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Inventory Investment Behaviour - Evidence from a Panel of Indian Firms

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The paper augments production-smoothing specification with cash flows and monetary policy variables in its application for the Indian data. Several interesting findings emerge from the analysis. However, the results obtained need to be viewed with the limitation of non-availability of quarterly data for the Indian firms. Given that our empirical analysis is based on annual data at the level of firm, it is unlikely to pick up the short run responses to sales shocks that are so important to aggregate analyses with monthly or quarterly data.

Key words :

JEL Classification :

Introduction

Inventory investment is highly volatile and is found to have strong relationship with recessionary declines in GDP. Understandably, this importance has led to a considerable research effort into the behaviour of inventories both at macro level and micro level. However, evidence on inventory behaviour of the Indian firms is scanty. In this paper, an attempt is made to analyse the inventory investment behaviour and its determinants using a panel data on Indian manufacturing firms. The stylised facts on inventory behaviour as observed for firms in US and other developed countries are also examined.

The paper is structured as follows. The next section of the paper briefly surveys empirical issues raised in inventory investment and describes the linkages between the internal finance and inventory investment. Section-III briefly describes the data and its source. Empirical evidences on stylised facts in inventory investment

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literature are studied in relation with inventory formation in Indian context in Section-IV. Section-V lays out the standard production adjustment model for inventory investment. Section-VI presents the empirical results on determinants of inventory investment. The robustness of the estimates generated for total inventory investment has been examined by disaggregating the total inventory investment to the stage of production process. In addition, the stability of estimated parameters relating to total inventory investment and its components is examined by estimating inventory equation in three sub-periods separately. Finally, in Section-VI, we summarise the main findings and conclude. Construction of variables is presented in data appendix.

II

Review of Literature

After lying dormant for much of the 1960s and 1970s, empirical research on inventory expenditure has found a renewed interest with a recognition that inventory fluctuations are highly correlated with business cycles. Microeconomic theory on inventory investment tells that business inventory investments may be held for a wide variety of reasons. These include smoothing production in face of fluctuating sales and to minimise possibility of stock-outs. Other reasons for holding inventories include to use them as hedge against asset price fluctuations, to reduce delivery lags, to improve production scheduling, to reduce inventory acquisition costs by bunching to get bulk discounts and save transport costs, to signal credibility against order book by displaying inventories or simply as outcome of unavoidable pipeline. These reasons may appear to be of a second order importance, but greater evidence is now available to show that they could critically alter the investment behaviour of a firm. While there is considerable scope of extending the literature on these lines, two main microeconomic theories that have established presence in the literature in this area are the production smoothing or the buffer stock model and the (S,s) model of inventory behaviour.

The production-smoothing model/ buffer stock model was developed by Charles Holt, Franco Modigliani, John Muth and Herbert Simon in 1960. The underlying logic of the model is that if firms face convex production costs and sales that vary over time, a cost minimization strategy would be to smooth production relative to sales[1]. The fact that firms face stochastic demand gives rise to the reason that inventories need to be held as a buffer stock. It explains why firms hold stocks of finished goods they have produced. This production smoothing/buffer stock hypothesis treats inventories as a stabilizing factor to fluctuating sales by acting as a buffer stock. Using the linear quadratic approach to optimisation, Lovell (1961) came out with the empirical specification of this hypothesis as stock adjustment model. If sales vary over time with rising production costs, a firm's cost minimising strategy is to equate the marginal costs of production in different time periods subject to the cost of holding inventories[2]. The theory also implies that the speed of adjustment depend on the real rate of interest. It further suggests that we should expect negative response of inventory investment to changes in the interest rates.

The production smoothing/ buffer stock model has, however, faced many empirical challenges, First and the foremost, the model's prediction that production should be less variable than sales fails frequently with the data (Blinder (1986)). Blinder (1981) and Blanchard (1983) provide industry-level evidence for the US data on this aspect. West (1986) and Eichenbaum (1989) provide strong formal evidence rejecting the model. Furthermore, Miron and Zaldes (1988) demonstrated that seasonal variations in manufacturing output closely match the seasonal variations in sales implying that inventories play insignificant role in smoothing seasonal fluctuations. The coefficients estimated in this model are found to indicate that firms close the gap between their actual and desired stock of inventories at an implausibly slow rate (Blinder (1986)). Feldstein and Auerbach (1976) find difficulties with the adjustment rates that vary from months to years to adjust to sales shocks. Maccini and Rosana (1984) and Blinder (1986) show that the result is not due to

any biases in econometric specifications. However, Christiano and Eichenbaum (1987) show that aggregation biases may provide some explanation for low adjustment speed, though even after adjusting for this factor the speed of adjustment remains implausibly low. Blinder and Maccini (1991) argue that production may vary more than sales if firms follow (S,s) inventory models. Kahn (1987) shows that uncertain demand combined with costly stockouts helps explain the behaviour of inventories. Carpenter, Fazzari and Peterson (1995) focus on capital market imperfections to account for this excess volatility. They argue that capital market imperfections limit the firm access to external finance, forcing them to rely mainly on internal finance. Since cash flow is procyclic, fluctuations in internal finance should affect inventory investment.

In a standard stock adjustment model, desired inventories are a function of expected sales (accelerator motive and buffer stock motive), interest rates and the inflation rates (expected holding gains or losses). The key buffer stock motive of the model has been rejected in many econometric investigations of inventory investment. Also, inventory investment in many empirical studies, is found to remain insensitive to changes in real interest rates. However, it must be said that empirical evidence on production smoothing has been by and large from the US data and there is little verification of the theory from other parts of the world, especially developing countries. One needs to see if the so-called puzzles of US inventory behaviour in which production has higher variance than sales is a global phenomenon or a stylised fact for the US economy alone.

Bo (2002), in his study on Dutch inventory investment uses firm level data on Dutch firms over the period 1984-1995. His results on the basis of Lovell model augmented with financial variables show that capital market imperfections are relevant to explaining inventory behaviour and provide evidence that the firms likely to be financially constrained respond much more sharply to cash flow shocks than firms that are likely to be unconstrained.

Carpenter, Fazzari and Peterson (1995) estimate within-firm regressions for a standard inventory stock adjustment model augmented with financial variables on quarterly firm-level panel data. They conclude that cash flow fluctuations explain a substantial amount of inventory fluctuations for the US firms. They find strong support for the existence of financing constraints due to adverse selection and moral hazard problems in debt and equity markets generated as a result of asymmetric information between firms and potential suppliers of external finance. They predict that investment depends primarily of internal funds because of limited availability of debt.

Louri (1991) examined the effect of monetary policy on inventory investment in Greek manufacturing industry. Using time series data from the annual accounts of Greek firms for the period 1958-85, they find interest rate and inflation rate expectations exercise a significant influence on inventory investment but in opposite direction. He also finds that interest rate coefficient is significant and has a negative sign in case of total inventory investment and raw materials, though in case of finished goods they have a negative sign but an insignificant coefficient. Like our results, he also concludes that different types of inventories behave differently, showing diverse responses to price and quantity variables. He also observed that expected inflation was having a positive and highly significant relationship with inventory investment, suggesting speculative motive for holding inventories. However, the study was not based on panel data, but on aggregate time series data.

Hay and Louri (1994), however, find for a panel of UK firms for the period 1960-85 that microeconomic factors matter much more and that interest rates were not a significant determinant of inventory investment. Acceleration effects as reflected in sales coefficients are found to be important in explaining inventory behaviour in all the cited studies. While Carpenter, *et.al.* (1995) did find cash flows to be a significant determinant of inventory investment for some classes of firms and for some periods, there were cases where cash flow turned out to be insignificant.

III

Data

Annual data are drawn from Company Finances Divisions' files of RBI based on uniform method of analysis of audited and published accounts of non-financial, non-government public limited firms have been used for this study. The firm-wise data are available from 1971 onwards. The data frequency is annual[3]. The panel consists of 1,800 listed firms and covers the period 1971-72 to 1999-2000. The original number of firms in the data set was much higher than 1,800 but firms with fewer than nine consecutive years of data are deleted from the data set. The average firm in the dataset has 16 years of data. Firms with zero inventory investment and non-positive sales are also excluded, since zero inventory investment or sales may indicate a temporary shutdown or other disruption in the firm's economic activities. This sample selection criterion generated 28,527 observations. As such, it is amongst the largest dataset used in such studies.

For the sample of manufacturing firms, analysis of inventories is carried out at disaggregated level with inventories broken down into finished goods, work-in-progress, raw materials and supplies and others. 'Others' includes *inter-alia* stores and spares. Availability of internal funds represented by cash flow variable proxies for the constraints in financing inventories. Given that inventory equation is specified in levels and there are large differences between the firms in terms of size, all the variables (other than interest and inflation rates) are scaled by the real total assets to control for heteroscedasticity.

In order to reduce the likelihood of introducing trends that might dominate cyclical movements in data, the long panel is split into three sub-panels covering periods 1972-73 to 1979-80; 1980-81 to 1991-92 and 1992-93 to 1999-2000. These panels consist of 10,626, 12,849 and 5,052 observations respectively. Each of three sub-panels is unbalanced and excludes firms with zero inventories. However, even a firm is excluded from one panel, it may enter others.

IV

Inventory Investment in India- Some Stylised Facts

In view of numerous reasons to hold inventories, inventory formation is found to be difficult to explain. One standard explanation for holding inventories, as pointed earlier, is that they are used to smooth production in presence of fluctuating demand since it is costly to change production. In order to minimize cost, firms facing variable demand for their product reduce inventories whenever sales exceed production and vice-versa. In other words, firms draw down and build up their inventories as necessary to limit fluctuations in production. As production decisions are made in advance, firms use inventories as a buffer stock. Lovell's (1961) stock adjustment model implies that production should be smoother than sales and that sales and inventory investment move in opposite directions[4]. However, it is generally found that production is typically more variable than sales and inventory investment and sales are positively correlated in contrast to the view that firms are attempting to smooth production against fluctuating demand.

The key buffer stock motive of the model has therefore been rejected in many econometric investigations of inventory investment. Blinder and Maccini (1991), in their comprehensive survey of the inventory investment literature enumerate three stylised facts on inventory behaviour as:

(1) The most volatile components of inventory investment are inventories of raw materials and supplies;

(2) The variance of production exceeds the variance of sales; and

(3) Sales and changes in the stocks are not negatively correlated.

The mean and variance of inventory investment

Based on de-tren]ded inventory investment data, Blinder and Maccini (1991) had observed that finished goods stocks were the least volatile component of inventories, while raw materials in the

form of material and supplies were the most volatile component. Table-1 below reports the means and variances of real inventory stock and the investment for the Indian manufacturing firms that are further broken down into its components.

Table 1: Mean Real Inventory Levels and Variance of Real Inventory Investment

(in '000s)

	Mean inventory stock	Percen -tage of total	Mean inventory investment	Percen-tage of total	Variance of detrended inventory investment	Percen-tage of total
Total inventory	1723.27	100	167.42	100	20267.74	*
Finished goods	560.61	32.53	57.97	34.63	3606.58	17.79
Raw materials and supplies	522.6	30.33	46.33	27.67	3002.99	14.82
Work-in-progress	292.33	16.96	30.56	18.26	674.99	3.3
Stores and Spares & others	347.74	20.18	32.55	19.44	712.95	3.5

* not adding to 100 as the covariance terms are not reported.

If inventory investment is a constant share of output and output is growing, the variance could simply reflect the increasing size of the production activity. In other words, trend growth in real level of sales can disguise smoothing. If sales are trending up (down), then production will also trend up (down). If firms smooth production annually, and adjust the target value of smoothed production each year, then the variance induced by the trend growth will also distort the smoothing measure. To remove any distortion of the results from possible trend movements, inventory investment has been de-trended in calculating the variance in the above table. For this, first log values of inventory levels were regressed on a constant and time trend. The exponential of the fitted value was then subtracted from the actual value to produce a de-trended levels series.

The table above reveals some results in contrast with the trends observed for the firms in the United States. First, while finished goods account for largest component of stocks and flows of inventories for the Indian firms, the work in progress and not

the finished goods inventories constitute the smallest component of total inventories. Second, and more importantly, unlike the US firms, Indian firms have finished goods as the most volatile component of total inventory investment. Ignoring the interactions captured by covariance, it accounts for about 18 per cent of the variance in total inventories. Blinder and Maccini show that for the US firms it accounts for about 12 percent of the total inventories of the manufacturing firms. So while overemphasis on finished goods stocks in understanding changes in inventory levels may be misplaced in the context of the US economy, it may not quite be the case for the Indian economy. In contrast, work-in-progress is a stable component of inventory investment in India. While for the US manufacturing firms it accounted for a fifth (20.7 percent) of the total variance in total inventories, for the Indian firms it accounted for about three percent. Raw materials constitute the most volatile component of inventories for firms in advanced countries, but it was the second most volatile component for the Indian firms accounting for 14.8 percent of the variance of inventories in contrast to 43.7 percent in case of the US manufacturing firms.[5] While raw materials are volatile component of inventories, the stores and spares constitute a stable component of inventories for the Indian firms.

Variance of Sales and Output

Typically, inventories are thought to be held by the firms so as to avoid stock outs or to minimise costs by smoothing production process amidst fluctuating sales. However, the production smoothing argument for holding inventories is questionable, as it has not found much empirical support. Here, we examine this question in the context of inventory behaviour of the Indian firms. In order to provide some descriptive evidence on this issue of production smoothing, variance of sales and production are calculated for the sample of Indian firms after de-trending both by procedure explained in the previous sub-section. Variance ratios are then calculated. The empirical evidence so obtained is presented in Table 2 below.

Table 2: Variance of Real Sales and Real Output, Industry-Wise

	Variance of De-trended Sales (S)	Variance of De-trended Output (Y_1) where Y_1=S+ ΔN_1	Variance of De-trended Output (Y_2) where Y_2=S+ ΔN_2	Var (Y_1)/ Var (S)	Var (Y_2)/ Var (S)
All industries	160497.3	181244.1	189043.4	1.13	1.18
Tea	519787.5	535743.6	537475.7	1.03	1.03
Sugar	2348248	3543859.8	3556335.5	1.51	1.51
Textiles	79421.2	76625.8	76867.6	0.96	0.97
Engineering, of which	320137.1	373488.3	378726.1	1.17	1.18
Electrical Mach., apparatus,appliances, etc.	1462514.3	1523107.6	1605176.1	1.04	1.1
Machinery other than transport and electrical	739631.5	726689.9	743177.3	0.98	1
Chemicals, of which	353011.3	412616.5	444594.2	1.17	1.26
Medicines and pharmaceuticals	389703.4	423730.8	441328.6	1.09	1.13
Basic Industrial Chemicals	1316313.9	1347333.8	1484917.5	1.02	1.13
Cement	11036462	11360923	11479025	1.03	1.04
Rubber and Rubber Products	6299944.5	6485939.5	6513454	1.03	1.03
Paper and Paper Products	449121.5	466815.7	466729.4	1.04	1.04
Construction	1879416.1	1880407.9	1913448.9	1	1.02
Trading	4712723	4846455	4855475	1.03	1.03
Shipping	1346514.1	1346609.9	1377428.5	1	1.02

ΔN_1=change in finished goods inventory; ΔN_2 change in inventories of finished goods and work-in-progress.

Data on production can be readily calculated by adding current period sales to the change in inventory from last period. If production exceeds (is less than) sales in a given period, then the difference must go to increasing (decreasing) inventories. In other words, A variance ratio (ratio of variance of production to variance of sales) more than one implies that production is more volatile than sales and therefore contradicts the smoothing hypothesis. However, a negative correlation between sales and change in inventory investment may be insufficient to produce a lower variance in production than in sales. We consider two alternative measures of output for computing the variance ratios. First, we add only finished goods inventories to sales to arrive at a measure of output of finished goods. Second, we add work-in-progress to finished goods inventories to arrive at a measure of total output of the firm. With both these measures, the variance

ratio exceeded unity for the full sample, implying that the variance of output exceeded variance of sales. In fact, the ratios of 1.13 and 1.18 for the two measures of output, respectively, is somewhat higher than Blinder and Maccini's corresponding ratios of 1.09 and 1.13, respectively, for the US firms. This indicates that inventories were not a stabilising factor in India too.

Similar ratios were computed for 11 major industry groups for the Indian firms. Almost for all industries, the two variances ratios measures exceeded one.[6] The variance of output exceeded that of sales considerably in case of sugar, engineering and chemicals. In case of basic industrial chemicals, the work-in-progress inventories apparently were a major volatile component. In sum, the industry-wise evidence weighs heavily against the production-smoothing motive for holding inventories.

Correlation Between Sales and Inventory Investment

The commonly held belief that inventories are held as a buffer stock requires that inventories are drawn down with rising sales, while they are accumulated when sales decline. This is the basis on which the inventories are used to explain cyclical behaviour in economic activity.

Blinder and Maccini (1991) have, however, dismissed this idea as it does not fit in the empirical analysis for the US firms. Evidence on this issue for the sample of Indian firms is presented in Table-3 below. Four alternative measures of inventories were considered. First, as the most narrow measure, *viz*., finished goods inventories were considered. Next, two other main components of inventories, *viz*., raw materials and work-in-progress were taken. Finally, total inventories were used. The correlation coefficient of the de-trended series of each of these with the de-trended series of sales was computed at all industry level as well as for each of the 11 main industries. Two alternative data series were considered for each of these variables/measures. First, the correlation was computed between the average of all firms for each variable/measure and the average sales. However, such a measure would suffer from scale effects with small number of large firms dominating the sample. To

Table 3: Correlation Between Real Sales and Real Inventory Investment, Industry-Wise

	Correlation between detrended Sales (S) and detrended inventory investment component (ΔN_i)							
	Cor(S,ΔN_1) i=1: finished goods		Cor(S,ΔN_2) i=2: Raw materials		Cor(S,ΔN_3) i=3: work-in-progress		Cor(S,ΔN_4) i=4: Total inventories	
	(*)	(**)	(*)	(**)	(*)	(**)	(*)	(**)
All industries	0.55	-0.30	0.38	0.11	0.57	-0.38	0.60	-0.24
Tea	0.47	-0.10	0.66	-0.07	0.17	0.01	0.7	-0.08
Sugar	0.83	-0.61	0.18	0.31	0.47	0.21	0.83	-0.58
Textiles	-0.07	-0.46	0.25	0.28	0.04	-0.46	0.21	-0.08
Engineering, of which	0.52	-0.15	0.26	0.15	0.29	-0.31	0.56	-0.09
Electrical Mach.,	0.22	-0.16	0.41	-0.18	0.30	-0.09	0.34	-0.24
Apparatus,appliances,etc.								
Machinery other than transport & electrical	-0.47	-0.01	0.16	0.04	0.12	-0.21	-0.03	-0.13
Chemicals, of which	0.48	0.15	0.15	-0.22	0.42	-0.01	0.44	-0.1
Medicines and pharmaceuticals	0.4	0.46	0.44	0.4	0.38	0.43	0.46	0.38
Basic Chemicals Products	0.25	0.17	0.16	-0.08	0.52	-0.15	0.46	0.02
Cement	0.32	0.27	0.16	0.32	0.1	0.16	0.27	0.1
Rubber & Rubber Products	0.05	0.2	0.31	0.03	0.15	0.06	0.25	0.26
Paper and Paper Products	0.27	0.2	0.58	0	0.25	0.13	0.5	0.16
Construction	0.32	-0.17	-0.1	0.32	-0.17	-0.12	-0.15	-0.17
Trading	0.34	0.42	0.33	0.34	0.29	0.37	0.47	0.29
Shipping	0.55	0.36	0.18	0.52	0.43	0.19	0.37	0.21

Note: * denotes correlation between average of aggregate real sales of all firms and average of aggregate of component of real inventory investment for all firms.

** relate to correlation between average of (real sales/real total assets) of all firms and average of (real inventory investment/real total assets) for all firms.

neutralize this scale effect, the second data series was generated by deflating all variables/measures by total assets before calculating the correlation on their averages. For all-industries the correlation coefficient of sales and finished goods inventories was 0.55. When deflated by total assets the correlation coefficient not only dropped, but changed sign to negative and turned out to be –0.30, implying that large firms may have a higher correlation between sales and inventories. Similar results are obtained for other components of inventories and for total inventories, though in case of raw materials the sign remains positive when deflated by assets. The correlation between sales and total inventories for all-industries is, in fact, still stronger than that of finished goods, with

correlation coefficients of 0.60 without deflating and -0.24 when deflated by total assets. At the disaggregated level of industry groups, positive correlation was obtained for most industries, with construction and machinery other than transport and electric being the two industries as notable exceptions of having negative correlations even when scale effects are not removed. The results on the whole decidedly contradict the buffer stocking explanation for inventory holding. Firms rather than running down stocks of inventories with rising sales, actually tend to build them up. Similar results were obtained by Blinder and Maccini (1991) for the US firms and Flood and Lowe (1993) for the Australian firms.

The evidence obtained in the case of Indian firms on the "stylised facts" of Blinder and Maccini (1991) reaffirm that the production smoothing/buffer stock motive for holding inventories has problems in explaining inventory behaviour of the Indian firms. However, unlike their results, we find that finished goods are a volatile component of inventories.

V

Determinants of Inventory Investment – an empirical exercise

The stock adjustment model whose background is the production smoothing or buffer stock hypothesis has been used intensively in empirical inventory research for estimating inventory investment. Blinder and Maccini (1991) in their survey paper writes "*production smoothing has not only been the model of choice of almost all theorists who have tried to model inventory behaviour, but also underlies the stock-adjustment model, which dominates econometric work on inventories*".

The production-smoothing model predicts that higher expected sales in the next period would lead firms to build inventories in the current period to avoid higher marginal costs of production when sales increase subsequently. This accelerator motive links today's inventories to tomorrow's expected sales. For finished goods inventories, for instance, this dependence comes from a stock-out

motive. As expected sales rises, the probability of a costly stock-out increases, inducing firms to hold more finished goods in inventory. The higher are expected sales, the greater the advantages of holding stock. The 'stock adjustment' relates the change in inventories to the gap between target inventory stocks and actual beginning of period stocks. The lagged level of inventories is also included on the conventional basis that a higher initial level of inventories will tend to reduce the returns from accumulating additional inventories. The coefficient on lagged inventory stocks is a measure of the adjustment speed with which the inventory shortage is corrected gradually so long as inventories remain below the targeted inventory level. Hence production adjusts in case of the gap between the actual and the expected sales with inventories acting as a buffer stock and smooth production so as to avoid stock-outs.

The financial health of firm may also affect its ability to smooth production. The firm that can show good prospects not only for sales but also for expected cash flows, may have easy access to external funds. Besides it may be in better position to run down its own cash-flows to finance inventory accumulation in case, it faces premium on external funds, in particular, in presence of capital market imperfections. The presence of capital market imperfections may not allow firms to finance the accumulation of inventories when demand falls. Similarly, when demand increases, the improvement of the firm's balance sheets may make the firms' access to external finance easier and less expensive leading to increase in inventories. Given that inventories are likely to have relatively low adjustment costs compared with fixed investment or investment in research and development, inventory investment bear the impact of any adjustment arising from a fall in cash flow if the firm is financially constrained. If firms do have a hierarchy of finance in view of capital market imperfections, then the investment, particularly inventory investment of some firms will be constrained. So the level of inventory investment undertaken will be determined by the availability of cash flow. Therefore, to improve upon the fit of the model and in order to test for the relevance of capital market imperfections, cash flow variable

has also been included. It is expected that the coefficient on this value will not be different from zero if firms face no information asymmetries. It may also be the case that cash flow may happen to be significant if it contains information about expected investment opportunities not captured by controls for investment demand. However, we assume that current sales included in all our regressions should be a good control variable for short run inventory demand.

Interest rate has been explicitly included in our model as it is expected to have an important bearing on inventory behaviour of a firm.[7] There is the opportunity cost of the funds invested in the inventory that depends on the level of nominal interest rates. Whilst we have increasing inventories with increasing expected sales, we have decreasing inventories with increasing carrying costs. Inventory holdings have to be financed by some source or the other. Generally in India, inventories are known to have been bank-financed by corporates in an essentially bank-dominated financial system. However, even if inventory financing is internal to the firms, they nevertheless bear an opportunity cost that can be proxied by the market interest rates. Higher the interest rates, the costlier are inventory levels. Therefore, interest rates would influence inventory accumulation. Since inventories are typically carried over the short and medium-term and are generally financed by borrowings of such tenures, it is useful to test for the interest sensitivity of inventories using an appropriate short-term interest rate.

There are two opposing effects on inventory decisions due to changes in prices. An increase in prices can cause producers to expect higher prices in the future, which leads them to increase inventories in order to take advantage of higher future prices. On the other hand, a price increase encourages producers to sell inventories immediately in order to profit from the current high price. Similarly, a decrease in price may induce producers to hold inventories in hopes of higher future prices. On the other hand, falling prices may lead producers to dispose of inventories because of the fear that prices will continue to fall in the future. There is appreciation (or depreciation) in the price of good while it is held in inventory. These inventory profits (losses)

reduce (increase) the per unit financial inventory carrying costs. Inflation rate is included in the regression equation to reflect the possibility that inventory behaviour is affected by expected holding gains or losses. The price expectations are formed autoregressively, which means that price variable is assumed to be a distributed lag function of current and past actual levels of inflation rate.

This stock adjustment inventory model based originally on Lovell (1961) model augmented with cash flow, price expectations and interest rates, has been used to examine inventory formation in Indian private corporate sector with a view to an improved understanding of inventory behaviour of Indian manufacturing. The final inventory investment is estimated with the following equation:

$$\Delta N_{it} = -\lambda N_{i,t-1} + \varphi S_{i,t} + \mu S_{i,t-1} + \phi r_{it} + \delta_0 PE_t + \delta_1 PE_{t-1} + \delta_2 PE_{t-2} + \theta_1 CF_{it} + \theta_2 CF_{it-1} + \varepsilon_{it} \quad \text{.....(7)}$$

where r_{it} is the real interest rate, PE_t is price expectations and CF_{it} is the measure of current cash flow for firm i and represents the marginal cash flow effect. The first three variables in above equation are the outcome of production smoothing model. These quantity variables act like controls, allowing us to test the importance of price variables and internal finance after controlling for the accelerator (sales) and stock adjustment effects. The cash flow terms are the main focus for our study that reflect the impact of internal finance on inventory investment implied by the literature on financing constraints.

Because the sample is panel, there are most likely problems of heteroscedasticity. To overcome this, we estimate the coefficients by within group OLS and use white heteroscedasticity consistent estimator of the least squares covariance matrix.

Table-4 reports summary statistics of the sample. Inventory stocks are, on average, 25 per cent of sales whereas cash flows are only 6 per cent of total sales. Inventory investment is on an average less than 3 per cent of sales. Inventory stocks and inventory investment as share of sales show a declining trend over the years, perhaps reflective of improved inventory investment by the firms.

Table 4: Key Statistics of Sample used in Estimation of Inventory Investment

	Full Period 1972-73 to 1999-2000	Panel I: 1972-73 to 1979-80	Panel II: 1980-81 to 1991-92	Panel III: 1992-93 to 1999-2000
Number of Firms	1,800	1,441	1,800	881
(No. of observations)	-28,527	-10,626	-12,849	-5,052
Mean(Total Assets) (in Rs. crore)	76.91	7.66	39.05	202.94
Mean (Inventories Stocks) (in Rs. crore)	13.15	2.69	9.64	28.88
Mean (Sales) (in Rs.crore)	61.21	9.18	38.83	146.81
Mean (Cash flow) (in crore)	4.31	0.46	2.27	11.21
Inventory stocks / total assets (in %)	25.78	35.08	26.77	15.01
Inventory investment / sales (in %)	2.6	3.13	2.95	1.55
Inventory stocks / sales (in %)	25.17	29.66	25.53	20.14
Cash flow / sales (in %)	6.02	5.13	5.51	7.69

Table 5: Key Statistics of Variables used in Inventory Investment Regressions

Variable	Mean	Standard Deviation	Minimum	Maximum
Inventory investment (t)/ Total Assets(t-1)	0.0322	0.1075	-0.6182	3.9405
Inventory stock(t)/ Total Assets(t-1)	0.3093	0.1730	0.0002	4.4270
Sales(t)/Total Assets(t-1)	1.3743	1.1482	0.0005	47.0501
Cash Flow(t)/Total Assets(t-1)	0.0643	0.1201	-1.9127	2.6877

VI

Estimation Results

Ordinary least square with group dummy panel estimation of the basic inventory equation modelled on lines of Blinder and Maccini (1991) shows evidence in favour of lagged inventory adjustment. Current and lagged sales and current cash flows are found to be important determinants of inventory investments of the Indian firms. In addition, interest rate and price expectations influence inventory investment

behaviour implying that monetary policy has an impact on inventory behaviour of the firms (Table 6).

Table 6: Estimates of Inventory Investment and its Components: 1972-73 to 1999-2000

Dependent Variable →	Inventory Investment in							
	Total Inventories		Finished Goods		Raw Materials		Work-in-Progress	
Explantory Variables ↓	Coeff.	T-Stat	Coeff.	T-Stat	Coeff.	T-Stat	Coeff.	T-Stat
N_{t-1}	-0.222**	-15.0	-0.308**	-11.0	-0.313**	-23.4	-0.228**	-7.4
S_t	0.038**	4.9	0.019**	3.3	0.012**	5.7	0.002**	3.1
S_{t-1}	0.003	0.4	0.003	0.7	0.001	0.8	0.001*	1.9
CF_t	0.144**	7.0	0.049**	4.3	0.066**	10.3	0.008	1.2
CF_{t-1}	0.018	1.4	0.016*	2.0	0.005	1.1	-0.005	-1.2
$SBIINT_t$	-0.001**	-5.0	-0.001**	-4.0	-0.001**	-6.0	0.000	0.1
PE_t	0.002**	7.7	0.000	-0.4	0.001**	8.3	0.000**	4.3
PE_{t-1}	0.001**	3.1	0.001**	3.8	0.000**	-2.9	0.000	1.4
PE_{t-2}	0.000*	1.8	0.001**	3.7	0.000	-0.9	0.000	0.8
Implied □	0.186		0.072		0.042		0.014	
Implied ϒ	0.003		0.003		0.001		0.001	
Deg of freedom	26718		26718		26718		26718	
Adjusted R^2	0.13069		0.12247		0.13332		0.14415	

Notes:

(1) : N=stock of respective inventory component; S=Total sales; CF=Cash Flow; SBINT=State Bank of India advance rate; PE=Price expectations proxied by adaptive framework using inflation rate based on GDP deflator; Neg= Negligible coefficient values.

(2) : Firms' level variables, viz., N, S and CF are deflated by total assets to neutralise scale effects of dominance by large firms.

(3) : time subscript *t* denotes annual time period with lags of one and two years denoted by *t-1* and *t-2*, respectively.

(4) : table value for t–statistics for large degrees of freedom is 1.645 for 5% level of significance and 2.326 for 1% level of significance.

(5) : to overcome the problems of heteroscedasticity in the panel of firms, the coefficients are estimated by within group OLS and using white heteroscedasticity consistent estimator of the least squares covariance matrix.

(6) : Implied ß (beta) is calculated as the ratio of sum of sales coefficients to coefficient on inventory stock. Implied g (gamma) is calculated as the ratio of the coefficient on lagged sales to coefficient on stock inventory multiplied by accelerator effect ß plus one.

Given that annual data are being used, one could expect the coefficient on lagged dependent variable to be minus unity, indicating complete adjustment within that time period. The obtained results, however, show that buffer stock adjustment is relatively fast for the raw materials and finished goods inventories, with an adjustment of about little over 30 percent per annum, while it is lower for total inventory investment

with an adjustment of 22 percent per annum of the desired inventory stocks. Inventory adjustment for work-in-progress is by far the slowest, with an annual adjustment of 23 percent. The coefficients obtained for the total inventory investment for period 1971-72 to 1999-2000 could be interpreted as being somewhat lower than what is generally obtained in the literature for advanced economies[8]. The coefficient on lagged inventory stocks is a measure of the speed with which the firm adjusts to the desired level of inventories. The relatively lower adjustment speed may partly reflect the better speedier response of firms in advanced economies, but could also be the result of data limitations arising from lack of quarterly or monthly data. This impact of time aggregation lowering the coefficients of adjustment speed has been noted by Carpenter, *et. al*. (1994). The low adjustment speed for total inventories may also reflect the result of clubbing of different inventory components of finished goods, raw materials, work-in-progress and stores and spares, each of which may have different inventory behaviour and cycles. This argument has been advanced earlier by Blinder (1986) in the literature. There is very little evidence even in the case of advanced economies on speed of adjustment for different components of inventory investment separately. However, such evidence improves our understanding of how business investments respond to gaps between actual and desired inventory stocks. Therefore, determinants of inventory investment are analysed at the total as well as for the three major components of inventory investment. The results of the estimated equations provide documentation that raw materials and finished goods have a speedier adjustment response than raw materials. The coefficient for raw material is distinctly smaller than what has been obtained in case of developed countries. In developed countries raw material adjustment is much faster than finished goods stock adjustment. But for the Indian firms these two components have roughly the same value.

The contemporary sales coefficient for total inventories and its components (finished goods, raw materials and work-in-progress) obtained for the Indian firms are positive and significant. These coefficients reflect a combination of stock accelerator effect arising from rising sales and the buffer stock effect arising from stochastic demand. Since the former is expected to cast a positive influence on

inventory investment, while the latter is expected to be negatively related, the total impact is indeterminate *a-priori*. We, however, obtain a consistently positive sign and coefficients significant at 1 percent levels for total inventories and all its components, implying that the accelerator impact is dominant. This means that the Indian firms inventory formation is dominated by expectations of future sales. Lagged sales coefficients are found to be insignificant. In studies on advanced countries with monthly or quarterly data, higher number of lags of sales are found to be positive and significant because lagged sales are positively correlated with expected sales following the accelerator effect. This reflects the positive dependence of target level of inventories with lagged sales, leading to a positive coefficient of lagged sales in a regression determining inventory investment. However, with annual data, the results show insignificance of lagged sales for the Indian firms, though the signs are positive for the first year lag.

The composite coefficients φ and μ have values of 0.038 and 0.003, respectively for total inventories. The implied β equals 0.186. The implied γ is near zero implying perfect foresight in expectation formation of sales. The estimate of long-run inventory to sales sensitivity captured by accelerator coefficient β is positive for all types of inventory investment that supports the stock-out avoidance motive.

Contemporaneous cash flows are found to have a significant impact on inventory investments with high t-ratios for total inventories and all the inventory investment components, except work-in-progress. The lagged cash flows are, however, not significant for all the components of inventories, except for finished goods inventories, which is significant at 5-per cent level of significance, but not at 1-per cent level. The positive coefficient for cash flows indicate that firms build-up inventories at times when internal funds are available with them, but offset declines in cash flows by reducing their stock of inventories. This is evidence for presence of some financing constraints.

Traditionally research on inventories of the firms has devoted considerable attention to cyclical impact, but still underplayed the

role of monetary policy variables such as interest rates and price expectations. Bhole (1985), Louri (1991) and Hay and Louri (1994), however, devote considerable attention to this aspect. Examining the inventory investment of Indian public limited companies for the period 1951-76, Bhole (1985) find that real rate of interest proxied by the real SBI advance rate was negatively related to real inventory investment and its components and the coefficient was significant at the 1 percent variable. The interest rate variable captures the cost of short-term loans, mainly bank borrowing. For a panel of Greek firms for the period 1958-85, Louri (1991) also find that interest rate coefficient is significant and has a negative sign in case of total inventory investment and raw materials, though in case of finished goods they have a negative sign but an insignificant coefficient. Hay and Louri (1994), however, find for a panel of UK firms for the period 1960-85 that microeconomic factors matter much more and that interest rates were not a significant determinant of inventory investment. Our empirical results for the panel of Indian firms for 1971-72 to 1999-2000 reveal that real interest rate was an important determinant of total, finished goods and raw material inventory investments, though not for the work-in-progress. Its coefficient had a consistently the expected negative sign. This reflects the behaviour of building up finished goods and raw material inventories if carrying costs were low, but depleting them if carrying costs rise.

Regarding price expectations, the current and lagged inflation rates are included in the equations explaining inventory investment because these variables reflect the possibility that inventory behaviour is affected by expected holding gains or losses. It also reflects the losses that are incurred on nominal assets. Bhole (1985) argues that inventories may often be held out of the speculative motive. Following Bhole (1985) and Louri (1991) in our model, inflation expectations are hypothesised to form by an adaptive expectations process. We find considerable impact of inflation expectations generation process with contemporaneous inflation rate turning out to be highly significant for raw material investments and work-in-progress. Some persistence was also observed for the impact of inflation expectations

on inventory investment with lags of up to two years being significant for total inventory investment. We find that firms hold inventories with a speculative motive and past inflation generates expectation of future inflation. This prompts companies to build up inventories to reap capital gains and to hedge against future inflation. In contrast, current inflation rate being high induces firms not to make new inventory investments.

Determinants of Total Inventory Investment during sub-periods:

The panel period in the above exercise spans nearly three decades. Since underlying inventory behaviour may have changed during this long period, it is of interest to examine the relationship for shorter panels as well. It is done by splitting the total sample period into three time periods, viz.: *1972-73 to 1979-80, 1980-81 to 1991-92 and 1992-93 to 1999-2000.*

The first period essentially covers a period of rapid branch expansion by commercial banks and a regulated interest rate regime that may have had an impact on the inventory holding and inventory financing of the Indian corporate sector that is quite distinct from that for the other two periods. This was also a period that was characterised by high inflation for the three-year period 1972-73 to 1974-75 due mainly to the OPEC induced oil price shock. The second period was characterised by beginning of the transformation from a banked-based financial system to a more market oriented system. The initial years were characterised by high inflation due to second oil price shock and balance of payment difficulties, while the terminal year witnessed severe credit compression to combat the external payments crisis. The third period marked the liberalisation and reforms of the financial system, enabling firms to raise financial resources liberally using a wide array of new instruments. Inventory investment equation was estimated for each of these periods for total inventory investment, as also for three of its components, viz., finished goods, raw materials and work-in-progress. The empirical results are reported in tables-7, 8, 9 and 10 respectively.

Table 7: Estimates of Total Inventory Investment

(Dependent Variable- Total Inventory Investment)

	Period –1 : 1972-73 to 1979-80		Period –2 : 1980-81 to 1991-92		Period –3 : 1992-93 to 1999-00	
	Coeff.	**t-ratio**	**Coeff.**	**t-ratio**	**Coeff.**	**t-ratio**
N_{t-1}	-0.338 **	-10.6	-0.297 **	-16.5	-0.461 **	-15.9
S_t	0.061 **	4.7	0.022 **	3.1	0.034 **	5.1
S_{t-1}	0.011	1.2	0.009	1.5	0.045 **	6.7
CF_t	0.179 **	3.6	0.174 **	7.2	0.058 **	3.4
CF_{t-1}	0.011	0.4	0.032 *	1.8	0.039 **	3.0
$SBIINT_t$	0.001 *	2.4	-0.109 **	-3.4	0.001	0.3
PE_t	0.004 **	11.5	-0.107 **	-3.3	0.004 *	2.0
PE_{t-1}	0.001 **	6.4	-0.001 **	-2.1	0.003 *	2.1
PE_{t-2}	0.000	-1.4	0.000	0.8	-0.002	-0.9
Implied □	0.213		0.105		0.172	
Implied □	0.010		0.009		0.042	
Degree of freedom	9176		11040		4162	
Adjusted R^2	0.1990		0.1179		0.2277	

Notes: As in Table-6.

Table 8: Estimates of Finished Goods Inventory Investment

(Dependent Variable: Finished Goods Inventory Investment)

	Period –1 : 1972-73 to 1979-80		Period –2 : 1980-81 to 1991-92		Period –3 : 1992-93 to 1998-99	
	Coeff.	**t-ratio**	**Coeff.**	**t-ratio**	**Coeff.**	**t-ratio**
N_{t-1}	-0.380 **	-7.0	-0.392 **	-15.2	-0.620 **	-14.5
S_t	0.041 **	3.7	0.008 *	2.5	-0.001	-0.1
S_{t-1}	0.005	0.7	0.008 *	2.4	0.034 **	7.6
CF_t	0.050 *	1.9	0.067 **	4.4	0.023 *	2.5
CF_{t-1}	0.028	1.5	0.022 *	1.8	0.004	0.5
$SBIINT_t$	0.000	0.3	-0.117 **	-5.1	0.002	1.1
PE_t	0.001 **	4.2	-0.115 **	-5.0	0.001	0.8
PE_{t-1}	0.001 **	5.8	-0.003 **	-7.0	0.000	0.5
PE_{t-2}	0.000	0.5	0.000	0.5	-0.002 *	-1.9
Implied □	0.123		0.041		0.054	
Implied □	0.005		0.008		0.033	
Degree of freedom	9176		11040		4162	
Adjusted R^2	0.1728		0.1066		0.2500	

Notes: As in Table-6

Table 9: Estimates of Raw Material Inventory Investment

(Dependent Variable: Raw Materials Inventory Investment)

	Period –1 : 1972-73 to 1979-80		**Period –2 : 1980-81 to 1991-92**		**Period –3 : 1992-93 to 1998-99**	
	Coeff.	**t-ratio**	**Coeff.**	**t-ratio**	**Coeff.**	**t-ratio**
N_{t-1}	-0.530 **	-16.7	-0.403 **	-19.7	-0.524 **	-16.9
S_t	0.009 **	3.0	0.009 **	3.3	0.025 **	8.9
S_{t-1}	0.007 **	3.0	0.001	0.7	0.009 **	3.4
CF_t	0.126 **	9.4	0.055 **	6.2	0.026 **	3.9
CF_{t-1}	0.023 *	1.8	0.014 *	2.0	0.021 **	3.3
$SBIINT_t$	0.001 *	1.7	0.007	0.4	-0.001	-0.8
PE_t	0.002 **	11.9	0.007	0.4	0.001	1.3
PE_{t-1}	0.000	1.5	0.001 **	4.3	0.002 *	2.1
PE_{t-2}	0.001 *	-2.1	0.000	-1.3	0.001	1.2
Implied □	0.030		0.027		0.065	
Implied □	0.007		0.001		0.009	
Degree of freedom	9176		11040		4162	
Adjusted R^2	0.2171		0.1574		0.2187	

Notes: As in Table-6

The speed of adjustment coefficient for inventory stocks is found to improve significantly with disaggregation of time period implying that the somewhat lower coefficient for full period may have been not just on account of aggregation of different types of inventories and lower frequency of the data, but also due to the long time period under consideration. Total inventory investment is found to adjust to the desired level at a rate of 30-46 percent per annum, while that of finished goods investment adjusts at a rate of about 38-62 percent per annum. The raw material inventories adjusted at an annual rate of about 53 percent, though the rate was somewhat lower in the 1980s at 40 per cent. The speed of adjustment remained the least for the work-in-progress in the range of 29-40 percent. The speed of adjustment for finished goods stock appears to have improved after the

Table 10: Estimates of Work-in-Progress Inventory Investment
(Dependent variable: Work-in-Progress Inventory Investment)

	Period –1 : 1972-73 to 1979-80		**Period –2 : 1980-81 to 1991-92**		**Period –3 : 1992-93 to 1998-99**	
	Coeff.	**t-ratio**	**Coeff.**	**t-ratio**	**Coeff.**	**t-ratio**
Nt-1	-0.290**	-4.0	-0.339**	-9.2	-0.404**	-6.6
St	0.003*	1.9	0.002*	2.0	0.001	0.6
St-1	0.001*	1.8	0.001	1.6	0.003*	2.1
CFt	-0.008	-0.4	0.021**	3.8	0.007	1.5
CFt-1	-0.019*	-1.7	-0.005	-1.0	0.011**	3.2
SBIINTt	0.0004	1.5	-0.008	-0.9	0.000	0.6
PEt	0.0002**	2.9	-0.008	-0.9	0.002*	2.4
PEt-1	0.0002*	1.8	0.000	-1.1	0.000	0.4
PEt-2	0.000	-0.9	0.000*	1.9	-0.001	-1.1
Implied □	0.016		0.009		0.009	
Implied □	0.001		0.001		0.003	
Degree of freedom	9176		11040		4162	
Adjusted R2	0.1536		0.2032		0.1751	

Notes: As in Table-6

liberalization and reforms initiated in mid-1991, with the adjustment process being completed in less than two years.

This indicates that the business is more responsive to carrying and other associated costs of holding finished goods stocks and may be making a better assessment of shifts in market trends and also making use of better inventory management techniques. Structural bottlenecks impeding the movements of goods may also have come down as a result of improved thrust to transportation and other infrastructure.

Current sales had a positive sign and were significant, except for the third period for the finished goods and the work-in-progress. The estimate of long-run inventory to sales sensitivity captured by accelerator coefficient β are positive in all three

periods for all types of inventories, which supports the stock-out avoidance motive. It decreased from 0.213 in the first period to 0.105 in the second period, but rose again to 0.172 in the reforms period for total inventories. This trend was generally observed for components of inventory as well, though in case of raw material inventories β increased sharply from 0.027 in 1980-81 to 1991-92 to 0.065 during 1992-93 to 1999-00 suggesting that accelerator effects were stronger for the raw material acquisitions. Interestingly, even in the 1990s the accelerator effects dominate buffer stock effects in spite of better inventory management that has been supported by new innovations, including information technology and supply chain management. Rising aggregate demand in the economy may have supported these trends. The accelerator effect is also seen from the positive and significant coefficients of lagged sales in almost all the cases for inventory investment and its components for all the sub-periods, specially so in the 1990s. The implied γ is also seen to increase markedly in the period 1992-93 to 1999-00 and its positive value implies under-reactions in the expectations formation of firms. In other words, this implies that firms underestimate sales when sales are increasing in time and overestimate them when sales are decreasing in time.

The cash flow coefficients were large and had the expected sign for the total inventories and its components. Sub-period analysis indicates that cash flows continue to have a significant impact on inventory investment during the post-reform period, though the size of the contemporary cash flow coefficient has somewhat decreased. This may mean that easier access to external finance has to some extent reduced firms' dependence on internal resources, but cash constraints continue to affect inventory investment. This could be the result of financing hierarchies, in which firms have to pay external financing premium.

The monetary policy variables, viz., interest rates and expected inflation, by and large, had a varied impact on inventories during the period under study. The interest rate coefficient for total inventories

was found to be highly significant during 1980-81 to 1991-92, but turned out to be insignificant during the post-reform period 1992-93 to 1999-00. This may be on account of the reduced relevance of SBI advance rate with a shift in bank lending from short-term loans to term loans and emergence of alternative financing sources that are also reflected in reduced significance of the cash flow variable. The significant impact of interest rate for total inventories, during 1980s was largely on account of financing of finished goods inventories, but generally interest rate was not found to matter for raw material and work-in-progress inventory investment. Current and lagged inflation rate had generally positive sign. For total inventories and all its components it was significant during 1970s. One may recall that 1970s included three years of double digit inflation following the first oil price shock and also a double digit inflation in the terminal year as a result of second oil price shock. This could have encouraged firms to build up inventories to beat the high inflation. Annual data on inventories confirms the hypothesis of inventory build up in these years. In the 1980s, however, the coefficient carries a negative sign and turns out to be significant for total inventories and finished goods. It is difficult to find any convincing explanation for the same. With low and stable inflation in the 1980s one would generally expect the price expectation coefficient to be insignificant. The price expectation coefficients for the total inventories again turned positive and was significant at 5 percent level for the period 1992-93 to 1999-00.

VII

Conclusions

The paper augments production-smoothing specification with cash flows and monetary policy variables in its application for the Indian data. Several interesting findings emerge from the analysis. However, the results obtained need to be viewed with the limitation of non-availability of quarterly data for the Indian firms. Given that our empirical analysis is based on annual data at the level of firm, it is unlikely to pick up the short run responses to sales shocks that are so important to aggregate analyses with monthly or quarterly data.

Firstly, we find that finished goods account for largest component of stocks as well as flows of inventories for the Indian firms. Unlike the firms from developed countries, the work in progress and not the finished goods inventories constitute the smallest component of total inventories. Secondly, unlike the US firms, Indian firms do have finished goods as the most volatile component of total inventory investment. Thirdly, variance of production for the Indian firms is found to exceed that of sales, indicating that like in other countries, the production smoothing argument for holding inventories is not strong in case of the Indian manufacturing firms. Fourthly, at the disaggregated level of industry groups, positive correlation is found between inventory investment and sales for most industries. This result contradicts the buffer stocking explanation for inventory holding. Fifth, the investment behaviour of finished goods, raw materials and work-in-progress show diverse responses to price, quantity and financial variables. Panel data estimation indicates that coefficients on lagged inventory stock variable are always negative and highly significant. The estimated speed of adjustment from the actual to the desired inventory stock was the fastest for finished goods inventories, while it is lower for total inventory investment. The speed of adjustment to targeted total inventories is estimated at 22 percent per annum for the full period. However, this has a downward bias arising from time aggregation. Disaggregated analysis for sub-periods shows that Indian firms adjust inventories exceeding 30-46 percent annually in all the three sub-periods. The adjustment is faster for finished goods at a rate of around 62 percent per annum during the post-liberalisation period 1992-93 to 1999-2000. The results reveal that the speed of adjustment for inventories of the Indian firm at 30-46 percent obtained for shorter time spans of around a decade in the three sub-periods is not very different from the 33-36 percent for the Dutch firms as reported in Bo (2001) and 27-30 percent for the US firms as reported in Carpenter, et.al. (1994). However, the speed of adjustment for Greek corporations as obtained by Louri (1991) was higher at 63 percent. While for the Greek firms raw material adjustment was faster at a speed of 83 percent in comparison of 28 percent for finished goods, we find that the adjustment speed at 31

percent was same for these two components of inventories for the Indian firms.

Sixth, a consistently positive sign and significant coefficients on sales obtained imply that the accelerator impact is dominant. Seventh, real interest rate was found to be an important determinant of total, finished goods and raw material inventory investments, though not for the work-in-progress. Eighth, price variables are significant, but quantity variables viz. lagged inventory stock level and sales are much more important.

Lastly, while stock adjustment has a large influence on inventories, one robust result of the analysis of inventory behaviour in this paper is that cash flow is found to be an important determinant as well. The cash flows continue to significantly impact inventory investments in the post-reform period beginning 1992-93 implying that external financing premium may continue to exist in spite of the emergence of alternative sources of financing for the firms from the stock markets or elsewhere. Availability of internal finance amidst financial market imperfections, therefore, does cause fluctuations in inventory investments.

Data Appendix

Total Inventories Stock, Finished Goods Inventory Stock, Raw Materials Inventory Stock, Work-in-Progress Inventory Stock: The balance sheet data report the book value of total inventories, finished goods, raw materials, work-in-progress and 'others'. Firms value their inventories either by LIFO methods or FIFO methods. Indian firms are known to apply FIFO method generally to evaluate their inventories, the governing rule being "lower of cost or market value". To remove the inflation bias from FIFO firms', the inventory stocks are deflated by the index for change in stocks.

Total Inventories Investment, Finished Goods Inventory Investment, Raw Materials Inventory Investment, Work-in-Progress Inventory Investment: Total inventory investment and its components are the annual changes in the stocks of total inventory stock and

respective stocks of its components. For FIFO firms, the change in inventories will be overstated if there is a positive inflation rate because the end-of-period value will include the nominal inflation of the stocks. To remove the inflation bias from FIFO firms' inventory investment variable, the stocks are deflated by the index for change in stocks before computation of change in inventories.

Sales: Sales are net sales adjusted for excise and cess and excludes other income. To construct a real measure of sales, implicit GDP price deflator deflates reported nominal value of sales.

Internal Finance: The measure of internal funds is defined as cash flow relative to beginning of gross fixed assets. Cash flow is defined as income (or loss) from operations (net profit) plus depreciation, depletion and amortization of property, plant and equipment. The implicit GDP price deflator deflate cash flow to construct real measure of cash flow.

Short-term Interest Rate: Real short-term interest rate is calculated as the State Bank of India advance rate less the percentage change in the GDP deflator.

Price Expectations: The price expectations are formed autoregressively and are assumed to be a distributed lag function of current and past actual levels of inflation rate based on wholesale price index.

Notes

1 In practice, apart from the rising marginal costs the firms also face costs for changing levels of production reflected in say search and contract costs for additional labour or other inputs that may be needed or settlement costs for firing workers or exiting out of existing contract arrangements for other inputs. While these are not generally explicitly introduced in literature, these costs reinforce firms to smooth production.

2 Marginal cost of holding inventories consists of the cost of finance as well as storage costs, the risk of obsolescence etc. and the marginal benefits of holding inventories.

3 A drawback of using annual data is that one can miss some of the cyclical variation that characterizes inventory behaviour. However, higher than annual frequency of data on inventories or its breakups are not available for Indian firms. However, change in stocks at aggregative level is available from unaudited quarterly results from the year 2000 onwards.

4 Since production (Y_t) = Sales (S_t) + change in the stock of inventories(ΔN_t), $Var(Y_{it})=Var(S_{it})+Var(\Delta N_{it})+2Cov(S_{it},\Delta N_t)$, $[Var(Y_{it})/Var(S_{it})] < 1$ requires that $Cov(S_{it},\Delta N_{it}) < 0$.

5 Raw materials were also found to be the most volatile component for the Australian manufacturing firms accounting for 39.3 percent for the de-trended variance of total inventories (Flood and Lowe, 1993).

6 Only in case of textiles the ratio was the variance marginally less than unity for both the variance ratio measures. Also, in case of the sub-component of machinery other than transport and electric the first ratio was marginally less than unity.

7 Apart from the interest costs, inventories also attract carrying costs in the form of storage, decay and obsolescence.

8 For instance, Carpenter, et al. (1993) obtain coefficients that imply an estimated speed of adjustment of the actual to desired inventory stock in the range of 14 to 26 percent per quarter for the US firms depending upon different time periods and depending upon whether the firms were small or large.

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