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THE ROLE OF TECHNOLOGICAL CHANGE IN REGULARIZING PRIVATE INVESTMENT[1]

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INVENTIONS may influence the volume of investment. For this reason, if we can discover policies that affect the rate or kind of technological advance, we may be able to help regularize the rate of investment by use of these policies. Suppose, for example, that more rapid advance does not affect investment when it is approaching a peak (although a peak rate of investment may cause more rapid technological change) but increases the rate of investment when it is tending toward a trough. Then policies that induce more rapid technological advance, particularly in periods of decline, will tend to stabilize the rate of investment.

However, more rapid technological advance cannot be prescribed as a medicine that may do good but, in any event, will do no harm. More rapid advance will produce results that vary according to circumstances. Under some monetary policies desirable results will be produced. Change under other policies will produce undesirable results. If the Federal Reserve again pegs the interest pattern of government securities, inventions that increase the profitability of investment (in technical language, shift the marginal efficiency of investment upward) will lead to more borrowing from banks. Forced saving and an increase in output of investment goods industries will follow. This may occur in times of peak rates of investment and cause the peak to be even higher. The consequences for regularization are obvious.

If interest rates are flexible and banks have no excess reserves (or opportunities for obtaining additional reserves), the peak rate of investment will not be raised by more technological change of a kind that raises the productivity of investment. The only effect will be a rise in interest rates. If higher interest rates cause a reduction in idle money balances, forced saving may occur as a result of a rise in the velocity with which money circulates. To this extent, the investment peak may be raised in spite of stability in the quantity of money.

If monetary authorities follow a policy of stabilizing the price

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level, changes in interest rates will produce only negligible quantities of forced saving despite any effect on velocity. In this case, it is unlikely that investment peaks will be raised by the appearance of inventions ready for application. Under the proper monetary circumstances, more rapid technological advance will not raise the rate of investment when it is at high levels and may raise it when it would otherwise fall to low levels. With these effects, policies that bring forth more inventions will contribute to the regularization of investment.

Technological Change and the Rate of Investment

Before specifying policies for maintaining the rate of investment, let us delineate the relationship between technological change and the rate of investment. Opposite theses concerning the relationship between invention and the rate of investment have been presented. One, identified primarily with Alvin Hansen, relates drops in the rate of investment, like that which occurred in the early 1930's, to a slowing in the rate of invention.

Some writers have advanced a variant of the Hansen thesis. They argue that the rate of invention may not have dropped. Instead, a relative decline in the number of capital-using inventions ready for widespread application caused a decline in investment. The drop in the rate of investment occurred because of the large number of capital-saving inventions in this period in contrast to the capital-using character of previous inventions.[2]

Schumpeter's theory of the influence of technological change on investment relegates invention to a minor role. Innovators, and the imitation they set off, determine the rate of investment. Innovation is the key to a high rate of investment, although the banking system plays the significant role in making an upswing in investment possible. The upswing is set off by New Men who make New Combinations. Invention is not necessary for innovation (New Combinations). Periods of inventive quiescence do not preclude innovative activity since this may be based on inventions made long before.

Keirstead follows Professor Schumpeter in his belief that the rate of invention is irrelevant in determining the rate of innovation. He says: ". . . the state of entrepreneurial expectations and the institutional framework of the economy (whether making for a rapid adjustment of prices to costs, as under perfect competition, or for a

[2] See N. Belfer, "Capital-Saving Inventions and Technical Progress," *Social Research*, 1949, for a bibliography of writings on this view.

slow adjustment allowing for the prolonged retention of windfall differentials between prices and reduced costs) must be considered as determinants of the rate of innovation." However, Keirstead refuses to accept variations in the rate of innovation as *determining* the variations in the rate of investment. He argues that "Variations in the rate of introduction of particular innovations are. . . . effects, not causes, of cyclical fluctuations—otherwise generated—in the rate of investment."[3]

Theories on the relationship between technological change and investment run through a wide range. At one extreme, the rate of invention (or innovation) determines the rate of investment. At the other, the rate of investment, itself determined by other causes, determines the rate of invention (or at least the rate of adoption of inventions).

The thesis that secular stagnation will grip the economy if the rate of invention declines, given a static population and no open frontiers, is one of the most prominent of these theories. It has been given more credence than it deserves. Acceptance of the thesis that investment will drop below the savings available from a full-employment national income, if new inventions do not appear rapidly enough, depends upon the acceptance of a fairly rigid acceleration relationship. According to those holding the stagnationist view, a stable demand for consumers goods will confine investment to the replacement level, assuming no new inventions. A five per cent rate of growth in demand will accelerate investment 100 per cent, let us say, above the replacement level. A 10 per cent growth rate would accelerate it 200 per cent above the replacement level. Variations in the rate of investment, according to this theory, are produced by variations in the rate of growth of demand and the rate of invention.

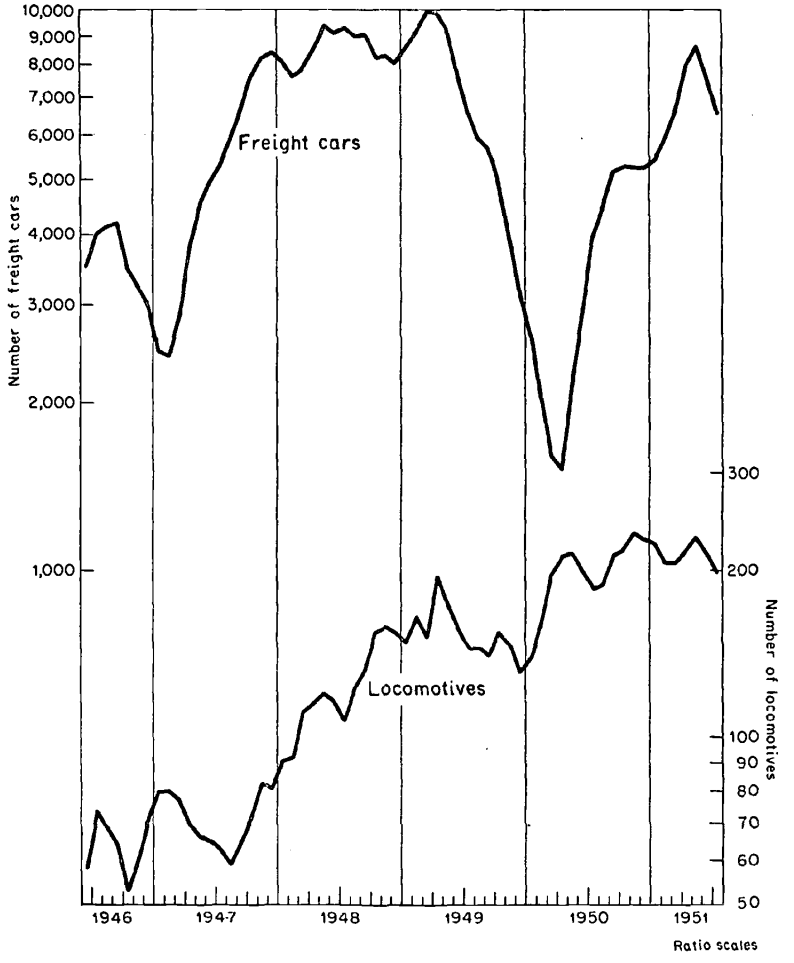
Changes in interest rates, relative prices, price levels, and expectations cause investment to move in a different pattern than that predicted by strict acceleration theory. Despite this, these factors have found little place in the reasoning of those holding the acceleration point of view. As a consequence, they unwarrantedly attribute maintenance of investment in the face of a declining rate of growth in demand to invention. When investment has declined, they unjustifiably attribute the decline to a lack of invention.

There are elements of truth in the accelerationists' view of the determinants of investment. The appearance of new techniques has

[3] B. S. Keirstead, *The Theory of Economic Change*, Toronto: Macmillan, 1948, pp. 133, 138.

maintained investment (at least in some industries) at levels higher than otherwise would have prevailed in periods of decline. An example of the role of new methods in maintaining investment is provided by the railroad industry (see chart 1). From 1946 to 1949,

Chart 1
Deliveries of Freight Cars and Locomotives
June 1946 – July 1951



the industry was engaged in normal replacement and in expansion that required large deliveries of boxcars and locomotives. When demand for transportation declined in 1949, orders for freight cars

fell (from 102,000 in November 1948 to 17,000 in November 1949, with deliveries falling from 7,800 to 3,700 per month) but the demand for locomotives continued (deliveries rose from 157 to 165 per month in this period). The reason for the continued locomotive demand lay in the superiority of the diesel-electric locomotive to steam. There was little need for freight cars, even for replacement, because idle freight cars could be used to replace those retired. In the case of locomotives, the industry had not ben able to obtain a sufficient stock of the new type after their appearance to dieselize completely (partly because of lack of capital, partly because of lack of productive capacity). They continued to dieselize, then, replacing steam locomotives despite the fact that many steam engines were idle. As long as any were in use, it paid to replace them because average total costs (out-of-pocket plus fixed costs per unit of product) with diesels, for many categories of service, were less than average variable costs (out-of-pocket costs per unit of product) with steam.[4]

The preceding two paragraphs may seem contradictory. In asserting that technological change should not be given full credit for the maintenance of investment when the growth in demand slows, we do not mean to assert that it should be given no credit. The seeming contradiction is an attempt to give technical advance only the credit it deserves. Moreover, though technological change has kept investment in some industries from declining, this may have been at the expense of investment in other industries. New techniques have done less to maintain stability in the economy-wide rate of investment than in the rate of investment in particular industries.

The essential point is that when the demand for investment goods to expand capacity declines, the demand for equipment to reduce costs can then absorb the flow of capital formerly soaked up by expansion needs. Costs may be reduced by replacing old with new equipment of the same design, as well as with equipment of improved design. Plant improvement programs usually involve replacement as well as modernization. Technological change cannot, then, be given sole credit for stemming the decline in demand for new capital caused by a decrease in the rate of expansion.

[4] Average total costs are defined above as a combination of out-of-pocket and fixed costs per unit of product while average variable costs are defined as out-of-pocket costs per unit of product. This is only approximately true. For a discussion of their character and their relationship to the replacement problem, see Y. Brozen, "Adapting to Technological Change," *Journal of Business*, April 1951.

Of course, when a shrinking demand for investment goods is produced by a drying up of the supply of capital, technological change can do nothing to stem the downturn (unless it reacts on the supply of capital). Improvements in technology may offset the factors causing a decline in the marginal efficiency (profitability) of investment, but they cannot offset the factors that, in the past, have limited capital supply.

The factor that has been crucial in reducing the supply of capital has been the behavior of the banking system. In periods such as 1920-1921 and 1930-1933, the banks drained capital from the economy.[5] This was double barreled in its action since the drain of capital not only slowed the rate of investment, but the form it took also reduced profit margins. The drain of capital through bank retrenchment caused a fall in selling prices relative to cost prices and, in this way, reduced the earning ability of investment. Technological change may offset the effect of rigid cost prices and bank action on opportunities for investment (the effect on earning ability), but it cannot appreciably offset the direct effect on the capital supply.

To show more precisely the influence of technological change on the rate of investment, let us divide investment expenditure into three categories. The first category includes expenditures on long established varieties of equipment. The second encompasses expenditures on relatively new varieties of equipment and consumer goods (or radically changed models). This second category should be considered in two segments. The first segment consists of new varieties of equipment that operate at a lower average cost than equipment made obsolescent, but whose cost exceeds the variable (out-of-pocket) costs of operating the obsolescent equipment. The second segment consists of those items whose average cost of operation is less than the variable cost of operating existing obsolete items. The third category of expenditures is outlays on research and development.[6] The last category is usually classed as an expense rather than as an investment. However, this is the result of conservative accounting and tax laws rather than an economically justified classification.

[5] See Y. Brozen, *Textbook for Economics*, Wm. C. Brown Co., 1948, pp. 324-327.

[6] These categories represent a somewhat finer division than that suggested by Haberler. He distinguishes between "routine investment" ("which follows more or less closely the ups and downs of consumer demand") and the investment that looks forward to the distant future for its utilization and has little connection with recent movements of demand for its product. G. Haberler, *Prosperity and Depression*, League of Nations, 1937, p. 98.

Investment in Long-Established Varieties of Equipment

Investment in long-established varieties of equipment is the type most influenced by the acceleration relationship. Even here, however, the relationship is muted by changes in the usually accepted constants of single industry analysis (partial equilibrium analysis). Although the rate of growth in demand at any given price for a product may decline, a sufficiently rapid fall in the price of the product may increase the amount of demand and maintain investment.[7] This may be brought about by a drop in interest rates or in the price of equipment. In acceleration theory, the interest rate pattern and the price of equipment are considered constant.

If interest rates (cost of capital) decline,[8] the demand for equipment may be maintained because lower costs may lead the industry to continue its expansion. However, with the decline in interest, the maintenance of demand for equipment will not require the industry's expansion at its old rate. New demands will be generated by lower interest rates.

The new demands for equipment, which will help fill the gap left by any reduction in the rate of expansion, will come from the following sources:

1. If the cost of capital is lower, equipment will be replaced sooner.[9]

[7] In public utilities, where price is not allowed to rise to the level that reduces the amount of demand to the level of the amount of supply, a backlog of demand—unfilled orders for telephones or for gas for home heating, for example—accumulates in periods of rapidly rising demand. When the upward movement of the demand schedule (the increase in the several amounts that would be bought at several different prices) slows, this backlog is then worked off. The use of telephone or gas service continues to increase despite the cessation of growth in demand.

[8] By interest rates, we do not mean the return on riskless bonds. The concept here means the return that must be earned on additional investment to attract capital. Thus, the interest rate exceeds the return to bondholders insofar as a higher return is necessary to attract equity capital to in turn provide the safety margin for bondholders that makes them willing to accept a low rate of return. The interest rate exceeds even the return to shareholders insofar as a portion of the return on investment is confiscated by the corporate income tax. With present rates of corporation taxation, some concerns may have to earn more than 30 per cent to yield 6 per cent to stockholders advancing additional capital.

Another influence on interest rates is underwriting costs. If slackening demand for capital reduces the cost of selling new issues, the same return to security holders may be obtained with investment goods of lower earning capacity.

[9] R. Frisch, "The Interrelation between Capital Production and Consumer Taking," *Journal of Political Economy*, October 1931.

2. Spare capacity margins will be extended with the aid of capital formerly absorbed by expansion needs. The McGraw-Hill survey of *Business' Needs for New Plants and Equipment, 1949-53* found that even after the huge expansion of plant that raised capacity in 1948 to a level 56 per cent above 1939, "half of all companies [were] operating at 90 per cent of capacity or better. Most of them feel that is 5-10 per cent above a desirable rate. They would like more elbow room to fill orders promptly, avoid over-time hours and wages in bottleneck departments, and, in general, to handle production more efficiently." The telephone industry, in the present period of capital stringency, designs only enough margin in its new installations to take care of six months of growth in demand beyond the time of completion of installations. Normally, new installations are designed with enough spare capacity to meet three years of growth in demand.[10]

3. Another form of capital use in periods when capital becomes available on better terms is also illustrated by the telephone industry. In periods of capital stringency, a longer holding time on trunk calls in busy hours is used in determining the number of trunk lines to install for interconnection of exchanges. When capital becomes available, more trunk lines are installed to improve the quality of service. Similar deterioration and improvement in other industries take the form of longer and shorter delivery dates.

But interest costs are only a small part of total costs. We can conceive of circumstances where even a decline to the Keynesian irreducible minimum rate of interest would be inadequate to maintain the demand for equipment. The tendencies toward expansion and earlier replacement produced by interest rate reductions may be reinforced, however, if producers of equipment will accept reduced prices. This measure, too, is limited because depreciation costs are not ordinarily a major part of the cost of product. Only if reductions in the rate of growth of demand are small can these measures alone succeed in stemming a decline in investment.

Investment in Relatively Novel Varieties of Equipment

If labor, material, and power prices are rigid, decreased interest and depreciation costs may not cause a drop in product price suf-

[10] Testimony of Illinois Bell Telephone Co. officers before the Illinois Commerce Commission in 1949 (Docket Nos. 36883 and 36870).

ficient to generate enough growth in product demand and enough advance in replacement dates to maintain the volume of investment in an industry. The rigidity may be offset by the introduction of new varieties of equipment that save on the cost of complementary factors (or save interest and depreciation costs). These may attract a demand sufficient to maintain investment even in the face of declining demand for the product.

The strength of this influence depends upon how the average cost with the new variety of equipment compares with the variable cost with old equipment. Suppose the average cost is above the variable cost of operating with new items of the old type. If variable costs do not rise gradually with age of the old type but, instead, jump to high levels late in its life (when, for example, major maintenance is needed), new models will do little to maintain capital formation. If variable costs rise continuously with age, however, and the age distribution of existing equipment is not lumped toward the new end of the scale, the oldest equipment left idle by a decline in demand, which would have been kept to replace units as they wear out, will be scrapped. The new model will replace older units of existing equipment, which would otherwise have been continued in use, and will replace items that would otherwise be succeeded by units from the existing stock.

If the new models operate at an average cost less than the variable cost of even relatively new items of the old type, new investment in the industry will rise. Under these circumstances, investment will rise even in the face of a declining demand. There will be a rush to replace existing equipment of recent, as well as that of more ancient, vintage. The rate of investment will be limited, in this case, only by the supply of capital and the capacity of the equipment industry.[11]

Technological change may work through product changes, as well as equipment changes, to maintain the rate of investment. By sufficient change in product design, or by introduction of new products, demand that was declining may be maintained or even increased. The sale of electric refrigerators grew through the 1930's for this reason while aggregate demand in the economy was declining. The chemical industries also maintained some growth in this period by constant introduction of new products.

[11] For an analysis of the determinants of the rate of investment in this case, see Y. Brozen, "Welfare Theory, Technological Change, and Public Utility Investment," *Journal of Land Economics*, 1951, pp. 123-124.

Introduction of new models has been recognized as a method of spurring lagging sales of capital goods and has been used for this purpose. Technological changes of this kind have been timed to regularize sales. In order to maintain sales, apparatus and automobile manufacturers have developed new designs sufficiently superior to equipment in place to induce early replacement in times when sales would otherwise decline. Appliance producers are beginning to make model changes in order to induce replacement in those lines where the market is nearing saturation with old models.[12]

The case of the Toledo Scale Company illustrates this point. As *Business Week* (April 16, 1949, p. 84) put it: "The perpetual challenge to the Toledo Scale Co. is that it builds its products too well. Thus: (1) It has all but eliminated friction in its weighing machines to make them ultra-accurate, but (2) when you cut out friction, you cut out wear: the scale lasts almost forever. So Toledo over the years has tirelessly looked for more uses for scales, beat the bushes to sell improved machines to owners of old models, and kept a sharp eye open for products that can be made and sold along with weighing machines."

When industry is expanding and demand for manufacturing equipment is booming, new designs tend to be postponed. Capital is difficult to obtain, because of the many competing demands for it, and manufacturers of inferior equipment are sometimes more successful in selling equipment by providing capital advances (and low priced items) than those who sink their capital in improvements and, as a consequence, are unable to offer attractive payment terms. Such a situation prevailed in the textile machinery industry in the last third of the nineteenth century when textile mills were being founded at a rapid rate in the South.[13] Also, when the demand for equipment is so strong that equipment-producing capacity is strained, the drive to produce more equipment pulls capital away from the development and application of new techniques. Quick delivery is often more important to customers (investors) than improved models. The American Gas and Electric Company, for example, bought inferior equipment in 1947 and 1948 rather than wait two to four years for better items.[14]

[12] "Appliances: The Tide Turns," *Business Week*, June 28, 1952, p. 27.

[13] T. R. Navin, "Innovation and Management Policies—The Textile Machinery Industry: Influence of the Market on Management," *Bulletin of the Business Historical Society*, March 1951.

[14] "Utility President Looks at the Future," *Business Week*, April 23, 1949.

These generalizations cannot be regarded as complete categories. Moderate declines in demand for equipment may lead to the development and introduction of new varieties, but severe decline will inhibit this reaction. A pay-off on outlays to introduce technical advances is difficult to obtain in the face of a sharp decline.

Industry's expenditures for applied research in the face of the decline of the 1930's is not out of accord with the thesis that moderately adverse movements, which have not been long continued, may bring increased developmental activity as a defensive measure while greater declines cause reductions in such programs. Industrial research expenditures increased from $106 million in 1929 to $116 million in 1930 and $131 million in 1931. This was higher than would have been expected from the trend in research outlays. The year 1932, however, saw research expenditures cut back to $120 million and 1933 saw a drop to $110 million.[15] The years of increase in research were years of moderate decline in the sale of durable goods while the years of decrease were years of severe decline.

The years 1945-1948, when productive capacity was strained, saw few model changes and little increase in productivity,[16] confirming the thesis that very strong demand relative to capacity causes a decline in the flow of research results into industrial use. As growth in capacity began to catch up with the rate of demand generated by prices based on minimum average costs, model changes began to appear, producers sought to increase efficiency rather than capacity, and the flow of research results into practice accelerated.

The change in emphasis from expanding output to raising efficiency as the economy shifted from the period of straining productive capacity (because of the high rate of demand at prices that exceeded average cost) is demonstrated in the McGraw-Hill survey of *Business' Needs for New Plants and Equipment, 1949-53*. The survey found "that expansion took the largest share of capital expenditures in 1946 and 1947. But in 1948, . . . 58 per cent went for replacement and modernization. Manufacturers plan to raise this share to 74 per cent in the next five years."

[15] V. Bush, *Science: The Endless Frontier*, U.S. Govt. Printing Office, 1945, p. 80.

[16] Real gross private product per man-hour dropped sharply from 1945 to 1947. It rose in 1948, but it did not recover to its prewar trend until after the recession year of 1949. See John W. Kendrick, "National Productivity and Its Long-Term Projection," *Long-Range Economic Projection*, Princeton University Press for National Bureau of Economic Research, 1954.

Research and Development Expenditures

Expenditures on research and development may be defensive as well as aggressive. By increasing these expenditures when demand slows its growth or moves adversely, the adverse movement may be stopped or growth may be spurred to its former level. The Trumbull Electric Company, for example, increased its development work in 1948 when demand for its products began declining. As a result of the product improvements developed by the increased expenditures, this company's sales moved up in 1949 in the face of a decline in aggregate demand in the economy.

Research investment has been more stable than gross investment and more stable even than the aggregate rate of consumption (see chart 2). The reasons lie not only in its defensive utility. They lie also in the nature of research. In addition, research is a relatively new industry with the usual resistance to decline possessed by industries with an inherent growth drive.

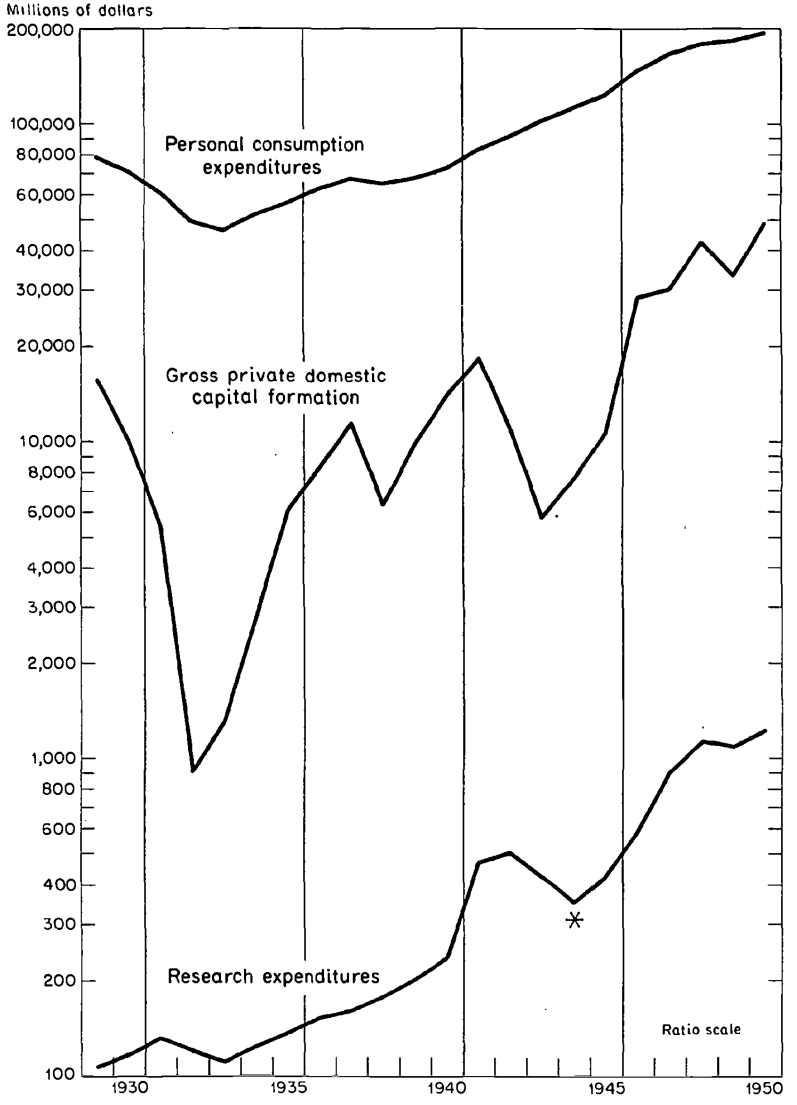
Research outlays are maintained in the face of economic decline for the same reason that half-finished apartment houses are completed in the face of a decline in the demand for apartments. The additional investment required to complete a project is worthwhile although the total investment would not have been made if the decline had been anticipated. Research projects often involve years of work. Completion of a project half done may require two or three years' work beyond that already completed at the time a decline begins.

It would be possible to postpone completion of a project to a later date but for the fact that much of the half-finished work is in the form of an investment in finding and training technical personnel. Also, the early part of a research project may consist of self-education by the personnel involved rather than preparation of information or designs that can be handed on in a half-completed state to a later team of workers. Since the primary asset acquired by a partly completed investment in research is men who have been brought to the point where they are ready to yield concrete solutions to problems, abandonment or temporary reduction of the program means more than delay. It means loss of the capital already sunk.

Investment in research tends to resist downswings for the reasons given. It also resists upswings because research personnel cannot be

Chart 2

Expenditures for Research, Capital Formation, and Consumption 1929 – 1950



* The drop in industry's research expenditure at this point was not the result of a decline in performance of research by industry but of a decline in support of research by industry. Research performed by industry rose from a level of $610 million in 1942 to $790 million in 1944 and has continued to rise, with no decline in intervening years, to an estimated level of $1.6 billion in 1951. The research performed by industry but not supported by it has been supported by the government.

increased rapidly in any one program except at the expense of other programs. The training of research personnel is a long process with lags of four to seven years between increases of input and increases of output.

It would seem, then, that the encouragement of research and development on a large scale would introduce a stable component in total investment which should help stabilize the total. However, if maintenance of research in periods of decline reduced the capital available for other uses, the result would be greater instability in other investment sectors.

An Aggregate View of the Role of Technological Change

The discussion so far has been within a partial equilibrium (one-industry-at-a-time) framework. We have indicated that the rate of investment in an industry can be maintained by technological change when demand slows its growth or when the industry becomes well stocked with capital goods. Does this mean that aggregate investment in the economy can be maintained by technological change when aggregate demand slows its growth or when the economy is well stocked with capital goods?

Our answer depends upon the circumstances. If aggregate investment declines because of a decline in the rate of growth in the supply of capital, then technological change will increase the rate of investment in any one industry at the expense of others with no influence on the aggregate rate.[17] If the supply of capital has zero elasticity in the relevant range, and if the rightward movement of the capital supply curve proceeds at a rate that is not influenced by the return that can be earned or the rate of increase in income, then

[17] This is the implication of Earl Hamilton's appraisal of the effect of innovation on price level movements in the fourteenth, sixteenth, and eighteenth centuries. "Since economists often experience difficulty in distinguishing between cause and effect, it is not strange that innovation and other types of economic progress, which tend to accompany rising prices, have been regarded as their cause. If ever tenable, this thesis is clearly not so for the periods 1351-1400, 1551-1650, and 1751-1800. In each instance, the rise in prices synchronized with, and largely resulted from an increased output of the precious metals not caused by technological innovation.

". . . the invention and utilization of the eighteenth century machinery was accelerated by the abundance of capital and the incentive to invest resulting from the lag of wages behind prices. Without profit inflation, the industrial progress would hardly have been revolutionary in character." E. J. Hamilton, "Profit Inflation and the Industrial Revolution," *Quarterly Journal of Economics*, vol. 56, p. 273.

technological improvement will have no effect on the aggregate rate of investment.[18] Its effect will be purely local.

If the supply of capital has a positive elasticity (that is, if the quantity of capital supplied increases with an increase in the profitability of investment) or the curve moves rightward at a rate that is influenced by profitability, then a technological change that raises the marginal efficiency of investment will raise the aggregate rate of investment. This is the case in an economy that has a banking system with excess reserves (or that can obtain reserves from a central bank that is pegging the market for some of the investments held by banks) or in which the amount of balances held idle falls when the interest rate rises. If there is less than full employment in such an economy, technological change that raises the marginal efficiency of investment will raise the level of investment. With full employment, it may do more to create inflation than to raise investment, although it may still do the latter insofar as the inflation results in forced saving.

If we discuss positive measures for using technological change to regularize the rate of investment, we implicitly assume that the supply of capital has the characteristics described in the preceding paragraph. If declines in investment are caused by a slowing of the rightward movement of a perfectly inelastic supply curve, technological change cannot affect the rate of investment. Any discussion of how it might be used to regularize investment has no reality. But if declining investment is caused by a drying up of opportunities for investment (and this may occur because capital has grown more rapidly than other productive resources and interest rates have not adapted properly; or consumer tastes have shifted to products whose production requires less capital investment and interest rates have not adapted to the new conditions; or selling prices are not sufficiently above rigid costs to return a profit), then technological changes raising the earning power of capital will increase investment.

Capital-saving technological change has been condemned because it apparently reduces the marginal efficiency of investment (oppor-

[18] M. V. Jones asserts that savings-investment relationships will not be affected by innovations in his *Secular Trends and Idle Resources* (University of Chicago Press, Studies in Business Administration, vol. 14, no. 4, 1944). He argues that there is no reason to believe that major innovations are perfected at an uneven rate, and that unevenness in the imitation of innovations or the introduction of innovations is a result of adverse economic conditions that slow the rate of investment.

tunities for investment that will provide some given yield). This reduction has been said to cause a decline in the rate of investment. However, there has been some confusion as to the role of capital-saving change because there has been no precise definition of such change. New techniques that use less capital per unit of product are not necessarily capital-saving if we define capital-saving changes as those that reduce the marginal efficiency of investment. A reduction in the amount of capital required per product unit may result in a rise in the marginal efficiency of investment if demand for the product is sufficiently elastic. The higher the proportion of cost occasioned by capital (interest and depreciation cost), the less the elasticity of demand necessary to lead to a rise in marginal efficiency.

Capital-saving techniques seem to be introduced on a scale that reduces the marginal efficiency of investment in the economy primarily as a response to a decrease in the supply of capital. In the 1930's, when such changes appeared in great profusion, producers were finding it difficult to earn enough to pay customary dividends and fixed interest obligations. In the attempt to maintain dividends and avoid default on interest payments, firms drew on their surplus. Since this reduced the capital available to them, they attempted to use techniques requiring less capital per unit of product whenever they made the investments necessary to maintain even a reduced rate of production.

These capital-saving changes made possible payments to security holders and, to this extent, increased the propensity to consume. They made business dissaving possible. Capital-saving innovations, then, maintained aggregate consumer demand in this period. Although they may have reduced marginal efficiency of investment in their direct effect, they indirectly increased it by maintaining the derived demand for producers' goods.

Much of the capital released by capital-saving changes was used to repay bank loans that were not replaced by new loans (or other increases in bank portfolios) or was used for hoarding (holding of idle balances). To this extent, we might blame capital-saving changes for a fall in the rate of investment that was not offset by a rise in consumption and in derived demand for investment goods. However, where loans were not renewed, repayment of bank loans had to be made whether or not capital-saving techniques were available. The fall in the rate of investment was primarily a consequence of bank contraction. The availability of capital-saving inven-

tions made it possible to maintain production in the face of a shrinkage in the supply of capital. Without such inventions, the alternative might have been no investment instead of some investment. What funds were left after loan repayment might have been hoarded and aggregate demand would have fallen further than it did.

Technological change may contribute to a rise in the rate of investment by a direct effect on the average propensity to consume as well as by its effect on the marginal efficiency of investment. New products or new models may lead people to spend a higher proportion of their income. The reduced propensity to save may react to produce a shortage of capital voluntarily saved from current income, with the result that investors (borrowers) are forced to turn to banks. If the bank rate is below the natural rate, and banks have or can get excess reserves, the increase in money and consequent increase in aggregate demand will lead to a higher rate of investment, assuming there are unused resources that may be put to work.

Duesenberry has suggested that the propensity to save fails to rise as per capita income rises because the habit of saving depends on relative social status rather than on income. We can suggest another interpretation: The propensity to save may fail to rise as per capita income goes up because of the increased variety and improved quality of goods made available by technical advance. Since the supply of technology is irreversible, a decline in per capita income from previous high levels does not cause a reversion to the old level of saving associated with that income. This could account for the finding that the propensity to consume is determined by the highest previous level of income rather than by the current level of income.

Technological change may help stabilize investment by damping the strength of the accelerator in translating fluctuations in consumption into fluctuations in investment. Insofar as technological change turns variable depreciation costs due to wear and tear into fixed depreciation costs due to obsolescence, selling prices are made more flexible (if markets are kept competitive). If rigidities in variable cost prices are offset in recession by reduction of the fixed costs, output and employment will be maintained. Equipment orders will also be maintained.

This reacts on investment decisions in prosperity. Firms attempt to avoid a fixed cost future of much length by purchasing shorter-lived equipment. The effect of the accelerator is thereby reduced. The shorter the life of equipment, the smaller the increase or de-

crease in rate of investment resulting from a given change in the rate of growth in demand. Less decline in the rate of investment results, then, from a slowing in the rate of growth of sales, insofar as interest rates and prices of capital equipment are not sufficiently flexible to handle this problem.

If the depreciation resulting from obsolescence is greater than the depreciation from wear and tear at capacity operation, given physical items are made shorter-lived. This, too, damps the influence of the accelerator with a consequent damping of fluctuations in the rate of investment.

Policies for Regularizing Investment by Controls Affecting Technological Change

Except where falling investment is caused by a drop in the supply of capital, technological change that raises the marginal efficiency of investment or the propensity to consume may stop the fall. Policy directed toward producing technological change of this kind, then, may contribute to economic stabilization. Also, if the influence of the accelerator is damped by more rapid technological change, the amount of swing in investment produced by changes in the rate of growth of aggregate demand may be reduced by generating a higher rate of change.

Research expenditures must be consistently treated as an expense or as capital expenditure under present tax laws. As a consequence, if they are expensed (and in most cases they are), these expenditures must be reduced to avoid tax penalties in times when business income is low or losses occur. Only to the extent that future income can be counted on and the law permits carrying losses forward can this "expense" be continued without tax liability. Since concerns do not like to gamble more than they must on future income, there is a tendency to reduce these expenditures at the very time when a good case can be made for increasing them (from the point of view both of economical use of resources to serve society and of maximizing the profits of the firm, taxes apart).

By permitting carry-back of losses (or at least of losses caused by research expenditures) or by permitting capitalization at some times (which, in effect, permits the use of a longer carry-forward period) with the privilege of returning to an expensing basis, the pressure for cutting research in periods of depression because of tax penalties may be reduced. The privilege of choosing to capitalize research

might be restricted to periods of very low or negative income to prevent gambling on changes in tax rates.[19]

The education of management in the defensive value of product development can also help in this direction. By making and publishing studies of the influence of applied research in stemming declining sales, management and investors may be educated to the value of increasing research expenditures in periods of decline.

Everett Hicks has indicated that sales of machine tools for modernization and cost reduction have helped to fill troughs, but that these sales have always been small.[20] By educating management on replacement policy, much can be done to increase such sales.

George Terborgh, in his *Dynamic Equipment Policy*, has pointed out that the rules of thumb used to guide replacement policy lead to underreplacement. Engineers and investment committees educated in the use of economic studies of replacement will undertake modernization programs with more alacrity in times when the available supply of capital is not absorbed by expansion needs.

Research should be undertaken to determine the proper pay-off period to be used in making replacement studies at various times during the cycle. The available data indicate that short pay-off periods should be used in prosperity and long pay-off periods in depression (from the point of view of maximizing returns to investors). At present, however, depression pessimism (and desire for liquidity) leads to the use of short pay-off periods and prosperity optimism to the use of long pay-off periods.

An economics of replacement (or an economics of technological change) course should be offered in every engineering and business school. Seminars in this field might be conducted by such organizations as the Society for the Advancement of Management. With better information and better education, technological change would occur more rapidly in times when it can contribute most to economic stabilization. As was indicated above, it is to the interest of the firm to time change in this way. It is already being done in many concerns.

Although adequate data are lacking for a definitive statement on the role that the improvement of intermediate credit markets might

[19] See J. K. Butters, "Taxation and New Product Development," *Harvard Business Review*, summer 1945, for a discussion of methods of removing tax deterrents to research.

[20] See "Regularization of Business Investment for Industrial Machinery and Equipment Manufacturers," in part 1, above.

play in increasing modernization programs in periods of decline, it is suspected that inadequate supplies of intermediate credit have inhibited such programs. T. R. Navin has found that modernization of textile mills has been hampered by lack of intermediate credit.[21] The positive influence of a better intermediate credit supply is indicated by experience in the railroad industry. Railroads could not have carried on the extensive modernization program they undertook in the 1930's but for the development of equipment trust certificates and of a market for them.

Studies should be made of the intermediate capital problem of other industries and the possibility of improving the supply. If devices similar to those used by the railroad industry were developed, modernization programs might be more readily undertaken in periods of contraction to help fill the investment trough.

COMMENT

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Mr. Brozen states that "technological change may contribute to a rise in the rate of investment by its effect on the average propensity to consume as well as by its effect on the marginal efficiency of investment." True as this is, we should not overlook a contrary effect that labor-saving devices may exert upon the average propensity to consume and thus indirectly upon the aggregate rate of investment. Unless such devices are supported by a banking policy that counteracts technological displacement and sustains the level of consumption, the result may well be an accentuation of investment fluctuation. There is little doubt that this destabilizing force was at work during the late twenties and contributed to the subsequent breakdown—another indication that the chances of private investment "regularizing" itself without a supporting public policy are limited.

[21] *op.cit.*