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Force of Long-Run Economic Growth: Technology Progress or New Consuming Product

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***Abstract*—In economic growth theory, force of long-run economic growth is considered to be capital accumulation, exogenous then endogenous technology progress. Economic aggregate cannot be represented as a production function of only production factors because it is related to both demand and supply. In this study, economic aggregate is divided into business revenue of growing product and that of mature product. Growing product provides surplus demand and mature product consumes surplus demand. Economic aggregate depends on innovation, the amount of growing products. In addition, two kinds of innovation, invention of new consuming products and technology progress play different role in economic growth. The former brings final demand increase and the latter leads to production cost reduction. Technology progress often exceeds new invention of consuming product because of strong externality.**

***Index Terms*—Economic growth, growing product, mature product, technology progress, new consuming product.**

I. Introduction

A purpose of growth theory is to explain basic mechanism of long-run economic growth. Growth models of neo-classical economics attribute force of long-run growth to saving rate [1]-[2] or exogenous technology progress [3]-[4]. Obviously, these models are not satisfactory because they put long-run economic growth down to exogenous and unmanageable factors which cannot explain the sustained growth of world economy. In contrast, endogenous growth theory holds that long-run economic growth lies in the investment in human capital, innovation and knowledge which are internal factors of economic development.

Early works of [5], [6] and [7] formed basis of research of endogenous growth theory. Representative models of endogenous growth theory were made since 80s last century. In Romer model [8]-[9], technological change arises in large part because of intentional actions of people and has the characteristic of externality. Then, this endogenous technology progress can overcome the effect of diminishing return to scale (DRS) and cause long-run growth. [10] emphasized the improvement of human capital which includes intelligence, skill and knowledge for production of product and service has incremental marginal output in the level of all society. Increasing human capital can overcome diminishing marginal output of labor and material capital, and cause long-run growth of macro-economy.

In addition, many theories which are bent on more elaborate or sophisticated growth models were developed in recent decades. The learning by watching model of [11] emphasized investment of knowledge may result in multiple steady-state growth rates in a deterministic setting. [12] presented the endogenous model of creative destruction. [13] researched the effect of learning by doingin international trade between developed and undeveloped countries. Moreover, many literatures focus on empirical test of effect of a factor on economic growth in a country or several countries.

However, a problem still exists with growth theory: total product cannot represent economic aggregate and production function cannot explain growth. In this study, the gross amount of goods is denoted by total product (TP) and the gross business revenue is denoted by gross output (GO). In each form of production function, independent variables include only supply factors as material capital, human capital and technology progress. As a result, dependent variable has to be TP rather than GO because TP is related to only supply and GO is decided by both supply and demand. Economic aggregate of an economy can be measured by GO or gross domestic product (GDP). In todays case of oversupply, TP is not positively related to GO, so TP is not suited to economic growth research and production function cannot accurately illustrate economic process.

This study includes three parts in following sections. First, we build an idea economic process which includes production and trading of products. Then, we obtain a function of GO in which independent variables include both supply and demand factors. Second, products are divided into two types, growing product and mature product. Third, innovation is classified as technology progress, new consuming products and services. The former brings supply increase by promoting productivity and the later leads to demand increase. These two kinds of innovation need progress synchronously to promote economic growth.

II. Discrete economic process

To avoid ambiguity, we assume a few conditions for this study:

- Research target of this study is the growth of a closed economy with constant population, as a country or a region.
- Investors including enterprises and individuals are the economic agent.
- Profit is the sole purpose of investment, so investment depends on profit rather than saving when financial capital is not scarce.

Production and sale of products and services is the core content of economic activity. To understand correctly the process from production to sale is necessary for economic development research. In Fig. 1, we exhibit an entire economic process which applies to a closed or an open economy.

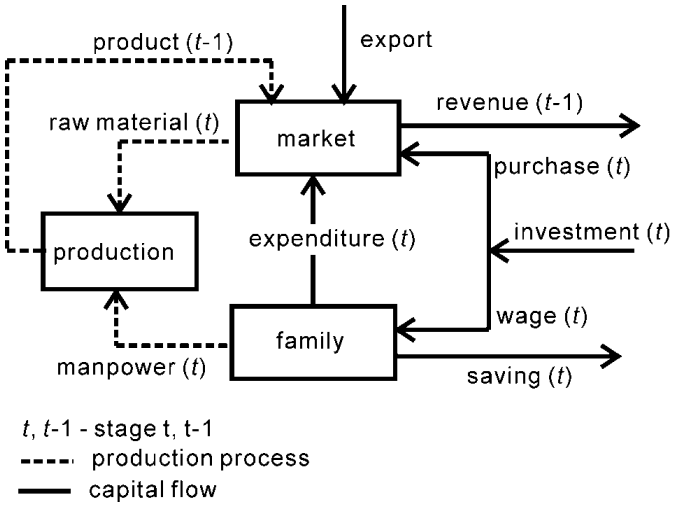

Fig. 1. Economic process consists of production process and capital flow.

All variables occur at the same stage even if some is marked as t stage and some as $t-1$ stage. All variables begin from investment so a variable marked as $t-1$ means it is a result of the investment of $t-1$ stage.

We need to make some explanations about the economic process of Fig. 1.

Economy process is divided into discrete equal length stages instead of a consecutive process. Production and sale of products are independently completed in each stage. That is, products produced at present stage will be put into market in a batch at next stage. The length of a stage depends on production period which is the meantime expended to produce various products.

Similarly, consumption period is defined as the time span which investment brings demand. A large proportion of demand is investment demand as the purchasing money to buy intermediate product or raw material. Final demand is the money for final consumption of families which is mainly the total wages removed saving. Consumption period is the mean time period from investment to family expenditure and raw material purchase. It is obvious that production period is far longer than consumption period because not only the time span from wages to expenditure is shorter than production period but also investment almost immediately leads to the purchase of intermediate product and raw material. Therefore, investment causes demand at present stage and brings supply at next stage in fact.

In Fig. 1, a series of variables as investment, purchase, wage, saving, expenditure, manpower, raw material, product and revenue take place in sequence. Investment is the first variable and other variables can be considered as results of investment. In this model, all variables in same series are denoted as same serial number. Although all variables take place at present stage t, product and revenue are results of investment of previous stage so they are denoted as the serial number $t-1$.

This process can be used to describe the economic process of a closed or an open economy. Under the condition of zero export, the target is a closed economy. In addition, the cycle of product and currency in an industry is similar to an open economy.

Variables are indicated as I investment, S saving, Re revenue, r profit rate, Ex export measured as money and Co other cost including interest and tax etc. From Fig. 1, revenue in stage t is

$$Re(t-1) = I(t) - S(t) + Ex(t) - Co \tag{1}$$

Profit rate in stage t is

$$\begin{aligned} r(t-1) &= \frac{Re(t-1)-I(t-1)}{I(t-1)} \\ &= \frac{I(t)-I(t-1)-S(t)+Ex(t)-Co}{I(t-1)} \end{aligned} \tag{2}$$

Assume η is the increasing rate of investment per stage, η' is saving rate which is the proportion of saving part of wage in total investment and η'' is the summation of interest rate, tax rate and other general non-productive cost rate caused by non-market factors. Equation 2 becomes

$$\begin{aligned} r(t-1) &= \frac{(1+\eta)I(t-1)-I(t-1)-(1+\eta)\eta' I(t-1)+Ex(t)-\eta'' I(t-1)}{I(t-1)} \\ &\approx (\eta - \eta' - \eta'') + \frac{Ex(t)}{I(t-1)} \end{aligned} \tag{3}$$

Second order item $\eta\eta'$ is ignored.

According to the condition profit is the sole purpose of investment, positive profit rate leads to investment increase, negative profit rate leads to investment reduction and zero profit rate leads to investment does not change. For a pure imported economy, i.e. $Ex(t) < 0$, investment increasing rate satisfies

$$\eta > r + \eta' + \eta'' \tag{4}$$

In other word, an economy provides surplus demand for external. In opposing case, an economy consumes surplus demand from external.

Obviously, profit rate decides increasing rate of investment which decides whether an economy provides surplus demand.

III. Growing product and mature product

A. Product price

In this study, we assume demand is the volume of transaction. Gross demand is related to gross income in a closed economy.

Assume price is flexible. If demand increases, product price rises as arrow 1 in Fig. 2. Under the condition of fixed demand, product price decline with increase of supply, as solid line in Fig. 2. At present transaction period, supply and demand decide product price rather than the other way round.

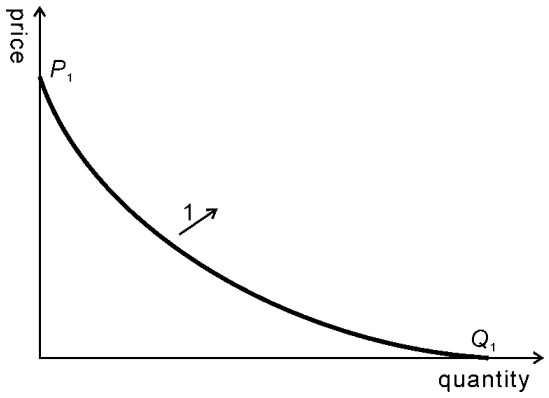

Fig. 2. Product price declines with increase of supply. Increase of demand leads to right shift of price line as arrow 1. Price line is crossed with axes in points $P1$ and $Q1$.

In Fig. 2, why price line crosses with axes in points $P1$ and $Q1$? If products can be replaced in market, $P1$ is the highest price of a specific product. $Q1$ is the lowest amount which leads to a product free.

B. Classification of products

Increase of supply is derived from the increase of investment for production. Meantime, increasing investment also leads to demand rise. In a closed economic process, demand responds the change of investment faster than supply according to the discussion above.

Assume price line in Fig. 2 is a smooth concave curve, i.e. it has continuous incremental first derivative, and is crossed with axes. Business revenue of a product is represented as a convex line in Fig. 3 through price multiplies by quantity.

Under the assumption of free market, product can be divided into two types as mature product and growing product.

For a mature product, market share has reached saturation, i.e. It is at point B in Fig. 3. There is not profit with a mature product. Investors do not increase investment for a mature product. A mature product often keeps steady volume of production and zero increasing rate of investment. A large proportion of GO of an economy is derived from mature products.

Growing product implies its market share is increasing, i.e. a product is in area $O-A-B$ of Fig. 3. Investment of a growing product increases gradually because of positive profit. A growing product will finally become a mature product with

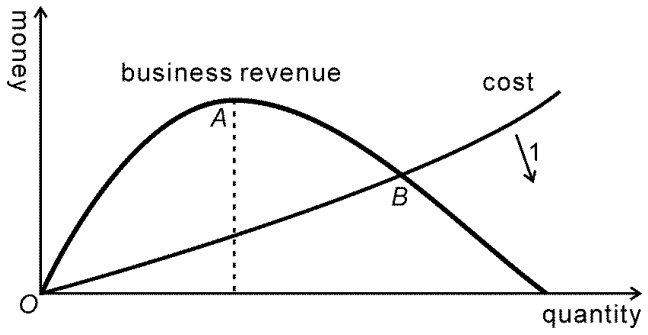

Fig. 3. Business revenue which price multiplies by quantity. A product has positive profit only in area $O-A-B$. Point A is the maximum business revenue. Technology progress leads to cost reduction as arrow 1.

increase of investment, as a process from O to A to B in Fig. 3. A growing product is a new product or a new service generally. In special cases which some conditions cause market to expand fast, a mature product may play the role of a growing product.

Obviously, growing products may provide surplus demand when its investment increasing rate satisfies (4). From (3), mature products with steady output need surplus demand to offset saving and general non-productive costs, as tax and interest.

C. Composition of GO

Economic aggregate of a closed economy as an indicator in economic growth research can be represented by GO or GDP. In this study, we adopt GO to measure economic growth. GO of a closed economy consists of two parts, business revenue of growing products and that of mature products.

For growing product, investment is I_g, investment increasing rate is η_g and profit rate is r_g in a given period. For mature product, investment is I_m, investment increasing rate is η_m and profit rate is r_m. Obviously, $r_m = 0$ and I_m keeps steady $\eta_m = 0$ because mature product keeps a steady business revenue in a long time. According to (3), mature products need surplus demand from external which is denoted as Dsm. $Dsm = Ex$, (3) becomes

$$Ds_m = (\eta' + \eta'')I_m \tag{5}$$

Here η' is saving rate and η'' is the summation of interest rate and tax rate. From (3), if there is not external demand, negative profit will cause investment reduction so investment of mature products I_m cannot keep steady. In additional, investment I_m is also the gross business revenue of mature products in a given period.

In a free market, investment of growing products increases gradually because of profit greater than zero. If investment increasing rate satisfies (4), growing products will provide surplus demand to external, which should be equal to import $-Ex$ of (3). Substituting $Dsg = -Ex$ to (3), surplus demand provided by growing products is

$$Ds_g = \eta_g I_g - r_g I_g - (\eta' + \eta'') I_g = (\eta_g - r_g - \eta' - \eta'') I_g \quad (6)$$

For a closed economy, surplus demand provided by growing products is equal to that mature products need, i.e. $Dsm = Dsg$. Combining (5) and (6), so $I_m = (\frac{\eta_g - r_g}{\eta' + \eta''} - 1) I_g$.

Let $a = \frac{\eta_g - r_g}{\eta' + \eta''}$, so

$$I_m = (a - 1) I_g \quad (7)$$

When variables η_g, r_g, η' and η'' are constant, coefficient a is a constant. In general, coefficient a is far greater than 1. (7) demonstrates the business revenue of mature products depends on the scale of growing products for a closed economy. Then, GO of a closed economy is

$$Go = I_m + (1 + r_g) I_g \approx a I_g \quad (8)$$

Therefore, GO depends on the scale of growing products for a closed economy in the long run.

IV. Two types of innovation

Innovation can be divided into two types based on their different effect on economic growth. One type is technology progress including new method or new tool of production process of products. It improves production efficiency but does not change the quality of product. Its price is included in cost of final product and its value lies in reducing cost of final product.

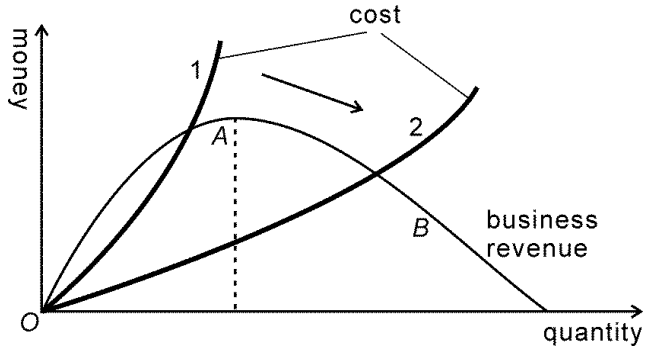

Fig. 4. A result of technology progress is cost fall, as cost line moves along the arrow.

Another type of innovation is new product or service for final consumers, which includes quality improvement of old product. Every new product or service will undergo a growing process from O to A to B in Fig. 3, in free market. That is growing product, which provides surplus demand for mature product.

In early period of economic development which cost line of production is at the area $O - A$ as cost line 1 in Fig. 4, technology progress leads to growth of GO. When technology is developed as todays case, cost line of production is at the area $A - B$ as cost line 2 in Fig. 4 so as to pure technology progress results in reduction of GO.

Therefore, two kinds of innovation have opposite function on gross business revenue of a closed market in the long run.

V. Discussions

A. Final demand

Besides gross supply, gross demand is also a factor deciding GO. Gross demand includes investment demand and consumption demand. Investment demand is also called intermediate demand. Consumption demand is also called final demand.

Investment demand depends on consumption demand in the long run. Therefore, consumption demand decides gross demand.

If population keeps constant as the assumption of this study, consumption demand increases with the rise of resident income level. Increasing rate of gross consumption demand is diminishing with the rise of resident income level.

B. Unbalanced innovations

An invention of production tool or method may bring cost fall of many existing products. As a result, new production technology develops often faster than new final products. Two types of innovation are unbalanced because technology progress often exceeds new products. Therefore, technology progress brings recession of whole economy although it may lead to local growth.

VI. Conclusions

In most of existing development theories, economic growth is studied based on production function. Economic aggregate obeys monotonously with production factors. Innovations result is to counteract DRS effect. In production functions, demand is ignored.

In this study, product is divided into mature product and growing product. The former makes a large proportion of GO, the latter decides the amount of GO. Compared with production factors, product has more direct relation with GO. We concluded decreasing return lies in firstly price fall of product caused by supply increase rather than DRS effect. In fact, DRS effect never cause production fall in todays case. Lack of demand is the primary problem in today and future, and it cannot be solved by increasing intermediate demand.

A conclusion of this study is production technology and new products as two parts of innovation have different role on macro-economic growth. The former leads to economic recession and the latter leads to economic growth for a closed economy.

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