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DEPRECIATION AND REPLACEMENT COST

by

Ramesh Gupta

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DEPRECIATION AND REPLACEMENT COST*

The sharp rise in prices in recent years has stirred up a brisk debate on the meaning and measurement of business income. The discussion is not limited to the question of income shown by financial statements but also to the methods of determining taxable income. In this regard, the accounting treatment for two types of assets - inventories and depreciable assets - has received major emphasis. In the case of inventory, the generally accepted accounting principles allow Last-in, First-out (LIFO) method to be used for measuring cost of goods sold. While LIFO is not a perfect surrogate for price level adjustments, it often provides cost-of-goods-sold figures that are reasonable approximations of current costs. But the generally accepted accounting principles offer no real relief from the effect of inflation on depreciation charges.

Purpose of the Study

This article appraises the arguments used in the controversy about the depreciation allowance at replacement cost. There are two main lines of reasoning behind this controversy.[1] First, the depreciation charged against the revenue in a given period should be

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[1] A.R. Prest, 'Replacement Cost Depreciation,' Accounting Research, I (1948-50), p. 385.

such that it does not simply deemed to recover the original, historical cost of capital equipment, but in some sense or the other, replacement costs. Second, we have the theoretically less clear but more popular position that depreciation at replacement cost (or, more generally, enhanced depreciation allowance) is propagated as a means to save on taxes. We will try to explore the various approaches to the problem of providing appropriate depreciation allowance in measuring income.

Depreciation Methods Used

It is generally recognized that in times of inflation the depreciation provided in the books is not sufficient to replace the asset. Accountants admit the gravity of underprovision, but dislike to abandon traditional methods. They try to meet the depreciation shortfall by speeding up the normal process of writing off historical costs. Some do so by making the amortization period as short as possible, while others may feel that the length of life used in depreciation is satisfactory, but the method of spreading cost over this period is wrong. There is a general tendency to switch from the straight-line to the 'fixed percentage of the declining balance' (W.D.V. Method) and similar other methods to speed up depreciation. They may adopt a depreciation formula that makes heavy charges in the early part of the life of the asset (perhaps justifying this by pointing to abnormal physical activity in the early years), or they may write off an arbitrary initial allowance in the first year. 'Sometimes, a gross amount is picked up out of the air, and a formula found which will yield that figure.'[2] Other times, management keep an eye on earnings in choosing the depreciation policy, depreciation would be speeded up if profit equalization is the most desirable goal. The methods of accelerating depreciation require an enormous degree of managerial judgement and discretion. In view of these considerations, it is not surprising that regulatory bodies and tax authorities have more or less forced companies to adopt some rigid method of providing depreciation.

All such tricks for speeding up depreciation to some extent are useful during inflation. A firm can set aside receipts earlier than it would do otherwise and buy new assets before their prices go up. However, so long as funds are accumulated via depreciation charges based on historical cost the recoveries are bound to be inadequate. Faster recovery of original cost does not provide sufficient funds to replace the asset which can now be bought only at higher prices. Sometimes, the inadequacy of depreciation charges is taken care of

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[2] E. Cary Brown, '<u>Depreciation Adjusted for Price Changes</u>', Harvard University, Boston, 1952, p. 54.

by levying a special surcharge, in addition to normal historical cost based depreciation. Most often, this is treated as an appropriation of net income or surplus rather than as an item of cost. Such surcharge is set aside in the form of a special reserve to be used to replace the depreciated asset. In reality, the surcharge becomes a part of equity.

In all these cases, it will be noticed that the depreciation base is historic cost. Of quite a different character, therefore, are the proposals to change the depreciation base in such a way as to recognize differences in the price level between the time when an asset is purchased and the time when it is being used or replaced. One such method could be to restate in each year the historical cost of asset using the specific price index applicable to that asset and then providing depreciation on a straight-line basis. We call it Straight-Line Inflation Adjusted (SLIA) method. In this paper, we have tried to examine the relationship between Written Down Value (WDV) and the SLIA method of providing depreciation.

In WDV method the depreciation for each year is found by applying a rate significantly higher than a comparable depreciation rate under the straight-line method. The WDV rate is applied to the net book value of the asset at the beginning of that year rather than to the original cost of the asset. Net book value is the cost less total depreciation accumulated up to that time. In SLIA method, the annual depreciation on any machine not only includes depreciation at replacement cost for the current year but also allows for any shortfall in previous allowances based on a lower replacement cost. The earlier year's shortfall in accumulated depreciation is known as backlog depreciation.

The important characteristic of WDV method is that the depreciation is higher in the initial years and will decline as time passes by, whereas SLIA depreciation will be increasing progressively due to increases in gross value and backlog depreciation. The behaviour of cumulative depreciation curves under the two methods is depicted in Exhibit 1.

From the exhibit we can observe that when cumulative depreciation approaches the original acquisition cost, WDV curve flattens out, but SLIA cumulative depreciation curve go on increasing. The slope of the SLIA cumulative depreciation curve depends upon the assumed inflation rate. Curves A and B are SLIA cumulative depreciation curves for a machine life of 10 years and annually compounded inflation rate of 6 per cent and 10 per cent respectively. Curves C, D and E are cumulative depreciation curves under WDV for a rate of 20 per cent, 30 per cent and 40 per cent respectively. The figures for the graph are given in Table 1.

From the exhibit we would also notice that in the initial years accumulated depreciation under WDV exceeds the SLIA cumulative depreciation, but after a certain period WDV depreciation is not sufficient to equalize SLIA depreciation. In the initial years, the additional depreciation in WDV method even exceeds the differential of replacement-cost depreciation over historic-cost depreciation. In the later years, under WDV, the base (i.e., net book value) to which the rate is applied becomes smaller and smaller, while under SLIA due to inflationary trends the base increases and increasing amount has to be provided for backlog depreciation. . . . Thus, up to a point depreciation provided under WDV is sufficient to equalize inflation adjusted depreciation. If a machine is replaced when the WDV equals SLIA cumulative depreciation, the funds provided under either method of depreciation should be sufficient to meet the cost of replacement. No doubt in this claim, there is an implicit assumption that undepreciated value of the assets under SLIA can be recovered as salvage value by disposing of the used machine, or can be traded-in with new machine by paying depreciated amount. Assumption may not hold true in all the situations, but is not entirely unrealistic either.

What would be the point where WDV and SLIA cumulative depreciations are equal. To find this point, we have employed simulation technique using depreciation models. We have chosen this technique because it has a number of advantages. It offers substantial flexibility; models may be varied in many ways. It enables one to communicate clearly the conditions and assumptions on which models are based and, more importantly, modelling can establish norms which can be extended to actual situations. If one understands how a real-world situation differs from a related model, it is possible to adjust or modify the model-based generalization to the actual situation.

Specification of the Model

Models are based on assumptions and are explained and operated by symbols. Symbols used in this study are: p_i is inflation rate for ith period, N is life of machine, and let K be the WDV depreciation rate. Inflation rate p_i could be general price index or specific price index for the asset. The one year depreciation under WDV is K multiplied by written down value (i.e., net book value). The net book value at point n is $(1-k)^n$ proportion of the historical cost and the accumulated depreciation would be $1-(1-K)^n$. Thus, we can observe that WDV cumulative depreciation would always be less than 1 (i.e., 100 per cent of the historic cost) and in the limit would recover the original cost of the asset.

Under straight-line method, the cumulative depreciation at the end of nth period would be equal to $\frac{n}{N}$ (proportion of expired period to the total useful life of the asset). Under the SLIA method this proportion would be applicable to the enhanced value of the asset.

If asset prices are increasing by p_i in ith period, at the end of nth period the replacement cost of the asset would be equal to $\prod_{i=1}^{n}(1+p_i)$ multiplied by historical cost. For simplification, if we assume p_i is the same for all the period, then cumulative depreciation under SLIA would be equal to $\left[\frac{n}{N}(1+p)^n\right]$ proportion of the historical cost. The depreciation for a year in nth period is $\frac{1}{N}(1+p)^n$ plus backlog depreciation. The backlog depreciation can be measured by $\left[\frac{n-1}{N}\,p(1+p)^{n-1}\right]$. In this, $(1+p)^{n-1}$ is replacement cost in the previous period, p is the increase in the asset cost during this period and the whole term $\frac{n-1}{N}\,p(1+p)^{n-1}$ is under provision of depreciation in earlier years for increase in replacement cost during nth period. The simpler way to calculate depreciation in nth period is to compute differential amount in accumulated depreciation in period n over n-1th period. This amounts to $\left[\frac{n}{N}(1+p)^n\right]$ minus $\left[\frac{n-1}{N}(1+p)^{n-1}\right]$ which is equal to nth period depreciation $\left[\frac{1}{N}(1+p)^n\right]$ plus backlog depreciation $\left[\frac{n-1}{N}\,p\,(1+p)^{n-1}\right]$.

Thus at the end of period n, WDV cumulative depreciation is equal to the $\left[1-(1-K)^n\right]$ proportion of the historical cost, while under the SLIA method cumulative depreciation is $\frac{n}{N}(1+P)^n$ proportion of historical cost.

Simulation Results

From the above formulation, we can observe that the time period at which WDV cumulative depreciation would be equal to SLIA cumulative depreciation depends upon the WDV rate (K), the rate of price changes in the cost of asset (p) and the life of the machine (N) over which cost has been depreciated. In Table 2 we have computed the values of n, time period when the WDV cumulative depreciation equals the SLIA cumulative depreciation, for various values of K, p and N. If the life of machine is 10 years, for various values of the WDV rate (K = 20%, 30% and 40%), and of the inflation rate (P = 6%, 10% and 12% annually compounded), Table 2(a) indicates the time period up to which funds accumulated under each method would be sufficient to replace the asset. After that period funds accumulated under the WDV method would begin falling short of required funds for replacement. For example, if the asset life is 10 years, and the price of the asset is rising on an average at 6 per cent per annum, then the firm providing depreciation at 30 per cent WDV rate, must think of replacing the asset by 6.2 years, otherwise it has to rely on some other sources to make good the deficit. If the firm does not intend to replace the asset by 6.2 years, then it would be wrong to claim that the firm is providing enough for replacement by using the accelerated method of depreciation.

After 6.2 years there will be a shortfall in the funds, and this shortfall as a percentage to replacement cost increases progressively. The shortfall as a percentage to SLIA cumulative depreciation is approximately 13 per cent in the 7th year, 26 per cent in the 8th year, 37 per cent in the 9th year and 46 per cent at the end of the life of 10 years. Thus, after the 7th year the WDV method really does not take care of the need for replacement funds. Reduction in shortfall sought by increasing the WDV rate also is very marginal because the WDV cumulative curve is flattened around that region irrespective of the rate. For example, if we increase the WDV rate to 40 per cent from 30 per cent, the shortfall in funds at the end of 10th year would be 44.5 per cent, a reduction of 1.5 percentage point.

Table 2 (b) and 2(c) indicate the latest replacement time of assets keeping in view the sufficiency of funds for various values of K and P for a machine life of 15 years and 20 years respectively. A generalization can be made that if prices are rising at 6 per cent per annum, and if we are providing depreciation at 20 per cent WDV rate, after the expiry of half of the life of the asset, the WDV cumulative depreciation provision would not keep up with the increasing replacement cost. If prices are changing at the rate of 10 per cent, then on an average such period is reduced to 40 per cent of the life of the asset. The figures in the brackets in tables 2(a), 2(b) and 2(c) indicate the percentage deficit in the funds if the asset is being used until the end of its normal life.

Now, if it is the firm's policy that the asset is replaced on or before the nth period (for illustration N = 10, P = 6 per cent, WDV = 20 per cent, then n is 6.2 years) WDV may serve as a naive method to take inflation into account. So the question is whether the time period up to which the SDV exceeds or equals SLIA is the real usage period of the asset. It is also clear that as the inflation rate increases the effectiveness of WDV method reduces. The deficit in the last year of the machine life increases substantially.

With the life of machine being 10 years and a WDV rate of 20 per cent, for a price change of 6 per cent per annum the shortfall is about 50 per cent, but if price change increases to 12 per cent such shortfall increases to 71 per cent of the replacement cost. For the same inflation rate the deficit in WDV cumulative depreciation decreases as the life of machine is reduced. For a 6 per cent inflation rate the deficit for a WDV rate of 20 per cent reduces from 69.2 per cent when the life is 20 years to 50 per cent when the life is 10 years. So, the shorter the life of the machine the better is WDV as an approximation to SLIA depreciation.

Effects of Reequipment Policy

If the firm has to finance its own reequipment, we have noticed that the firm not only has to provide for depreciation at replacement cost for the current year but it should also allow for a shortfall in previous allowance based on a lower replacement cost. The provision for this backlog depreciation may not be necessary if we make an assumption that the company is acquiring the fixed assets in every period at a constant rate. In this case, providing depreciation based on SLIA method would create a float - an accumulation of excess fund over what is required for continuous replacement. If the firm is continuously growing in size, this float would also increase. The size of the float depends on a variety of circumstances: the original cost of assets, the rate of growth of the capital stock, the rate of price rise, the age distribution of the stock of equipment.[3] The price changes are not the only reason why discrepancies may arise between funds accumulated by depreciating at original cost and funds needed for reequipment. Such discrepancies invariably occur when there is net investment or disinvestment (acquisition of new assets net of depreciation) on the existing

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[3] A.R. Prest, op. cit., p. 394.

capital stock, and if the rate of net investment is large enough, the effect of any price rise may be smothered. It is only in the limiting case of a constant stock of capital that price movements have clear-cut influence. Furthermore, if accumulated depreciation is invested in securities or other assets that appreciate in value, this is yet another reason why the float may increase in size.

WDV Funds Invested in Securities

If the WDV depreciation is invested every year in interest bearing securities, are the accumulated funds sufficient to cover the cost of replacement at the end? We have computed the accumulated funds for various values of K (WDV rate), funds reinvestment rate (6%, 10% and 15%) and different life period of machines (N = 10, 15 and 20 years). The simulated results are summarised in Tables 3(a), 3(b) and 3(c). From the results, it is clear that for all WDV rates, even if the amounts are invested in interest bearing securities, the accumulated funds are not sufficient to cover the replacement cost if the interest rate earned is less than the inflation rate. Secondly, as the life of a machine becomes shorter, even the higher reinvestment rate may not be sufficient to cover the replacement costs. For example, for a WDV rate of 30 per cent with 12 per cent inflation rate and 15 per cent reinvestment rate, the accumulated funds are sufficient to cover the replacement cost of a machine which has 20 years of life. But if the life of asset is only 10 or 15 years, funds accumulated may not be sufficient to meet the replacement cost. This is because interest is compounded and as the years pass by the compounded interest accrued would be a larger sum compared to the increase in replacement cost if reinvestment rate is higher than inflation rate.

In Table 4(a) 4(b) and 4(c) we also present the simulated results indicating for a given WDV rate (K = 20, 30 and 40 per cent) and a given reinvestment rate (for rates of 6, 10 and 15 per cent), what would be the maximum inflation rate a firm can absorb without worrying about deficit in the accumulated funds for replacement.

From this analysis we find that WDV method can approximate the inflation adjusted depreciation only up to a certain period of machine life. If the rate of inflation is low and the usage period of the machine is short then the WDV method can approximate the SLIA method. If the assets are to be used for their full life then the deficit in WDV method is very large. If a firm replaces the asset before it is fully worn out then WDV can be a good approximation of SLIA depreciation if price changes are small. Further, if the depreciation amount is to be invested in a fund WDV can cover the replacement cost at the end of machine's usual life, if such reinvestment rate is sufficiently high.

Policy Implications of the Results

It is possible that pragmatists may regard the foregoing simulated results as too theoretical, too **simple** or both, but it has several policy implications. Some are as follows:

First and foremost, in profits reported according to generally accepted accounting principles, the costs of labour and material (by use of LIFO method in computing cost of goods sold) are reflected in current prices, but no account is taken of the effect of price changes on depreciation charges. Those seeking relief have two options. One is to try to depreciate on the basis of artificial shortened service lives, and the second is to employ some variation of accelerated depreciation method as an approximation to replacement cost depreciation. But this also does not solve the problem. What a firm needs is to adjust depreciation for changes in prices. This requires, not faster recovery of original cost, but rather a recovery of replacement cost. By undercharging for depreciation, the profits are overstated and it is possible that as a result the dividends declared might be too large, the firm might fail to maintain the real investment in its productive capacity, unreasonable wage demands might be stimulated, or prices might be unrealistically low.[4]

Second, these methods of accelerating depreciation require an enormous degree of managerial judgement. There are tremendous variations in the accelerated depreciation methods used. Indeed,

[4] E. Cary Brown, op. cit., p. 47.

these variations are so great that inter-firm or intra-firm comparison of profits are as difficult as they would be with replacement cost depreciation. There is no way of converting depreciation to a common basis without knowing all the facts. Replacement cost depreciation, on the other hand, can be tested by price indices.

Third, management may not be always objective. If we do not base our depreciation charges on some objective criteria like spreading evenly historical cost or the cost adjusted for price changes, the depreciation might be speeded up because profit equalization might be the desirable goal for the management. It is this aspect of depreciation that may lead to great inaccuracies in reporting a firm's profits.

Lastly, the disparity between cost of replacement and the original cost of facilities causes postponement of replacement of over-age facilities,[5] if we fail to provide for economic depreciation. The allowance of historic-cost depreciation ignores the real economic cost, and thus, effectively imposes a substantially higher rate of income taxation on those companies which have substantial investment in fixed assets. If we continue to ignore economic depreciation in measurement of business income, price fixation, dividend distribution, wage negotiations, etc., we may jeoparadise the needed modernization of productive facilities.

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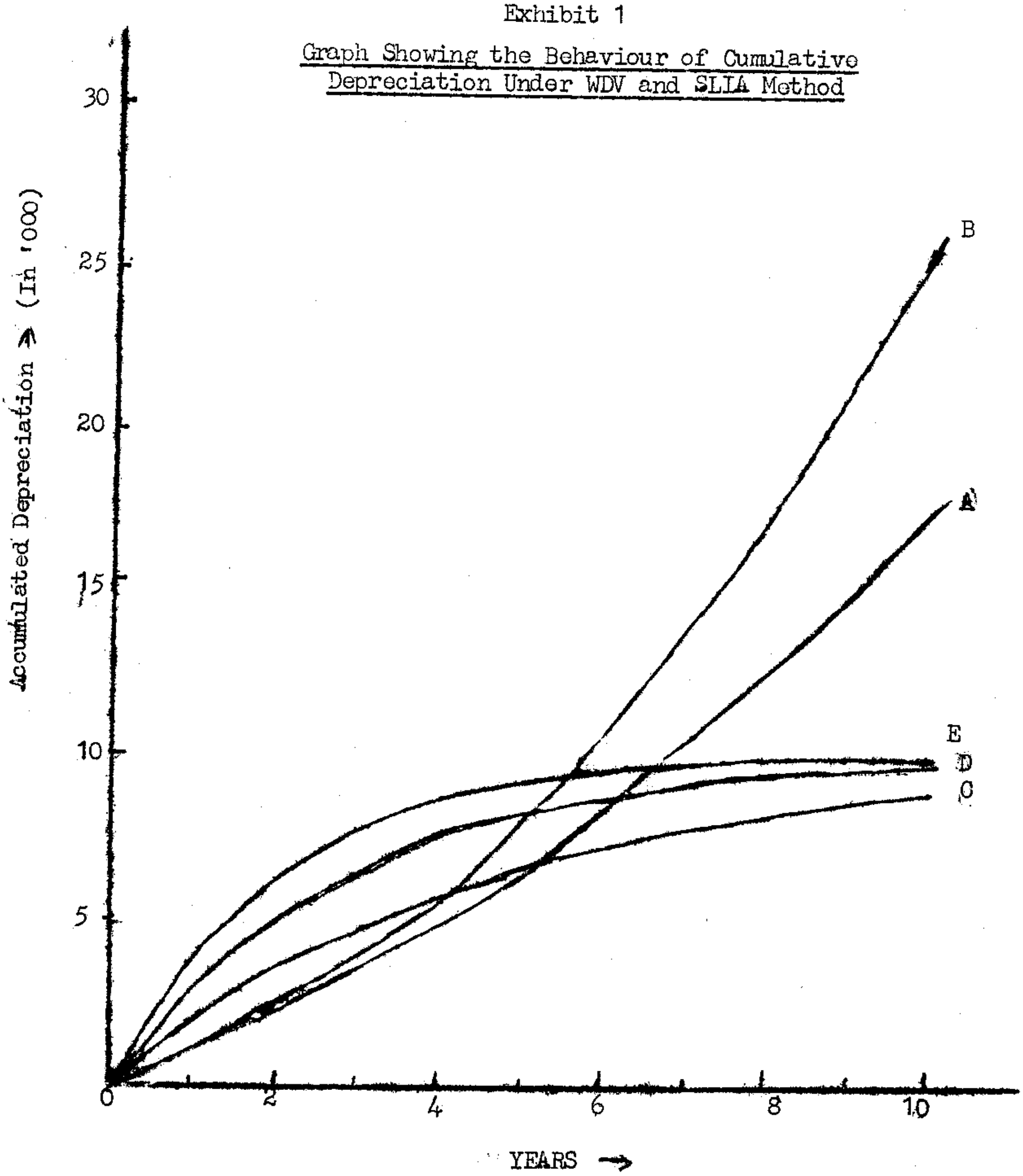
[5]Paul Grady, 'Depreciation - To Measure Income or to Provide Funds for Replacement', N.A.A. Bulletin, 1959.

Conclusion

In conclusion, I must state that the urgency of the problem which we have been examining is naturally proportional to the instability of the value of money. As long as the inflation is with us, resisting changes in traditional accounting methods are bound to have far-reaching social, economic and political consequences. We have examples of many sick units in various industries mainly because the firms did not retain adequate funds to modernize the units. Sufficient provisions were not made for depreciation charges in measuring business income. As a result large amount of funds which should have been reinvested in the business in order to maintain assets at the same level of productive capacity were withdrawn in the form of dividends, higher wages or lower prices for the company's products. An important, but difficult responsibility of the accountant is not to be a prisoner of accepted principles.

Exhibit 1

Graph Showing the Behaviour of Cumulative Depreciation Under WDV and SLIA Method



Curve A showing SLIA Cumulative Depreciation with 6% inflation rate.
B showing SLIA Cumulative Depreciation with 10% inflation rate.
C showing WDV Cumulative Depreciation with 20% depreciation rate.
D showing WDV cumulative Depreciation with 30% depreciation rate.
E showing WDV cumulative Depreciation with 40% depreciation rate.

Table 1

Cumulative Depreciation Under WDV and SLIA Method

Year	WDV Method with a rate of			*SLIA with an inflation rate of	
	20%	30%	40%	6%	10%
1	2000	3000	4000	1060	1100
2	3600	5100	6400	2247	2420
3	4880	6570	7840	3573	3993
4	5904	7599	8704	5050	5856
5	6723	8319	9222	6691	8053
6	7379	8824	9533	8511	10629
7	7903	9176	9720	10525	13641
8	8322	9424	9832	12751	17149
9	8658	9596	9899	15205	21222
10	8926	9718	9940	17908	25937

*Assuming a machine life of 10 years.

Table 2(a)

Summary of the results indicating the time period when WDV Cumulative Depreciation is equal to SLIA Cumulative Depreciation

Asset Life 10 years

Inflation Rate \ W.D.V. Rate	20%	30%	40%
6%	5 (50.2)	6.2 (45.7)	6.6 (44.5)
10%	4 (65.6)	5.1 (62.5)	5.5 (61.7)
12%	3.7 (71.3)	4.8 (68.7)	5.2 (68.0)

Table 2 (b)

Asset Life 15 years

Inflation Rate \ W.D.V. Rate	20%	30%	40%
6%	7.8 (59.7)	8.6 (58.5)	8.9 (58.3)
10%	6.2 (76.9	7.0 (76.2)	7.3 (76.1)
12%	5.7 (82.4)	6.5 (81.8)	6.8 (81.7)

Table 2(c)

Asset Life 20 Years

Inflation Rate \ W.D.V. Rate	20%	30%	40%
6%	10 (69.2)	10.6 (68.8)	10.7 (68.8)
10%	7.8 (85.3)	8.5 (85.1)	8.7 (85.1)
12%	7.1 (89.8)	7.8 (89.6)	8.0 (89.6)

Note: Figures in the bracket show the percentage shortfall in WDV fund if asset is replaced at the end of the machine life.

Table 3 (a)

Accumulated Funds under WDV if Depreciation Funds are Invested in Interest Bearing Securities in Every Period Assuming original Cost of Asset Rs 10,000

Machine Life - 10 years

WDV / Reinvestment Rate	20%	30%	40%
6%	12950	14688	15520
10%	16576	19241	20701
15%	22504	26782	29378

Funds needed for replacement if inflation rate is

6%	17908
10%	25937
12%	31059

Table 3 (b)

Machine Life - 15 years

WDV / Reinvestment Rate	20%	30%	40%
6%	18164	19932	20836
10%	27614	31294	33414
15%	46297	54216	59175

Funds needed for replacement if inflation rate is

6%	23966
10%	41772
12%	54736

Table 3 (c)

Machine Life - 20 years

WDV / Reinvestment Rate	20%	30%	40%
6%	24582	26720	27888
10%	44773	50450	53820
15%	93457	109105	119029

Funds needed for replacement if inflation rate is

6%	32071
10%	67275
12%	96463

Table 4 (a)

Inflation Rate that can be Covered for a Given WDV rate and a Given Reinvestment Rate

Life of the Machine - 10 years

Reinvestment Rate \ WDV	20%	30%	40%
6%	2.62	3.92	4.49
10%	5.18	6.76	7.55
15%	8.45	10.35	11.38

Table 4 (b)

Life of the Machine - 15 years

Reinvestment Rate \ WDV	20%	30%	40%
6%	4.06	4.70	5.02
10%	7.01	7.90	8.37
15%	10.76	11.93	12.58

Table 4 (c)

Life of the Machine - 20 years

Reinvestment Rate \ WDV	20%	30%	40%
6%	4.60	5.04	5.26
10%	7.78	8.43	8.78
15%	11.82	12.69	13.18