# Sustained Economic Growth and Technology Policies

ByungWoo Kim
Associate Research Fellow
STEPI

02-3284-1841, Fax: 02-849-8015
byungw@stepi.re.kr



## Sustained Economic Growth and Technology Policies

**Abstract:** Government can consider technology policies that directly augment the incentives for research. We analyzed what the technology policies have effects on the growth rate in the one-sector economy. We know that any increase in the subsidy rate causes the rate of innovation to increase. A subsidy to R&D spurs product development. Faster innovation and growth come as a result.

We showed that considering goodness of fit of regression model, we can see that the empirical evidence is strongly in favor of the character of R&D subsidies as the instrument spurring economic growth. We could see that 10% increase in the subsidy (amount) causes the rate of economic growth to increase by 0.8%.

So, we can expect that through product innovation supported by technology policy, faster economic growth can be attained in the Korean economy.

**Key Word:** R&D investment, product innovation, knowledge capital, sustained growth, monopolistic competitionm, technology policies, R&D subsidies

### 1. Introduction

In the 1920s and 1930s considerable progress was made in the analysis of economic equilibrium, "monopolistic competition revolution".

Monopolistic competition was introduced by Chamberlin(1933). His concern was to deal with market structures characterized by advertising and product differentiation. If a firm is making a profit selling a product in an industry, and other firms are not allowed to perfectly reproduce that product, they still may find it profitable to enter that industry and produce a similar but distinctive product. Economists refer to this phenomenon as product differentiation. Each product has its following of consumers, and so has some degree of market power.

Since Harrod(1939) and Domar(1946), economists have looked to captital formation for their explanation of rising standards of living. It was Solow(1956) who formalized the idea that capital deepening could cause labor productivity to rise in a dynamic process of investment and growth. The model's critical assumption concerning the product function is that it has CRS(constant returns to scale) in its two arguments, capital and labor. In addition, intangibles such as human capital and knowledge capital have pecular economic properties that may not be well represented by the standard formulations.

Although Linder(1961) stressed increasing returns to scale(IRS) in trade theory, it was not until much later (Krugman, 1979) that a more formal treatment of trade and productivity under IRS was provided. One of the problems with incorporating IRS into a theory of trade and productivity is the need to deal with imperfect competition. Krugman uses a model of monopolistic competition to show that trade can be viewed as a means of exploiting economies of scale in the presence of a less than completely elastic home market.

Grossman and Helpman(1991) developed coherent theoretical framework that previous discussions of trade, growth, development, industrial organization(IO) and innovation have lacked. They attempted to integrate the theory of IO with the theory of growth. As growth theory, they focused on the economic determinants of technological progress. As IO theory, they applied tools from the theory of IO to develop aggregate models of ongoing investemnts in new technologies. Their premise was that new technologies stem from the intentional actions of economic agents responding to market incentives.

In this paper, we review new models of intentional industiral innovation. We deal with innovation that serves to expand the range of goods avaliable on the market. Firms devote resources to R&D in order to invent new goods that substitute imperfectly for existing brands. Producers of unique products earn monopoly rents, which serve as the reward for their prior R&D investments. In addition, we adapt new growth theory to real Korean economy data by empirical analysis.

We introduce government policy in the economic growth model. We can consider both technology policies that directly augment the incentives for research and industrial policies that do so indirectly by encouraging production of technology−intensive goods. We analyze what the technology policies have effects on the growth rate in the previous one−sector economy.

We develop a model that predicts sustained growth (in real income.) We also examine how various parameters describing tastes and technology interact to determine the endogeneous growth rate. We continue our investigation of the factors that influence long−run growth performance by introducing government policies. We focus here on the positive effects of government intervention.



## 2. Economic model and empirical analysis

### 2.1 Imperfect competition and new growth theory

It was Solow(1956) who formalized the idea that capital deepening could cause labor productivity to rise in a dynamic process of investment and growth.

Many of the early models treated technological progress as an exogeneous process driven only by time. The view that innovation is driven by basic research, which is implicit in the models with exogeneous technology, was made explicit in a paper by Shell(1967).

Arrow(1962) was the first to view technological progress as an outgrowth of activities in the economic realm. Romer(1986), who discussed the possibility that learning−by−doing might be a source of growth, maintained this treatment of technological progress as wholly the outgrowth of an external economy.

Now we let the productivity of labor depend upon the economywide cumulative experience in the investment activity, that is, on the aggregate stock of capital. Then aggregate output of Z will be given by

$$Z=F[K,\ A(K)L].$$

The first argument in F( ) represents the private input of capital by all firms in the economy. The second argument reflects their aggregate employment of effective labor, which depends in part upon the state of technology, as represented by the term A(K).

Romer(1986) provides an alternative interpretation of this specification. He views K itself as knowledge. Knowledge is created via an R&D process. Firms invest in private knowledge, but at the same time they contribute inadvertently to a public pool of knowledge, which is represented here by A(K).

Shell(1967) makes knowledge the intended output of those who create it. The production function $F[K_Z,\ AL_Z]$ describes the relationship between inputs and output of the final good. We assume that the same production function applies to the generation of knowledge as applies to the production of tangible commodities:

$$\Delta A=F[K_A,\ AL_A]$$

where $K_A$ and $L_A$ are the inputs of capital and labor, respectively, into the research activity.

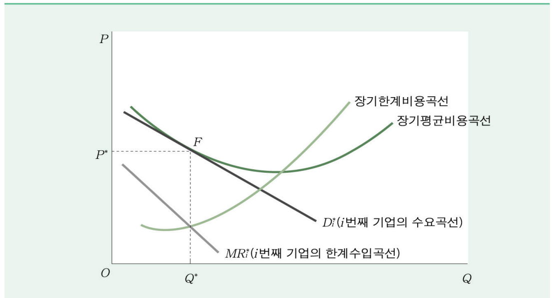
Grossman and Helpman(1991) developed endogenous growth based on intentional innovation. Industrial research may be aimed at inventing entirely new commodities(product innovation). They incorporated tools from the theory of industrial organization(IO), and their extensions in trade theory to general equilibrium settings to develop aggregate models of ongoing investments in new technologies. They represent the set of brands available on the market by the interval [0, n]. With this convention n is the measure of products invented. They referred to n as the "number" of available varieties.

Monopolistic competition was introduced by Chamberlin(1933). It is probably the most prevalent form of industry structure. If a firm is making a profit selling a product in an industry, and other firms are not allowed to perfectly reproduce that product, they still may find it profitable to enter that industry and produce a similar but distinctive product. Economists refer to this phenomenon as product differentiation. Each product has its following of consumers, and so has some degree of market power.

We can describe the (long-run) equilibrium of the industry in the following way:

(i) Each firm faces a downward-sloping demand.
(ii) Each firm makes no profit.
(iii) A price change by one firm has negligible effect.

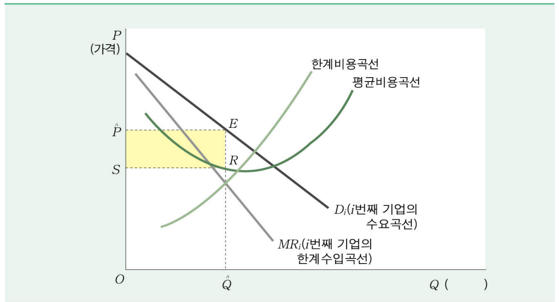
<Figure 1> Long-run equilibrium in Monopolistic competition




If we treat commercial research as an ordinary economic activity, returns to R&D come in the form of monopoly rents in (short-run) imperfectly competitive product markets.



<Figure 2> Short-run equilibrium in Monopolistic competition




The representative household maximizes utility over an infinite horizon.

$$U(t)=\int_t^{\infty} e^{-\rho(\tau-t)}\log D(\tau)d\tau$$

Here $\log D(\tau)$ represents an index of consumption at time $\tau$, and $\rho$ is the subjective discount rate.

We adopt for D a specification that imposes a constant elasticity of substitution between every pair of goods. It is straightforward to show that, with these preferences, the elasticity of substitution between any two products is $\varepsilon = 1/(1-\alpha)$ $(>1)$.

$$D=[\int_0^{n} x(j)^{\alpha}dj]^{(1/\alpha)} \qquad (2.1)$$

where x(j) denotes consumption of brand j.

It is useful to develop an interpretation of the consumption index D. We may think of households as consuming a single homogeneous consumption good in quantity D. We suppose that the final good is assembled from differentiated intermediate inputs or producer services.

In equilibrium manufacturers of consumer goods would employ equal quantities x(j)=x of each. Then (2.1) implies that $D = n^{(1/\alpha)}x$.

Then final output per unit of primary input(TFP) is given by $D/X = n^{(1-\alpha)/\alpha}$.[1)]

1) We can use X=nx to measure the resources embodied in final goods.

Returning to the consumers' allocation problem, we consider now its intertemporal component. The representative household maximizes utility subject to an intertemporal budget constraint. Using D=E(aggregate spending)/$p_D$, we can rewrite the maximand as

$$U(t)=\int_t^{\infty} e^{-\rho(\tau-t)}[\log E(\tau) - \log p_D(\tau)]d\tau$$

Note that this indirect utility is weakly separable in the level of spending and the price index. In effect, the household can solve its optimization problem in two stages. First, it can choose the composition of given levels of spending to maximize instantaneous utility. Then it can optimize separately the time path of spending. Thus the maximization of indirect utility subject to an intertemporal budget constraint requires that spending evolve according to

$$\Delta E/E = r-\rho$$

This condition holds for every household and also for aggregate spending. We impose a normalization of prices that makes nominal spending constant through time. With

$$E(t) = 1 \quad \text{for all } t,$$

the above equation implies that

$$r(t) = \rho \qquad (2.2)$$

Firms may enter freely into R&D. An entrepreneur who devotes *l* units of labor to R&D for a time interval of length *dt* acquires the ability to produce $dn=(l/a)dt$ new products. The effort creates value for the entrepreneur of $v(l/a)dt$, since each blueprint has a market value of *v*.

$$\Delta n=F[L_N]$$

It is known that when the initial number of brands exceeds $n_0$, there always exists a perfect foresight equilibrium with no product development.

In the momentary equilibrium all varieties are priced equally at p, where



$$p=w/\alpha$$

(The specified technology makes marginal manufacturing costs equal to the wage rate w.)

With symmetric demands and E(aggregate spending)=1, this pricing strategy yields per brand operating profits of

$$\pi=(1-\alpha)/n \qquad (2.3)$$

We let *v(t)* denote the value of a claim to the infinite stream of profits that accrues to a typical firm operating at time *t*. In the brief time interval between *t* and *t+dt*, the total return to the owners of this firm amounts to $\pi dt+\Delta v dt$. We assume that arbitrage in capital markets ensures equality between this yield and that on a riskless loan. The latter return for an investment of size *v* is *rvdt*. Thus equilibrium in the capital market requires

$$\pi + \Delta v = rv \qquad (2.4)$$

We can substitute the formulas for the interest rate (2.2) and the profit rate(2.3) into the no-arbitrage condition(2.4) to derive an equation for the change in firm value as a function of the current value of a blueprint and the number of available brands. The result is

$$\Delta v = \rho v - (1-\alpha)/n \qquad (2.5)$$

The inverse relationship between the number of available varieties and profits per brand[equation (2.3)] suggests that product development may never get underway if an economy inherits a sufficiently diverse set of differentiated commodities. In other words, in the endogeneous growth model which treats knowledge capital as a private good, when the initial number of brands exceeds some number(eg. $n_0$), there always exists a perfect foresight equilibrium with no product development. We can see that with these initial conditions, the dynamic equilibrium without any R&D is unique.

Ideas do not become exhausted, and there are no diminishing returns in the creation of knowledge. Nonetheless, growth ultimately ceases in this simplest model of endogeneous innovation.

As yet, we treated knowledge capital as a private good. But, the originators of many new ideas often cannot appropriate all of the potential benefits from their creations.

So in this point, we modify formulation of knowledge creation to allow for the existence of non-appropriable benefits from industrial research.

Romer(1990) argued that each research project also contributes to a stock of general knowledge capital $K_N(t)$.

In place of technology for product innovation $\Delta n=F[L_N]$, we assume that

$$\Delta n=F[K_N, L_N]=(1/a)(K_N L_N)$$

where $K_N$ and $L_N$ are stock of general knowledge capital and aggregate employment in R&D, respectively. Of course the previous formulation is a special case of this equation with $K_N(t)\equiv 1$.

We take the knowledge capital stock to be proportional to the economy's cumulative experience at R&D.

$$K_N=n$$

Before beginning the analysis of the equilibrium growth path, we can define a new variable. We use $g\equiv\Delta n/n$ to denote the instantaneous rate of innovation in the economy (the rate at which new products are being introduced).

Let's ask what the equilibrium implies about the rate of growth of final output and the rate of growth of GDP. When the differentiated products are interpreted to be intermediate goods, clearly faster innovation implies faster output growth.

It is apparent that the economy innovates faster the larger is its resource base(large L), the more productive are its resources in the industrial research lab(small a), the more patient are its households(small $\rho$), and the greater is the perceived differentiation of products(small $\alpha$).

If we treat knowledge capital as a public capital considering of its non-appropriable benefits, economic growth can be sustained in the economy.

In this case, the higher is the rate of innovation, the greater is employment in R&D. In the steady-state equilibrium, product development continues indefinitely, always at a constant rate. We may calculate the steady-state rate of innovation as follows:

$$g=(1-\alpha)/(L/a)-\alpha\rho$$

L: labor supply

Sustained innovation is possible in this case because the cost of product development falls with the accumulation of knowledge capital, even as the return to the marginal innovation

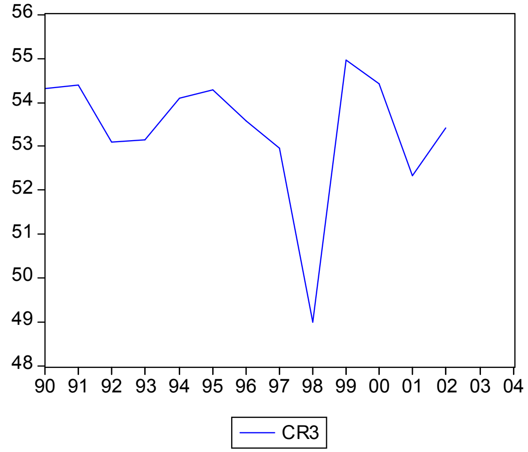


declines. The nonappopriable benefits from R&D keep the state of knowledge moving forward, and so the private incentives for further research are maintained.

IO economists have long tried to summarize the distribution of market shares among firms in a single index to be used in econometric and antitrust analysis. Such an aggregate index is called a concentration index.

The 3-firm concentration ratio(CR3), which adds up the 3 highest shares in the economy has been changed as in <Fig. 3> From this, we can infer that oligopolistic market structure like monopolistic competition is probably the most prevalent form of Korean industry structure.

<Figure 3> 3-firm concentration ratio of Korea(CR3)



2.2 Technology policies

In this point, we can introduce government policy. We can consider both technology policies that directly augment the incentives for research and industrial policies that do so indirectly by encouraging production of technology−intensive goods. In this section, we analyze what the technology policies have effects on the growth rate in the previous one−sector economy.

In the last section we developed a model that predicts sustained growth (in real income.) We also examined how various parameters describing tastes and technology interact to determine the endogeneous growth rate. In this section, we continue our investigation of the factors that influence long−run growth performance by introducing government policies. We focus here on the positive effects of government intervention.

Let us return to the case of a linear relationship between cumulative research and public knowledge capital, and ask what the equilibrium implies about the rate of growth of final output and the rate of growth of GDP. Concerning the former, there is a simple answer when the differentiated products are interpreted to be intermediate goods. Since the allocation of labor is constant in the steady state, so too is X=nx. Final output, which equals $Xn^{(1-\alpha)/\alpha}$, grows at the constant rate $g_D=g(1-\alpha)\alpha$. Clearly faster innovation implies faster output growth in this case.

In addition, we substituted the formulas for the interest rate and the profit rate into the no−arbitrage condition to derive an equation for the change in firm value as a function of the current value of a blueprint and the number of available brands. The result is

$$\Delta v = \rho v - (1-\alpha)/n \qquad (2.5)$$

We can get resource constraint equation linking the steady−state aggregate output of manufactured goods X and the rate of innovation g. Since each unit of output (is assumed to) require one unit of labor, while product development at rate g uses ag units of labor, the resource constraint takes the form

$$ag + X = L \qquad (2.6)$$

Next we recast the no−arbitrage condition in terms of g and X. In an equilibrium with an active R&D sector, the value of the representative firm is v = wa/n. Wages are constant in a steady state. Aggregate sales are equal to X = 1/p = α/w. So the no−arbitrage condition can be written as



$$(1-\alpha)X/(\alpha a) = g + \rho \qquad (2.7)$$

We get the relationship, which equates the profit rate(expressed in terms of the aggregate output of manufactures) and the real interest rate in terms of R&D. The steady−state is found at the intersection of two equations.

We consider a policy whereby the government pays a fraction ϕ of all research expenses. Such a subsidy to R&D lowers the private cost of invention to (1−ϕ)wa/n. This changes the incentives facing entrepreneurs in exactly the same way as would a decline in the unit labor requirement for R&D from a/n to (1−ϕ)a/n. With the policy in effect, the free−entry condition implies that v = (1−ϕ)wa/n in an equilibrium with g>0. The resource constraint is not affected by the government intervention, but the no−arbitrage condition becomes

$$(1-\alpha)X/[(\alpha a)(1-\phi)] = g + \rho \qquad (2.7)'$$

From (2.7)', we see that any increase in the subsidy rate causes the rate of innovation g to increase. A subsidy to R&D spurs product development.(Romer, 1990) Faster innovation and growth come as a result.

2.3 Data and empirical analysis

The term "panel data" refers to data sets where we have data on the same individual(industry; i) over several periods of time(t). The main advantage is that it allows us to test and relax the assumptions that are implicit in cross−sectional analysis.

The data set consists of 5 industries in manufacturing sector observed yearly for 15 years(1990−2004), a "balanced panel". Because of no missing data on some of the variables, we obtained 75 observations.

We examined a simple model for the technology for product innovation of 5 industries in manufacturing sector:[2)]

$$n_{it} = \alpha_i + \beta' x_{it} + \varepsilon_{it}$$

n: the number of firms in each industry[3)]

x: R&D investment, R&D stock, R&D personnel

The fixed effects approach takes $\alpha_i$ to be a group(industry) specific constant term in the regression model. The random effects approach specifies that takes $\alpha_i$ is a group(industry) specific disturbance in the regression model.

Fixed and random effects regression produces the following results. Estimated standard errors are given together. <Table> also contains the estimated technology for product innovation equations with individual industry effects.

2) In this point, we need to consider Schumpeter's(1943) thesis about the link between market structure and R&D. Schumpeter's basic point - that monopoly situations and R&D are intimately related - is articulated in the following clearly distinct argument: that if one wants to induce firms to undertake R&D one must accept the creation of monopolies as a necessary evil. While all firms stand prepared to use useful information created by other firms, no one firm is willing to pay the sums of money necessary to produce it without compensation. In practice, such compensation often comes through the granting of a patent that provides the innovating firm with a temporary monopoly. Previous empirical studies on Schumpeter hypothesis show that the prediction of Schumpeter does not accord well with empirical observation of Korean economy.(Lee and Cheong 1985, Kim and Cho 1989, Kim 2005, Sung 2005)

3) Strictly speaking, n(t) is the measure of products invented before time t. Grossman and Helpman(1991) referred to n as the "number" of available varieties. In this paper, we use the number of firms for n due to limitation of getting data for the number of products by industry. This may be the limit of the paper.



**<Table 2> Panel data by industry classification**

| Industy variable (1990−2004) | R&D(OECD, KOSIS) Value Added, Number of firms, Subsidy to R&D(KOSIS) |
|---|---|
| FOOD | Food products, beverages and tobacco |
| CLOTH | Textiles, textile products, leather and footwear |
| CHEMICAL | Chemical, rubber, plastics and fuel products |
| METAL | Basic metals |
| MACHINE | Machinery and equipment, instruments and transport equipment |

<Table 3> contains the estimated production function for blueprints(knowledge) with individual industry disturbances. Considering chi−squared statistic for testing for the fixed and random effects, we can see that the evidence is strongly in favor of the random effects model.

We examined the following model for the technology for product innovation of 5 industries in manufacturing sector:[4)]

$$n_{it} = \alpha_i + \beta' x_{it} + \gamma GDP_t + \varepsilon_{it}$$

x: R&D investment

Significantly estimated elasticity of R&D to the number of firms in each industry is 0.14. It means that if firms increase R&D by 1%, then the number of blueprint is increased by 0.14%. GDP variable is used to control confounding factors(eg. business cycle).

4) In this specification of regression model, we again need to consider Schumpeter's thesis that imperfect competiton situations like monopoly and R&D are intimately related because there may be the endogeneity problem. A fundamental assumption of regression analysis is that the explanatory variable(R&D) and the disturbance are uncorrelated in the market structure equation. In this situation, Ordinary Least Squares(OLS) estimates of the structural parameters are inconsistent, because the endogeneous variables(R&D and market structure) can be determined simultaneously. So, it is necessary to analyze the causalty between the two panel variables.(Canning and Pedroni, 2001) In this paper, we omit causality analysis and this may be the limit of the paper.

**<Table 3> Random-effects model estimation for panel data[5)]**

| Dependent Variable: LOG(N?) | | | | |
|---|---|---|---|---|
| Method: Pooled EGLS (Cross-section random effects) | | | | |
| Sample (adjusted): 1991 2004 | | | | |
| Included observations: 14 after adjustments | | | | |
| Cross-sections included: 5 | | | | |
| Total pool (balanced) observations: 70 | | | | |
| Swamy and Arora estimator of component variances | | | | |
| Period SUR (PCSE) standard errors & covariance (d.f. corrected) | | | | |
| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
| C | 2.464819 | 1.136276 | 2.169208 | 0.0336* |
| LOG(RD?(0)) | 0.137833 | 0.044106 | 3.125044 | 0.0026* |
| LOG(GDP(-1)) | 0.38548 | 0.09349 | 4.123231 | 0.0001* |
| Random Effects (Cross) | | | | |
| _FOOD--C | -0.37473 | | | |
| _CLOTH--C | 0.851245 | | | |
| _CHEMICAL--C | 0.425791 | | | |
| _METAL--C | -1.46356 | | | |
| _MACHINE--C | 0.561251 | | | |
| | Effects Specification | | | |
| Cross-section random S.D. / Rho | | | 1.013221 | 0.9933 |
| Idiosyncratic random S.D. / Rho | | | 0.083326 | 0.0067 |
| | Weighted Statistics | | | |
| R-squared | 0.729983 | Mean dependent var | | 0.203608 |
| Adjusted R-squared | 0.721923 | S.D. dependent var | | 0.157329 |
| S.E. of regression | 0.082965 | Sum squared resid | | 0.461168 |
| F-statistic | 90.5662 | Durbin-Watson stat | | 0.874371 |
| Prob(F-statistic) | 0.00 | | | |

Next, we examined the following model for the economic growth by product innovation of 5 industries in manufacturing sector:

<Table 4> contains the estimated grow rate function in each industry by product innovation with individual industry effects.

$$(\Delta V/V)_{it} = \alpha_i + \beta' n_{it} + \gamma GDP_{t-1} + \delta SUB_{it} + \varepsilon_{it}$$

V: Value added by industry, SUB: Subsidy to R&D

Significantly estimated elasticity of product innovation to the economic growth in each industry is 0.60. It means that if firms increase product innovation by 1%, then the grow rate of industry is increased by 0.60%. Lagged GDP variable is used to control confounding factors(eg. business cycle).

As for R&D subsidy, we see that 1% increase in the subsidy (amount) causes the rate of growth $g_D$ to increase by 0.08%. A subsidy to R&D significantly spurs product development and faster innovation and growth come as a result.

5) If estimated coefficient is statistically significant, we denote *, or **, by 5% or 10% confidence level, respectively.



**<Table 4> Random-effects model estimation for panel data**

| Dependent Variable: LOG(((V?(0))/MANUDFL(0))-LOG((V?(-1))/MANUDFL(-1))) | | | | |
|---|---|---|---|---|
| Method: Pooled EGLS (Cross-section random effects) | | | | |
| Sample (adjusted): 1992 2003 | | | | |
| Included observations: 12 after adjustments | | | | |
| Cross-sections included: 5 | | | | |
| Total pool (balanced) observations: 60 | | | | |
| Swamy and Arora estimator of component variances | | | | |
| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
| C | -0.152639 | 1.312527 | -0.116294 | 0.9078 |
| LOG(N?(0)) | 0.602970 | 0.095374 | 6.322137 | 0.0000* |
| LOG(GDP(-1)) | 0.467181 | 0.112968 | 4.135507 | 0.0001* |
| LOG(SUB?(0)) | 0.079915 | 0.028673 | 2.787175 | 0.0072* |
| Random Effects (Cross) | | | | |
| _FOOD--C | 0.070966 | | | |
| _CLOTH--C | -0.732925 | | | |
| _CHEMICAL--C | -0.109801 | | | |
| _METAL--C | 0.384645 | | | |
| _MACHINE--C | 0.387115 | | | |
| Cross-section random S.D. / Rho0.2465250.8656 | | | | |
| Idiosyncratic random S.D. / Rho0.0971540.1344 | | | | |
| R-squared | 0.802296 | Mean dependent var1.394679 | | |
| Adjusted R-squared | 0.791704 | S.D. dependent var0.240684 | | |
| S.E. of regression | 0.109847 | Sum squared resid0.675713 | | |
| F-statistic | 75.75036 | Durbin-Watson stat0.776242 | | |
| Prob(F-statistic) | 0.000000 | | | |

This result gives the implication that through product innovation supported by technology policy, sustained economic growth can be attained fastly in the Korean economy.

### 3. Summary and conclusion

Grossman and Helpman(1991) presented the models of endogeneous growth based on intentional industrial innovation. Innovations serve to expand the range of available products. They find that if the creation of knowledge generates nonappropriable benefits that allow later generations of researchers to proceed at lower resource cost than their predecessors, then the process of endogeneous innovation and growth may be sustained.

If we treat knowledge capital as a public capital considering of its non−appropriable benefits, economic growth can be sustained in the economy.

In this paper, we introduced government policy. Government can consider both technology policies that directly augment the incentives for research and industrial policies that do so indirectly by encouraging production of technology−intensive goods. Among two policies, we analyzed what the technology policies have effects on the growth rate in the one−sector economy.

We know that any increase in the subsidy rate causes the rate of innovation to increase. A subsidy to R&D spurs product development. Faster innovation and growth come as a result.

We showed that considering goodness of fit of regression model, we can see that the empirical evidence is strongly in favor of the character of R&D subsidies as the instrument spurring economic growth. We could see that 10% increase in the subsidy (amount) causes the rate of economic growth to increase by 0.8%.

So, we can expect that through product innovation supported by technology policy, faster economic growth can be attained in the Korean economy.

**<Table 6> Panel analysis summary: Estimated elasticity**

| Causal relationship | Innovation | (Elasticity) | Industry structure | (Elasticity) | Growth |
|---|---|---|---|---|---|
| Innovation and growth in monopolistic competition | R&D investment(X) | ⇒(0.14) | Product innovation(n) | ⇒(0.60) | Economic growth in industry($\Delta V/V$) |
| | R&D subsidy(SUB) | ⇒(0.08) | | | |



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