

A Study of The Acceleration Principle

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The object of this paper is to define in detail the meaning of the acceleration principle and to discuss some difficulties in its application in the real economic world. Since the acceleration principle has been regarded as an important component of economic theory it has been used for the explanation of business cycles, and recently it has been further developed to explain economic growth. This paper will emphasize the implication of the acceleration principle to the business cycle.

The acceleration principle can be stated as a quantitative relationship between a change in the demand for consumption goods and the resulting change in the demand for investment goods. A slight change in the demand for consumption goods will cause a greater fluctuation in the demand for investment goods. Because of this magnified effect of demand for investment goods, this relationship is called the "acceleration" principle.

In this definition, both terms—investment goods and consumption goods are used in relative concepts. In comparing two kinds of goods, if the difference of the procedural order exists in their process of production, then the one which is closer to the earlier stage of production is called an investment good; while the one which is closer to the use of the ultimate consumers is called a consumption good. Thus, the same good may be an investment good in one case and a consumption good in the other case. For example, construction tools are investment goods relative to the demand for houses, but the same construction tools are consumption goods in relation to those machines through which these construction tools are produced.

The distinction between investment goods and consumption goods used here

is not necessarily identical with the conventional way. For example, in national income analysis, automobiles are classified as consumption goods, but for our purpose here, automobiles are investment goods in comparison to the consumers' demand for transportation services. Generally speaking, capital goods and other durable goods are mostly investment goods; and final goods and other non-durable and semi-durable goods are mostly consumption goods.

In a primitive or an agricultural economy, economic factors such as labor and land are employed more or less directly for production of consumption goods. Thus the amount of employment of labor and land moves approximately in proportion to the level of the demand for consumption goods, except for some qualitative changes such as the law of diminishing returns relating to land or a change in labor skills. When consumers' demand increases twice, the employment of land and labor must also expand twice in order to satisfy consumers' wants, and there is no discrepancy whatsoever between the production of consumption goods and the employment of the economic factors.

In the case of an industrialized economy, this principle will no longer hold true. Instead of using productive factors directly for producing consumption goods, the capitalistic way of production uses the round-about technique; namely that of producing a long series of capital goods before producing consumption goods. Generally, a greater value of capital goods is required in order to produce a given value of consumption goods. The ratio between the amount of investment goods which is required to satisfy the change in the demand for consumption goods is called the value of the accelerator. If five dollars' worth of capital goods is required to produce one dollar's worth of consumption goods, the value of the accelerator will be five. The value of the accelerator (or the capital coefficient) depends upon the technology of production and the kind of goods that capital goods are producing.

Capital goods which are created for the production of consumption goods can be used to produce consumption goods for a long time. Because of this

durability of capital goods, once capital goods are created, they will, except for the gradual wearing-out process, remain on and sustain the same level of productive capacity, thus enabling the production of the same amount of consumption goods in the future. For example, during the last half of the nineteenth century, railroad construction brought a tremendous investment boom. But once a railroad was built to the required level, there was obviously no need in rebuilding capital goods all over again. The only need of capital goods was for repairing, renewing, and replacing.

The explanation indicates that the acceleration principle is mainly concerned with part of investment which is related to the change in the demand for consumption goods or output. Some investments are independent of the demand for consumption goods or output. Such investments are termed autonomous investments. Autonomous investment is the process of providing more capital per worker on account of the improvement of technology. In contrast to an autonomous investment, the part of investment which occurs as a result of the change in the demand for consumption goods or output is sometimes called an "induced investment" or "derived demand for investment".

Furthermore, unless total demand for consumption goods or output changes (in a static sense) or unless the rate of change of total demand for consumption goods changes (in a dynamic sense), there is no need of investment. Thus the acceleration principle is apparently referring to "new investments." A new investment differs from a replacement investment in the sense that the former is an increment of the stock of capital goods, while the latter is the renewing process of old investments in order to maintain the existing level of capital goods.

Three cases of new and induced investment are particularly important in the operation of the acceleration principle. These are: the derived demand for capital goods, durable consumers' goods, and inventory stocks. In each of the three, the general formula of the acceleration principle is similar.

The first case is the derived demand for capital goods. The derived demand for capital goods takes place as a result of changes in the demand for consumption goods—goods which capital goods are intended to produce. The intensification of the derived demand for capital goods can be demonstrated most clearly by means of concrete examples.

Suppose there are 500 units of machines producing 100 units of consumption goods (or output) and the ratio of machines and production of consumption goods does not change (in this case the ratio is five). Furthermore, the average life of capital goods is assumed to be ten years; then, ten per cent of capital goods must be replaced every year. In this case, 50 units of machines must be replaced every year. Now, if the demand for consumption goods changes from 100 units to 110 units (a ten per cent increase), 50 units of new investment on machines will be required in order to produce an additional ten units of consumption goods. Adding together 50 units of the investment with 50 units of replacement investment, the total demand for investment goods (machines) needs 100 units, which is a 100 per cent increase of machines. Thus, a ten per cent increment of the demand for consumption goods ensues a 100 per cent increment of investment goods (machines).

If, in the next year, the absolute amount of consumption goods increases but with a smaller rate of increase, for example, an eight per cent increase instead of a ten per cent increase as in the previous year, then the demand for consumption goods will be 118.8 units. To produce 118.8 units of consumption goods, the total need for investment goods (machines) will be 94 units (44 units for the new investment and 50 units for replacement investment). This means that the production of investment goods decreases from 100 units to 94 units. The mere decline in the rate of increase in the demand for consumption goods, though the absolute amount of consumption goods is still increasing, will result in the absolute decline in the demand for investment goods.

The above example indicates clearly the essence of the acceleration prin-

principle; namely, the demand for investment goods depends upon the *rate* of change of the demand for consumption goods and not upon the *level* of the demand for consumption goods. Even the demand for consumption goods is increasing in its absolute amount, if the rate of increase is less than the previous year, the demand for investment goods will decline absolutely.

The same principle is also applicable to the reverse movement where the demand for consumption goods is decreasing instead of increasing. For example, if in the previous example the demand for consumption goods decreases from 100 units to 90 units (a ten per cent decline), the total demand for investment goods will be zero, because 50 units decline in the demand for new investment as a consequence of a ten per cent decrease of the demand for consumption goods. Now, if the demand for consumption goods decreases, but decreases at a smaller rate, for example, decreases eight per cent instead of a ten per cent decrease of the previous year, then the demand for consumption goods will decline from 90 units to 82 units. In this circumstance, the total demand for investment goods will increase from zero to 14, because of the 36 units of disinvestment, as a result of the decline in the demand for consumption goods from 90 units to 82.8 units, must be subtracted from 50 units of annual replacement demand for investment. Here, we reach the same conclusion as in the upward movement; that is, the demand for investment goods is related to the *rate* of the decline in the demand for consumption goods and not to the *level* of the demand for consumption goods, although in this reverse movement, the application of the acceleration principle is somewhat limited by the fact that the total investment can not be negative. Investment in machines can be measured only through the slow process of wearing out; thus, the disinvestment caused by the acceleration principle will cease to affect the demand for investment goods when the total investment becomes less than zero. As a result of the working of the acceleration principle, the demand for investment goods will increase, even though the demand for consumption goods is falling, if the

rate of the decline is less than that of the previous year.¹

Some writers explain that the most significant aspect of the acceleration principle is due to the fact that in spite of the continuous increase (or decrease) in the demand for consumption goods, the demand for investment goods will decline (or increase) only if the rate of increase (or decrease) diminishes in comparison to the previous year'. This fact explains not only the dynamic nature of the modern economic system, but also the turning points; in other words, why the economy moves inevitably downward after the upward movement and turns back to the upward movement again after the downward movement and so on continuously.

Another important proposition involved in the explanation of the acceleration principle is why a highly industrialized economy suffers more severe economic fluctuations than a less highly industrialized economy does. A highly industrialized economy uses more durable goods, and according to the explanation of the acceleration principle, the intensity of the economic fluctuation depends upon the ratio of the replacement demand to the total stock of capital goods, and this ratio is in turn determined by the degree of durability of capital goods. The longer the average life of capital goods, the longer will its service be available without further installation of capital goods; therefore, the ratio of replacement demand to the total stock of capital goods will be smaller. For a smaller ratio of replacement demand to the total stock of capital goods, the economic fluctuation will be more severe.

The dependence of the intensity of the fluctuation of derived demand on the average life of durable goods can be illustrated by varying the assumption of the average life of capital goods in the previous example and observing the

1. See Earl C. Hald, **Business Cycles** (Boston: Houghton Mifflin Company, 1954), p. 163 and p. 165; also J. R. Hicks, **A Contribution to the Theory of the Trade Cycle** (Oxford: The Clarendon Press, 1950.)

difference in the results.

Assume the average life of capital goods (machines) is twenty years instead of ten years as in the previous example; then five per cent of capital goods will be replaced every year. This means the annual replacement demand is 25 units. Now if the demand for consumption goods changes, as in the previous example, from 100 units to 110 units (a ten per cent increase), 50 units of new investment are required in producing an additional ten units of consumption goods. Adding together 50 units of new investment with 25 units of replacement investment, the total demand for investment goods is 75 units, which is 200 per cent increment of investment goods. Thus, with the longer life of capital goods, the greater will be the severity of fluctuation.

The second case of the working of the acceleration principle is the derived demand for durable consumers' goods. The best examples of durable consumers' goods are automobiles and houses. The intensification of the demand for automobiles or houses occurs as a result of the change in the demand for services for which these durable consumers' goods are intended to provide.

The previous analysis of the derived demand for capital goods can be readily extended to the derived demand for durable consumers' goods without any substantial change. Here, automobiles (or houses) represent investment goods, and transportation services (or rental services) represent consumption goods. Suppose public demand for transportation services rises to a new level, this demand can be satisfied only by investing more on production of automobiles. But once automobiles are created, no need of further investment is necessary except for replacement. Thus the demand for automobiles depends upon the rate of change in the demand for transportation services; consequently, the magnified effect of the demand for automobiles will occur because of the working of the acceleration principle.

The third case is the derived demand for inventory stocks. There are several points in the practice of retailers and wholesalers that are analogous

to the derived demand for capital goods and durable consumers' goods. The wholesaler does not purchase goods for the purpose of satisfying consumers directly, but his purchases are for future sales. Although goods held for inventory stocks may be perishable, the inventory stocks as a whole can be considered as durable. Furthermore, there seems to exist a fairly constant ratio between the amount of merchandise stocks and the volume of current sales (this ratio can be considered as the value of the accelerator).

The relationship between retail sales and wholesale sales can be illustrated by an arithmetical example: If the ratio of current merchandise stocks to monthly sales is 4 to 1, and the monthly sales in a given month are 100 units, then the merchandise stocks need 400 units. Now, if the monthly sales rise from 100 units to 105 units (five per cent increase), 25 units of merchandise will be newly purchased in order to maintain the 4 to 1 ratio between current sales and inventory stocks (20 units for the additional stocks for the increment of sales of 5 units, and 5 units purchased for additional consumers' demand). The result shows that when the sales rise five per cent, the purchase by the wholesaler will rise 25 per cent (100 units to 125 units). If, in the next month, the sales stay at the same level, 105 units, the wholesaler's purchase needs only 105 units, which means a *decline* from 125 units to 105 units. Thus, amount of inventory investment fluctuates according to change of the volume of sales. And even when the level of sales is expanding, if the rate of expansion in sales volume begins to slow down, inventory investment will decrease.

Kuznets' survey of statistical data during the period between 1919-1925, though materials are by no means complete, reveals an intensified fluctuation in the volume of wholesale sales as compared to retail sales.²

Of these three cases of the application of the acceleration principle, the

2. Simon S. Kuznets, *Cyclical Fluctuations* (New York: Adelphi Company, 1926), pp. 162-201,

derived demands for capital goods and durable consumers' goods are probably more important than the derived demand for inventory stocks. Capital goods and durable consumers' goods are by nature more durable than inventory stocks, and with the longer durability, the intensification of fluctuation will be greater as a consequence of the acceleration principle. On the other hand, the relationship between retail sales and wholesale sales is not very apparent, because wholesale sales are influenced not only by the amount of retail sales as the acceleration principle assumes, but also by speculation as to the expected price or cost of the merchandise in the future. When prices are going to rise, present purchases increase and inventory stocks will be accumulated. On the other hand, if the prices are expected to decline, buying will be discouraged and the existing stocks will tend to be disposed of.

Furthermore, between the derived demand for capital goods and durable consumers' goods, perhaps, durable consumers' goods suggest a more complete working of the acceleration principle than capital goods do. This is especially true during a depression when there is a large excess capacity in the economy. The acceleration principle will be limited more in affecting induced investment for capital goods, because capital goods can be satisfied by utilizing the excess capacity. This limitation of the acceleration principle is less in durable consumers' goods, because even in a deep depression, at least replacement investment is necessary in order to maintain transportation services or rental services.

So far, the demonstration of the acceleration principle under simplified assumptions shows clearly the logical consequence arising out of the technical relationship between the demand for investment goods and the change in the demand for consumption goods or output. The validity of an economic principle, however, rests largely on its applicability to reality as well as on its logical consistency. In the actual world, perhaps, investment is likely to interrelate with consumption or output in a more complex manner than the acceleration principle tends to suggest. Particularly, there are three assumptions, which need our

critical reconsideration. These are: the problem of replacement demand, the problem of excess capacity, and the problem of expectations.

The first problem, the problem of replacement demand, is mainly concerned with capital goods and durable consumers' goods and not so much with inventory stocks. Usually, a discussion of the acceleration principle comes under the assumption that the level of replacement demand is constant throughout the cycle. Is replacement demand constant? If not, how would replacement demand affect the working of the acceleration principle?

There are two ideas in regard to variations in replacement demand: One, represented by J. M. Clark, emphasizes the level of output as the determinant of the level of replacement demand; the other, represented by J. R. Hicks, emphasizes the average life of investment goods as responsible in determining the level of replacement demand.

J. M. Clark distinguishes between new investment and replacement demand. New investment is related to the *rate* of change of consumption goods, but replacement demand is related to the level of the demand for consumption goods.³

A difficulty arises when the influence of replacement demand is taken into consideration. According to the acceleration principle, when the demand for consumption goods is expanding continuously in its absolute amount but diminishing in its rate of expansion, the resultant investment will decline absolutely. This conclusion is not necessarily true, because when consumption or output expands to the higher level, the necessity of replacement will also be greater. This greater amount of replacement demand may be large enough to offset the decline of new, induced investment, so that investment as a whole may continue to grow instead of decline.

3 J. M. Clark, "Business Acceleration and the Law of Demand," **The Journal of Political Economy**, Vol. 25, No. 3, (March 1917), p. 220.

The other idea explains changes in replacement demand in terms of the average life of investment goods. The average life of investment goods is found by averaging the lives of various kinds of investment goods, and this average is assumed to be constant. The difficulty of this explanation, however, is that the assumption of constant life distribution is uncertain. Usually, investment takes place during the boom period, and for a considerable time after an investment boom, investment goods remain new and do not require replacement. Later, when the time comes that investment goods start wearing out, replacement demand will rise; thus, replacement demand constitutes its own cycle instead of remaining constant. Furthermore, on account of technological improvement new machines may not be needed so much to replace old machines in order to maintain the same productive capacity.

J. R. Hicks discusses this problem also from the standpoint of life distribution of investment goods. He admits the importance of replacement cycles in the working of the acceleration principle, but thinks that replacement cycles will become so damped after a time that they may be ignored.⁴

The complexity of the problem of replacement demand is intensified by the lack of empirical knowledge on this subject. The difficulty of empirical study is largely due to the vagueness of the distinction between new and replacement investment. It is difficult to determine whether a particular act of investment is adding to or merely maintaining the stocks of capital. In some cases, investment of investment goods appears to be both new and replacement demand. This is the cause of the difficulty of distinction.

Another problem is concerned with excess capacity. Usually, a discussion of the acceleration principle is carried on under the assumption that there is no excess capacity existing in the economy as a whole. In other words, firms are assumed to be operating at full capacity. Thus, any expansion of the

4) J. R. Hicks, *op. cit.*, pp. 37-55

demand for consumption goods or output must be met by the proportional increase in the production of investment goods. If the expansion of the demand for consumption goods starts from a condition of large excess capacity, production of consumption goods can be satisfied by utilizing the excess capacity without investing in new investment goods.

This problem is especially important during a period of depression when a large excess capacity exists in the economy. Some writers, consequently, criticize the unsymmetrical nature of the acceleration principle on the ground that the principle can make but little explanation of the lower turning point of business cycles. To this problem, J. M. Clark argues that excess capacity is merely a temporary phenomenon, which will exhaust itself during an upswing of economic activity, and the acceleration principle will sooner or later start operating.⁵

The problem of excess capacity is undoubtedly an important qualification of the acceleration principle. But the discussion is sometimes confusing because of the lack of a clear-cut definition of the term "excess capacity." If by definition excess capacity means there is no idle capacity at all, then the economy always has an excess capacity because entrepreneurs must prepare for seasonal fluctuations and emergencies. The vital problem of excess capacity, therefore, is not the physical volume of excess capacity but rather whether or not firms are operating under the most efficient way of production.

A third problem is concerned with expectations. Usually, the acceleration principle assumes that induced investment is related mainly to current demand for consumption goods or output. Whenever consumers' demand or output is increasing, entrepreneurs do not hesitate to invest. In other words, intensity of the utilization of capital goods does not vary over the cycle.

But, investment activities are not only affected by change in the demand

5. J. M. Clark, *op. cit.*

for current consumption goods or output, but also are affected by the pessimism and optimism of entrepreneurs as to the expectations regarding the future behavior of consumption goods and output. Furthermore, in actual business practice, it is generally observed that the variation of the ratio between output and investment goods occurs when entrepreneurs change the proportion of labor and capital in the process of production. If in the process of production more is used, such as overtime work or the employment of additional workers, entrepreneurs can expand output without a proportional increase in the use of investment goods. As to whether entrepreneurs will produce by labor-consuming or capital-consuming methods, decisions are dependent upon expectations of changes in wage-rate, price level, profit-rate, and credit availability.

Some writers deal with this problem by taking an eclectic viewpoint, and combine the psychological factor of expectation with the technical factor of the acceleration principle in explaining business cycles. After all, it is difficult to say to what extent new investment is determined by expectations or by the change in demand for consumption goods or output. But there is a strong element of truth in the acceleration principle; namely, that the amount of an entrepreneur's decisions on investment are, to some extent, governed by a comparison of the output he can produce by the most efficient utilization of his existing facilities and the output to which consumers' demand is expected to change.

加 速 原 理 之 探 討

劉 榮 超

近代工業國家最感傷腦筋的問題是景氣循環的現象。一國之經濟繁榮往往不過是恐慌之先聲，並且恐慌所帶來之資源浪費之程度亦益加嚴重。研究景氣循環的經濟學者發現消費需求（或所得）與投資之間存有加速原理的關係，使得（1）投資之波動比較消費財之波動更厲害。（2）工業發達之國家比農業國家更容易發生嚴重的景氣循環現象，因為工業國家使用比較多的耐久性投資品。本文之目的在（1）闡明加速原理之意義，（2）其不同類型，（3）其適用範圍之限制。

關於加速原理之意義文中特別指出兩點：（1）所謂投資財及消費財（或所得）乃指生產過程的先後關係，因此兩者是相對而非絕對的概念。一個物財可能在某一種情形之下是投資財，但在另一種情形之下是消費財。（2）投資之變化是受消費需求（或所得）變化率的影響而非受消費（或所得）之絕對水準而定。

關於加速原理之類型可舉出三個例子，（一）資本財，（二）耐久性之消費財，（三）存貨量。加速原理對這三種物財之需求皆能適用，但其通用時所應考慮的因素不同。分別說明以後可以指出加速原理對那一種物財比較重要。

最後檢討加速原理之應用範圍之限制。通常加速原理適用時，我們應假定（1）重置投資需求的固定。（2）過剩生產力不存在。（3）投資者之心理沒有影響。這三種假設是否符合現實，如果沒有這些假設加速原理是否仍然合適，本文之結論認為雖然加速原理之適用範圍有限，但確為景氣循環現象發生的重要因素之一。