as follows,

\[
k_t^* = f(S_t^*) \text{ under the accelerator theory,}
\]

where \( S_t^* = f_1(\alpha_0 + \alpha_1 S_{t-1}) \), under static expectations and \( S_t^* = f_2(\alpha_0 + \alpha_1 S_{t-1} + \alpha_2 \Delta S_{t-1}) \), under constant expected change.
Thus, by similarly assuming a non-homogenous linear relationship, the problem of expectations is overcome for the alternate theories of investment behaviour.

Model A is the first of the four models considered, and is based on the accelerator theory. It is composed of the following two equations, obtained by assuming alternate models of expectations.

\[ I_t = \lambda[(a_0 + a_1 S_{t-1}) - K_{t-1}] + \delta K_{t-1} \]

Or

\[ I_t = \lambda a_0 + \lambda a_1 S_{t-1} + (\delta - \Lambda) K_{t-1} \quad \ldots \quad (1) \]

\[ I_t = \lambda[(a_0 + a_1 S_{t-1} + a_2 \Delta S_{t-1}) - K_{t-1}] + \delta K_{t-1} \]

Or

\[ I_t = \lambda a_0 + \lambda a_1 S_{t-1} + \lambda a_2 \Delta S_{t-1} + (\delta - \Lambda) K_{t-1} \quad \ldots \quad (2) \]

Equations (1) and (2) are obtained by assuming static expectations and constant expected change, respectively.

The residual funds theory of investment behaviour is dealt with in Model B. In this model, \( K^* \) is assumed to be a function of retained earnings.

\[ K^*_t = f(r^*_t), \]

where

\[ r^*_t = a_0 + a_1 r_{t-1} \]
The equation used for empirical analysis is the following,

\[ I_t = \lambda \left[ (a_0 + a_1 r_{t-1} - K_{t-1}) + \delta K_{t-1} \right] \]

or

\[ I_t = \lambda a_o + \lambda a_1 r_{t-1} + (\delta - \lambda) K_{t-1} \] \hspace{1cm} (3)

Model C covers the neo-classical theory of investment behaviour. The four equations which compose this model are as follows.

\[ I_t = \lambda [a_o + a_1 (P_t Q_t/C_{t1})_{-1} - K_{t-1}] + \delta K_{t-1} \]

\[ = \lambda a_o + \lambda a_1 (P_t Q_t/C_{t1})_{-1} + (\delta - \lambda) K_{t-1} \] \hspace{1cm} (4)

\[ I_t = \lambda [a_o + a_1 (P_t Q_t/C_{t1})_{-1} + a_2 \Delta(P_t Q_t/C_{t1})_{-1} - K_{t-1}] \]

\[ + \delta K_{t-1} \]

\[ = \lambda a_o + \lambda a_1 (P_t Q_t/C_{t1})_{-1} + \lambda a_2 \Delta(P_t Q_t/C_{t1})_{-1} \]

\[ + (\delta - \lambda) K_{t-1} \] \hspace{1cm} (5)

\[ I_t = \lambda [a_o + a_1 (P_t Q_t/C_{t2})_{-1} - K_{t-1}] + \delta K_{t-1} \]

\[ = \lambda a_o + \lambda a_1 (P_t Q_t/C_{t2})_{-1} + (\delta - \lambda) K_{t-1} \] \hspace{1cm} (6)

\[ I_t = \lambda [(a_o + a_1 (P_t Q_t/C_{t2})_{-1} + a_2 \Delta(P_t Q_t/C_{t2})_{-1} - K_{t-1}] \]

\[ + \delta K_{t-1} \]

\[ = \lambda a_o + \lambda a_1 (P_t Q_t/C_{t2})_{-1} + \lambda a_2 \Delta(P_t Q_t/C_{t2})_{-1} \]

\[ + (\delta - \lambda) K_{t-1} \] \hspace{1cm} (7)
The first two equations are based on the Neo-classical I theory, whereas the latter two are based on the Neo-classical II version. Under each version, the two equations are obtained by assuming static expectations, and constant expected change respectively.

The above seven equations based on the flexible accelerator specification assume that the speed of adjustment remains constant over the period of study. The adequacy of this assumption has been questioned in recent years by Harold Hochman, Greenberg, EM Coen, and Bischoff. They suggest that $\lambda$ be taken not as a constant, but as a function of finance variables. The availability of finance is assumed to be important in determining the speed at which discrepancies between the desired and actual stock of capital are eliminated. The following specification is used in the present study.

$$GI = \left[ \lambda_o + \frac{\lambda_1 F_{t-1}}{K^*_t - (1 - \delta)K_{t-1}} \right] (K^*_t - (1 - \delta)K_{t-1})$$

On simplifying,

$$GI_t = \lambda_o \left[ K^*_t - (1 - \delta)K_{t-1} \right] + \lambda_1 F_{t-1}$$

In this equation, the term $\lambda$ as defined in the flexible accelerator specification, is decomposed into two components where $\lambda_o$ the constant component is determined by $K^*_t$, the desired level of capital.
stock, and $\lambda_1$, is the component which is determined by the availability of finance. A significant coefficient for $\lambda_1$, would imply that the finance variables are significant determinants of the speed of adjustment, whereas a significant coefficient for $\lambda_0$ would imply that the variable is a significant determinant of the desired level of capital stock.

In this specification, $K^*_t$ is defined in terms of only the accelerator and neo-classical theories of investment behaviour. Since $\lambda_1$ is defined in terms of the internal finance variable, the definition of $K^*_t$ also in terms of the residual funds theory, would lead to a quadratic equation. Since this study is based only on linear equations, $K^*_t$, under this specification, is not defined in terms of the residual funds theory of investment behaviour.

The four equations in Model D are obtained by defining $K^*_t$ in terms of the accelerator and neo-classical theories, in the above specification.

$$I_t = \lambda_0 \left[ \alpha_0 + \alpha_1 S_{t-1} - (1 - \delta)K_{t-1} \right] + \lambda_1 r_{t-1}$$

$$= \lambda_0 \alpha_0 + \lambda_0 \alpha_1 S_{t-1} - \lambda_0 (1 - \delta)K_{t-1} + \lambda_1 r_{t-1} \quad \cdots \quad (8)$$
The above four equations assume static expectations.

Equations (8) and (9) define \( K^*_t \) in terms of the accelerator theory, and assume static expectations. They differ only in their definition of \( \lambda_1 \) in terms of finance variables.

Equations (10) and (11) define \( K^*_t \) in terms of the neo-classical II theory.

Thus based on the two basic specifications, using the alternative theories of investment behaviour, four models are obtained to facilitate empirical analysis.
3.3 Tools of Analysis

In the present study, the Ordinary Least Squares Method is used to estimate the parameters. Identification of the parameter value of some of the parameters; \( \lambda_{o1}, \lambda_{o2}, \lambda_{o} (1 - \delta) \), however is not possible.

Probably the best way to evaluate findings is to consider their economic implications before looking at the statistical and econometric tests. In this context it is necessary to consider the expected signs of the coefficients, based on knowledge of economic theory.

Considering the accelerator variable, namely sales, a positive relationship is expected between the level of sales, and the rate of investment. An increase in permanent sales are expected to result in an increase in investment.

A higher level of retained earnings implies a positive relationship between the level of internally generated funds, and the rate of investment.

In the context of the neo-classical theory of investment behaviour, when capital services cost less, the demand for capital goods that provide these services, increases. The neo-classical variable is
defined as $P_t q_t / C_t$. Thus, when $C_t$, the rental price of capital services falls, the total quotient increases. A positive relationship is thus expected between the neo-classical variable, and the rate of investment.

The variable $K_{t-1}$, defined as the existing level of capital stock is expected to be negatively related to the rate of investment. A higher level of capital stock would directly imply that less is being invested, and thus the negative relationship.

It is expected that an industry will resort to external financing only when there is a shortage of internal funds. An increase in external borrowing would imply a faster rate of investment.

The statistical criteria aim at the evaluation of the reliability of the estimates of the parameters of the model. Two of the statistical tests considered in this study are the coefficient of multiple determination ($R^2$), and the standard error of estimates (SEE).

$R^2$, the coefficient of multiple correlation shows the percentage of total variation of the dependent variable, being explained by the change of the explanatory variables. Introduction of additional explanatory variables in the function can never reduce $R^2$, and will
always raise it. The $F$-statistic is thus used as a measure of the goodness of fit of the equations.

The standard error of estimate is a measure of dispersion of the estimates around the true parameter. The SEE is thus another measure of the goodness of fit.

Econometric criteria aim at the investigation of whether the assumptions of the econometric method applied (namely, Ordinary Least Squares, in the present study) are not satisfied in any particular case.

When a disturbance term exhibits serial correlation, the value as well as the standard errors of the parameter estimates are affected. Ordinary least squares parameter estimates though statistically unbiased, are over-estimated. The test generally used to test for the existence of autocorrelation, is the Durbin-Watson statistic. When there is no serial correlation, the Durbin-Watson Statistic $d'$ lies close to 2.

Forecasting is an essential part of any econometric analysis. A forecast is useful when it reduces the uncertainty as to the actual outcome of a change in the exogenous variables, below a level of uncertainty that prevailed before the forecast was made.
There are various ways of evaluating the quality of predictions. Two of the criteria are considered in the present study. These are (1) The Theil U coefficient and (2) the number of turning points correctly predicted.

The Theil inequality coefficient measures the absolute difference between the predicted change and the actual change. The Theil's Inequality coefficient is defined as follows:

\[ U = \sqrt{\frac{\sum (P_i - A_i)^2}{n} / \frac{\sum A_i^2}{n}} \]

Where \( P_i \) = Predicted (forecast) change in the dependent variable, and \( A_i \) = actual (realised) change in the dependent variable. The value which this inequality coefficient assumes lies between 0 and \( \infty \). The smaller the value of the inequality coefficient, the better is the forecasting performance. This method however has one drawback in that extreme values tend to influence the value of U, and thus it may not present the true picture. The second criteria, namely the turning point analysis is thus also used along with Theil's inequality coefficient, to test for the quality of predictions.
The idea behind the turning point analysis is that given the considerable positive serial correlation in most economic time-series, it is rather easy to predict a continuation of expansions, or of contractions and therefore, a real success is only obtained if the end of such a one-sided movement is correctly predicted. A large number of turning points correctly predicted would thus imply a better quality of predictions.

3.4 The Variables and their Estimation

In the present study, the data on the sales variable, which represents the accelerator theory, are obtained from the Income Statement. The sales values selected are taken to be net of excise duties etc.

The retained earnings variable is measured net of depreciation. As the flexible accelerator specification employed in this study includes replacement investment, its inclusion once again in the estimation of the internal finance variable used to define $k_t^*$ would lead to double counting. For this reason, retained earnings, rather than cash flow, which is the sum of retained earnings and depreciation, is used to represent the residual funds theory.
In the present study, the components of 'C', the rental price of capital, are estimated as follows:

\[ C_t = \frac{q_t}{1 - w_t} [(1 - u_t w_t) \delta + r_t - \frac{q_t - q_{t-1}}{q_{t-1}}] \]

for the neo-classical I theory, which includes capital gains in the estimation of \( C_t \), and

\[ C_t = \frac{q_t}{1 - u_t} [(1 - u_t w_t) \delta + r_t] \]

for the neo-classical II theory which excludes capital gains in the estimation of \( C_t \).

The components of \( C_t \), the rental price of capital, are estimated in the following manner. \( q_t \), the price of capital goods, is represented by the price index of plant and machinery, the tax rate \( u_t \) is taken to be the statutory tax rate; \( w_t \) is obtained as the proportion of depreciation, to the sum of depreciation, interest and profits before tax and ' \( \delta \)' the rate of replacement is assumed to be 10% for plant and machinery. The cost of capital \( r_t \) is obtained as a weighted average of equity capital and debt. It is estimated as follows:
\[ r_t = \frac{w_1 \times \frac{\text{dividends}}{\text{Paid-up Capital}} + w_2 \times \frac{\text{Interest}}{\text{Debt}}}{w_1 + w_2} \]

where \( w_1 \) and \( w_2 \) are the two weights, estimated as follows.

\[ w_1 = \frac{\text{Equity + Reserves}}{\text{Total Liabilities}} \]
\[ w_2 = \frac{\text{Debt}}{\text{Total Liabilities}} \]

One component of \( C_t \), i.e. \( \frac{q_t - q_{t-1}}{q_{t-1}} \) which represents the capital gains component is measured as the change in the price index of plant and machinery as a ratio of the original price. The inclusion or exclusion of this ratio component results in the neo-classical I and neo-classical II theories respectively.

Having obtained the two values for \( C_t \), i.e. both including and excluding capital gains, the neo-classical variable is obtained as a ratio of the value of output to the rental price of capital i.e. \( \frac{P_t Q_t}{C_t} \), where \( P_t \) is the price of the product and \( Q_t \) the output level.

The stock of capital \( K_t \), is obtained through the Perpetual Inventory Stock approach. Taking gross fixed assets in 1950-51 to be the capital with which the industry begins, capital stock for the
following years is obtained through a process of cumulative additions of deflated changes in gross fixed assets over the years. Change in gross fixed assets in plant and machinery is taken to be the dependent variable.

In the present study, the deflation used to convert all the data to 1950-51 constant prices is obtained from Chandhok. Since the basic source of industry level data in this study are the Reserve Bank of India Bulletins, the year span for the RBI data is 1st July to 30th June. The year span of the data obtained for the deflator is also the same. All sales values are deflated by an output deflator, which differs from industry to industry. All other data pertaining to the remaining variables, including the dependent variable are deflated by the price index of plant and machinery. All the data used in the present study are at 1950-51 constant prices.

The alternate deflator available is the Central Statistical Organization (CSO) deflator. This deflator is however not used in the present study because the year span of the CSO data does not synchronise with the year span of the RBI data. Further, CSO does not provide individual industry level output deflators.

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3 HL Chandhok, Wholesale price statistics, India, 1947-78, Economic and Scientific Research Foundation.
3.5 **Data Sources, and Sample Selection**

The present study is conducted at two levels, the level of the industry and that of the firm. The data for the industry level analysis are obtained from the publications of the Reserve Bank of India, namely the RBI Bulletins. The Bombay Stock Exchange Directories are the source of the firm-level data.

The main source of the industry level data used in the present study is the quinquennial survey conducted by the Reserve Bank of India. The bulletins publish data for four categories of companies, namely (i) medium and large public limited companies (ii) medium and large private limited companies, (iii) small public limited companies and lastly (iv) small private limited companies. Data for the first category are available from 1950 onwards, for the second category from post 1955 only and for the last two categories, data are available only from 1960 onwards. Since the objective of the present study is to identify the determinants of gross fixed assets for the period since planning began, only medium and large public limited companies are included in the present study, due to the availability of data from 1950 onwards. The period of study for the industry level data is 1950-51 to 1978-79. The Reserve Bank of India has conducted sample studies since 1950 on the analysis of balance sheets and profit and loss accounts of medium and large public limited companies, and has reported these in the RBI bulletins.
periodically. These studies are prepared by the Division of Company
Finances, in the Department of Statistics, and the Division of
Monetary Economics in the Economics Department of the RBI.

The basic difficulty with the RBI data is that the sample size is
not uniform. The coverage from sample to sample has changed, and
thus adjustments have to be made to the original data in order to
obtain a continuous time-series. There are three approaches to
overcome this data problem. These are (i) blowing-up the series
with a blow-up factor, (ii) using dummy variables to represent the
different sample sizes, and (iii) using a scale-down factor.

In the blow-up factor method, the ratio of the paid-up capital of
the total population to the paid-up capital of the sample,
\( \frac{PUC_p}{PUC_s} \) is used to blow up all the included variables, and
thereby obtain their population estimates.

In addition to the time lag involved in getting the population
paid-up capital data, this procedure has its own limitations. The
data on population paid-up capital are obtained from the Statistical
Abstract of India. For many industries, the data on population
paid-up capital are not available. The paid-up capital of working
companies as published by the statistical abstract, includes the
paid-up capital of companies under construction. These companies
have no output. Since the RBI sample includes only companies in production, blowing-up with the paid-up capital series published by the Statistical Abstract may lead to biased time-series data for the included variables. Thirdly the use of the blow-up factor would imply the assumption that the behaviour of the non-sample firms is the same as that of the sample firms. This assumption again has its own drawbacks. Fourthly, this method also makes the implicit assumption that all items of the balance sheet and income statement will be linearly related to paid-up capital.

The second alternative method of circumventing this data predicament is to use dummy variables to represent different sample sizes. Since the present study includes six different samples, this would involve the inclusion of six dummy variables. As the data used covers only twenty eight years, the procedure restricts the degrees of freedom, and the stability of the parameter coefficients would thus be questionable.

The third method is that of applying a scale down factor. In this method all the variables are uniformly divided by the same variables. This method of circumventing the data problem is adopted in the present study. All the included variables, including the dependant variable are taken as ratios of capital stock, $K_{t-1}$. However, when
interpreting the results, the estimated constant term \((\delta - \lambda)\) is to be interpreted as the coefficient of capital stock, and the coefficient of \(\frac{1}{k_{t-1}}\) is the original constant term.

The empirical analysis in this study covers the industries involved in the production of cement, cotton textiles, jute textiles, paper and paper products, sugar, rubber and rubber products, chemicals and engineering products. The analysis also covers the manufacturing sector as a whole. The chemical industry as considered in this study is a summation of three sub-categories, namely Basic Industrial Chemicals, Medicine and Pharmaceutical Preparations, and other Chemical Products as classified in the RBI Bulletins. Engineering industry is similarly an aggregate of three industrial classifications, namely (i) Electrical Machinery, Apparatus, Appliances etc., (ii) Transport Equipment, and (iii) Machinery (other than Transport Equipment and Electrical).

The Reserve Bank of India studies are not the only source of information of Company Finance in India. There are some other sources like the Census of Manufacturing Industries and the Annual Survey of Industries which provide time series data. The Reserve Bank of India data has one drawback, that is size variation from sample to sample. The latter not only have this problem, but in addition there is a lack of uniformity in the industrial classification, while the Census of
Manufacturing Industries for the period 1946-1958 covers only 29 industries, the Annual Survey of Industries from 1959 onwards, covers 63 industries. Thus there happens to be not even one year common to both the studies, for comparison. Continuous time series data is thus not available.

The data for the firm-level analysis are obtained from the Bombay Stock Exchange directory. On the basis of certain pre-defined criteria which are explained below, fourteen firms are chosen for the final analysis. The published list of the top hundred companies on the basis of gross fixed assets is taken as the universe from which the sample is chosen. All multinationals are first excluded from the list. Next only those companies with continuous data for the period 1950-1978 are considered. From this list, only those firms with no change in the accounting year over the period of study, no amalgamations etc., are finally selected for the empirical analysis. This selection procedure finally resulted in a sample of fourteen firms. The data for these sample fourteen firms is used for the firm level analysis.
3.6 Problems of Linear Aggregation

Since the study is carried out at three levels (i) the level of the aggregate manufacturing sector, (ii) the individual industry level and (iii) at the level of the firm, it is necessary to analyse the problems of linear aggregation. Theil\(^4\) on the basis of his analysis of the aggregation over one set of individuals, namely industries or firms, concludes that "there may be contradictions between conclusions from the macrotheory and those from the microtheory."

One would expect the conclusions from both the macrotheory and the microtheory to be similar only when the microrelations are perfect. This in reality is rarely the case, and different conclusions are therefore only to be expected. Another inference made by Theil is that prior expectations concerning the signs of micro structural parameters are not necessarily fulfilled by the corresponding macrostructural parameters.

Evans\(^5\) in his study of industry investment decisions attempts to test some of the variables which determine investment behaviour. However, unlike other studies which have been undertaken, the viewpoint in Evans study is that these variables are likely to change from one industry to another. Similar to the present study, Evans

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study is also carried out at two levels; at the level of the aggregate manufacturing sector, and at the level of the individual industries which compose it. From his analysis Evans finds that there exists differences in investment behaviour between the aggregate manufacturing sector, and the individual industries that compose it. His conclusions are that more work therefore remains on the question of investment decisions in general, and industry differences in investment, in particular.

In a similar study of investment in manufacturing, Resek\(^6\) applies three alternative specifications to data on aggregate manufacturing, and thirteen individual industries. The results differ not only between the same equation for the different industries and aggregate manufacturing, but also between the alternate specifications for the same industry. It is therefore difficult to identify any one particular specification, and generalise it to be the best explainer of investment behaviour for all the individual industries, as well as aggregate manufacturing.

In the Indian context too, differences in investment behaviour could be expected between industries and between firms, which only further emphasizes the need for disaggregated analysis. Hence, in the present

study, the analysis is carried out at the level of (i) the aggregate manufacturing sector, (ii) the individual industries, and (iii) individual firms.