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On both scores the additional data problems are major, and it is not clear at this moment that the service unit viewed mainly from the production side would prove more appropriate than that emphasizing the consumption side. In addition, the selection of an appropriate public service unit should be guided by the feasibility of measurement as well as the general applicability of the concept. The public service unit which is viewed from the consumption side has the advantage that it facilitates benefit-cost analyses, so essential for the comparison of the desirability of alternative policies.

ON THE USEFULNESS OF USED MACHINES *

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1. Many underdeveloped countries buy a considerable quantity of second hand machinery from advanced economies. A similar transfer quite often takes place *within* an economy, from its advanced to its backward sector.[1] The object of this short note is to discuss, with simplified assumptions, the causation of this type of transfer. We assume, first of all, that the transport costs are negligible. It is also assumed that the productivity of any given machine is the same in all economies, and they have the same material costs and production periods. We start with some fairly obvious arguments, and then move on to some more complicated ones.

2. We can make alternative assumptions about the performance of machinery over its life. One easy explanation of the transfer lies in the rising cost of maintenance with the age of the machine. Since underdeveloped countries have cheap labor, and many of them (particularly in Latin America and in some parts of Asia) even cheap *skilled* labor of certain types, the cost of maintenance may be relatively lower in these economies. This may explain why many underdeveloped countries may be ready to buy what the advanced economies find too expensive to maintain. Similarly, a fall in the absolute productivity of the machinery with age can be more easily absorbed in the underdeveloped economy, thanks to its lower wages. A fall that will wipe out all profits in the advanced economy, may still allow a profit margin in the low-wage underdeveloped country. All this is fairly obvious. For the rest of the paper, we shall take a more difficult case, where a piece of machinery works at unchanged efficiency over its whole life (the "one-hoss-shay" assumption) and see whether there are reasons for transfer even in this case.

3. Businessmen often follow the principle of "straight-line depreciation" in their calculations. It is easy to see that if old machines are available at their linearly depreciated prices, it is profitable to buy used machines rather than new ones. The more used the machines are, the better investment they make. If the price of a new machine is M, its annual gross profits P, and its life T years, then the net rate of profit per unit of capital (machine) cost in the nth year of life of the machine ($n \leq T$), is (with straight-line depreciation):

$$R = \frac{P - \frac{M}{T}}{\frac{(T - n + 1)}{T} \cdot M}$$

As n increases from 1 to T, the value of R increases monotonically.[2] There is no reason, however, why the used machines would be available at their linearly depreciated prices. With the above assumptions, it is profitable for the users to *buy* old machines at these prices, but only those businessmen who are complete slaves of their own business practice would *sell* old machines at their linearly depreciated prices. What the above analysis shows is not that second hand machines are necessarily good

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[1] This is observable in Japan, where small-scale industries buy second-hand machinery in considerable quantity. The proportion (percentage) of *used* machinery in total investment in fixed assets is given in the following table:

Scale by number of employees	1954	1955	1956	1957	1958
4– 9	48.8	40.2	34.3	n.a.	n.a.
10– 19	44.1	40.8	29.9	n.a.	n.a.
20– 29	39.5	34.3	28.7	n.a.	n.a.
30– 49	35.0	28.9	26.1	26.8	26.5
50– 99	31.5	22.0	22.3	21.9	20.9
100– 199	23.0	16.3	16.8	14.5	13.8
200– 299	15.2	9.1	9.9	9.3	10.0
300– 499	13.9	10.1	9.1	7.4	7.6
500– 999	11.2	5.2	4.2	4.6	6.3
over 1000	4.6	4.1	4.9	3.3	3.1

The above table is given by Prof. M. Shinohara, in *Sangyokozo (Industrial Structure)*, (1959), 120. I am very grateful to Prof. Shinohara for making the table available to me.
See also S. D. Mehta, *The Cotton Mills of India 1854 to 1954*, Bombay (1954), 169, 185.

[2] Even when the industry *using* these machines does not follow the principle of straight-line depreciation, and takes into account the interests on its amortization fund, this qualitative result will hold good.

fields of investment, but only the fairly standard result that such machines would not be sold by rational entrepreneurs at their book-value obtained from the usual business practice.

4. If there is obsolescence in the advanced countries, due either to technological progress or to a rise in wages, old machines might be discarded and sold at low prices. Because of a lower level of wages in the underdeveloped countries these machines might not be obsolete there. When old machines are also old-fashioned machines, with a higher degree of labor-intensity, this type of transfer may be easy to explain.

5. In the absence of obsolescence, can there still be additional profits in the purchase of second hand machines? If there is equilibrium in the machine market in the advanced economy, the prices of new and old machines will be such that the rates of profit per unit of investment are equal for all types of machines. Under these circumstances, an entrepreneur in the advanced country cannot profit by moving from new machines to old ones. What about entrepreneurs in backward countries? The wages relevant to them will be lower. Would this make it profitable for them to buy machines of one age rather than another?

6. Since the machines are assumed to yield the same net output in both types of economies with equal material costs, the gross profits will be higher for any given type of machines in the lower wage economy. Let it be $(P + d)$ per year for a given type of machine in the underdeveloped country, compared with P in the advanced economy. If r is the equilibrium rate of profit in the advanced country, then the market value of the machine in the advanced economy, in the absence of working capital, is $\frac{P}{(1+r)}$ one year before its death, $\left[\frac{P}{(1+r)} + \frac{P}{(1+r)^2}\right]$ two years before its end, and so on. At these prices, old and new machines give the same rate of profit (r) in the advanced economy. If an underdeveloped economy buys the machine one year before its end, its profit rate per unit of investment, on the basis of annual replacement, will be:

$$\alpha = \frac{(P+d) - \frac{P}{(1+r)}}{\frac{P}{(1+r)}} = \frac{d}{P}(1+r) + r$$

If it is bought two years before its death, and sold to the advanced country after one year of use, the profit rate per unit of investment, on the basis of annual replacement, will be:

$$\beta = \frac{(P+d) - \frac{P}{(1+r)^2}}{\frac{P}{(1+r)} + \frac{P}{(1+r)^2}} = \frac{(P+d)(1+r)^2 - P}{P(2+r)}$$

It follows that:

$$\alpha - \beta = \frac{d(1+r)}{P(2+r)}$$

Since $P > 0$, $d > 0, r > 0$, we have $\alpha > \beta$. The result can be extended to machines of less or greater age, showing that profitability increases monotonically with age.[3]

7. The economic interpretation of the result seems to be the following. The lower cost of labour in the underdeveloped economies implies an inherently higher rate of profit. But the relative prices of machines of different age are determined with respect to the profit situation in the advanced economy, the underdeveloped country providing only a very small part of the total demand for machinery of any age group. The relative price differences between newer and older machinery correspond, therefore, to a rate of profit that is lower than the one ruling in the underdeveloped country.[4] Hence it pays the producers in the backward country to go in for older machines rather than for newer ones, which involve locking up a bigger fund, part of which will be earning profit at the lower rate ruling in the advanced economy. This is illustrated by the fact that the profit rate in the underdeveloped economy for a machine with two years

[3] The result can also be easily extended to the case where the entrepreneur buys a machine more than one year before its death with the intention of using it *until* it falls to pieces. Let r' be the equilibrium profit rate in the underdeveloped economy, and r, as before, the profit rate in the advanced economy. The present value of the gross profits of a machine with a year to go is, in the underdeveloped economy, $\frac{(P+d)}{(1+r')}$; the same for a machine with two years to go is $\left[\frac{(P+d)}{(1+r')} + \frac{(P+d)}{(1+r')^2}\right]$. The ratio of the former to the market value of the machine in the advanced country, i.e., the ratio $\left[\frac{(P+d)}{(1+r')} \Big/ \frac{P}{(1+r)}\right]$, will be greater than the ratio of the latter to the corresponding market value in the advanced economy, that is, the ratio $\left[\frac{(P+d)}{(1+r')} + \frac{(P+d)}{(1+r')^2}\right] \Big/ \left[\frac{P}{(1+r)} + \frac{P}{(1+r)^2}\right]$ since $r' > r$.

[4] This "disequilibrium" continues because of the limits that apply to the supply of capital in underdeveloped countries.

to go (β), is the same as the average profit rate that will result if a machine with one year to go is bought *plus* the difference between the price of the newer and the older machine, that is, $\frac{P}{(1+r)^2}$, is invested in the advanced economy at the ruling rate of profit there.

$$\alpha' = \frac{(P+d) - \frac{P}{(1+r)} + \frac{P.r}{(1+r)^2}}{\frac{P}{(1+r)} + \frac{P}{(1+r)^2}}$$

$$= \frac{(P+d)(1+r)^2 - P}{P(2+r)} = \beta$$

8. The working capital requirement does not change the result, since the requirements of material costs are the same for the machinery at different age, and so are the time lags between current inputs and outputs. Only that part of the working capital is affected which involves the value of labor, and there the saving of working capital goes in the same direction as the lower *recurring* wages cost, thanks to a lower wage rate. It makes the old machinery, with a higher ratio of working capital to total capital, even more lucrative.

9. What if the wage rate is the same in all the economies? In this case, if there is equilibrium in the machine market in the advanced economy, the entrepreneur in the backward economy will also get the same rate of profit from machines of all ages. Can there be, nevertheless, a *social* case for the use of second hand machines in this situation? If the net output per machine is Q, then that per unit of investment in a machine one year before its end, priced at $\frac{P}{(1+r)}$, will be:

$$X = \frac{Q(1+r)}{P}$$

With the same investment in machines two years before its death, priced at $\left[\frac{P}{(1+r)} + \frac{P}{(1+r)^2}\right]$ the net output plus the market value of the one-year-left machine, will be:

$$Y = \frac{Q + \frac{P}{(1+r)}}{\frac{P}{(1+r)} + \frac{P}{(1+r)^2}} = \frac{Q(1+r)^2 + P(1+r)}{P(2+r)}$$

Therefore, $X - Y = \frac{(Q-P)(1+r)}{P(2+r)}$

Since $Q > P$, the former being the net output (including wages) and the latter only the profits, we have $X > Y$.[5] The older machine still has an advantage over the newer one from the social point of view. While the flow of profit per unit of investment will be the same for any given amount of investment, the flow of net output produced per year (and also of employment per year) will be very much larger for older machines. This is true for the advanced economy also, but there labor is in short supply. To get the net addition to output *for the economy as a whole*, we must, therefore, subtract the alternative output sacrificed by drawing labor away from other fields into this. If wages are equal to alternative productivity, this equals the profits at the margin. In many underdeveloped countries, however, there is a large-scale availability of unutilized labor, and wages do not represent the social opportunity cost. Net output produced in this sector is, thus, totally additional. Therefore, in an economy with a considerable volume of structural unemployment, the import of old machines may be desirable, even if private entrepreneurs have no incentive for this.

10. To conclude, the movement of second hand machinery from the advanced to the underdeveloped countries (or sectors) is easy to understand in terms of rising maintenance costs and falling physical productivity with age, or in terms of obsolescence in the avanced economies. But *even when* these factors are *not* present, there is an inherent case for this type of transaction because of the differences in the conditions of labor supply. Two propositions have been derived in this context. First, if the prices of old and new machines in the advanced economies are such that they yield the same rate of profit, an entrepreneur in a lower wage economy will find it profitable to buy as old a machine as he can get. Secondly, if the wages are equal in both types of economies, the entrepreneur will have no incentive to import second hand machines, but the underdeveloped nation would still benefit relatively more from such imports as long as there is unemployed labor in that economy.

[5] If the two-year-left machine is not sold after using it for a year and instead the discounted value of its output in its last year is included in Y, we must replace $P/(1+r)$ by $Q/(1+s)$ in the numerator, when s is the social rate of return. Since $s > r$, we still have $X > Y$.