Trade Policies and Economic Growth

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Summary: To see the implication of trade policy in endogeneous growth model, we introduce trade protection that takes the form of an import tariff and represents one plus the rate of protection provided to industry sector. 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 trade policies as the instrument spurring economic growth. As for import tariff, we see that 1% increase in the rate of tariff that protect domestic market causes the rate of growth to increase by 0.87%. An imprort tariff to final product significantly spurs product development and faster growth come as a result. But, we should note that the effects of trade policy are muted by the induced changes in the output of intermediates in an economy that is relatively unproductive in the research lab.

Key Word: R&D investment, product inovation, sustained growth, monopolistic competition, dynamic comparative advantage, pattern of trade, intraindustry trade, trade protection, import tariff

1. Introduction

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.

The starting point for discussions of the pure theory of trade and productivity is Ricardo's *Principles*. A country will choose to obtain goods through trade when a unit of labor applied to exports will produce more goods for home use than will result from the application of labor to produce these goods domestically. This will be the case whenever the relative labor costs involved in the production of different commodities differ from one country to another. This difference comes mainly from the difference of productivity. If one country invests in R&D activities, then that country can lower labor costs relatively and exports more commodities. An alternative approach to the pure theory of trade and productivity originated in the work of Hecksher(1919) and Ohlin(1933). Hecksher's purpose was to analyse the effects of trade on the income distribution between factors of production.

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, and innovation have lacked. They attempted to integrate the theory of international trade with the theory of growth. As growth theory, they focused on the economic determinants of technological progress. As trade theory, they dealed with the dynamic evolution of comparative advantage and the consequences of international trade in a world of global technological competiton. 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.

Also, we review new trade theory that focuses on the association between factor endowments and both the direction of trade in high-technology goods and the growth rate of manufactured ouput. To see the implication of trade policy in endogeneous growth model, we introduce trade protection that takes the form of an import tariff and represents one plus the rate of protection provided to industry sector. We see whether the prediction of new trade theory seem to accord well with empirical observation of Korea.

Korean economy experienced between 1990 and 2004 a change of a structural transformation of ite production sector toward diversity and expanding product variety. This event was joined by an increase in R&D, and by a change in the source of Korean comparative advantage.

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:

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

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

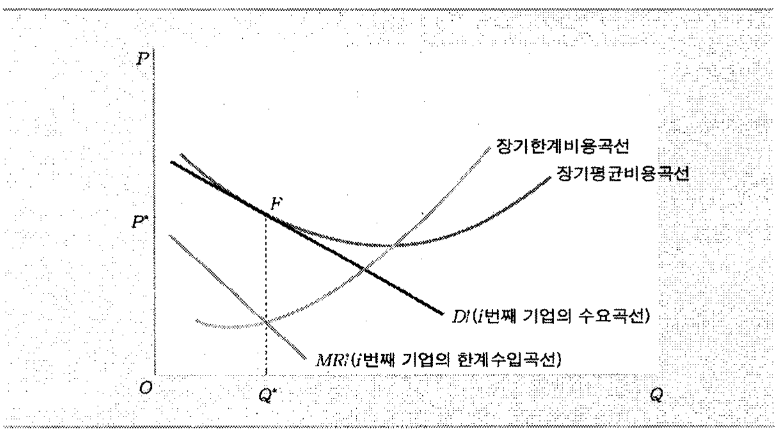
Grossman and Helpman(1991) developed endogenous growth based on intentional innovation. Industrial research may be aimed at inventing entirely new commodities(product innovation). They incorporated tools from the theory of industrial organization(IO), and their extensions in trade theory to general equilibrium 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:

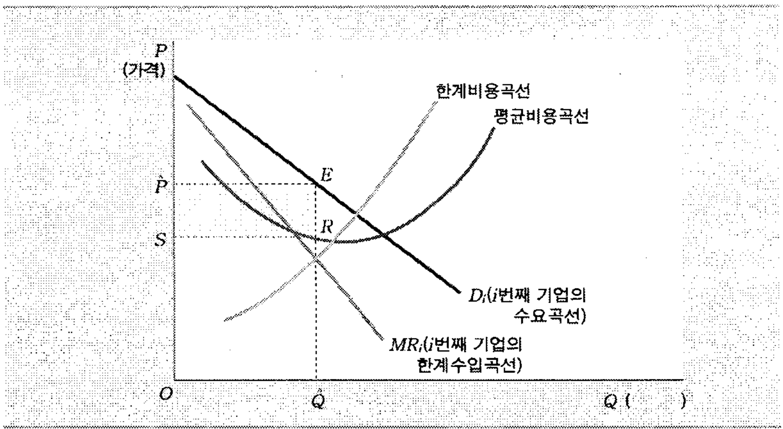
(i) Each firm faces a downward-sloping demand.
(ii) Each firm makes no profit.
(iii) A price change by one firm has negligible effect.

<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 τ, and ρ 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

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

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 $\upsilon(l/a)dt$, since each blueprint has a market value of υ.

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

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 ρ), and the greater is the perceived differentiation of products(small α).

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:

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

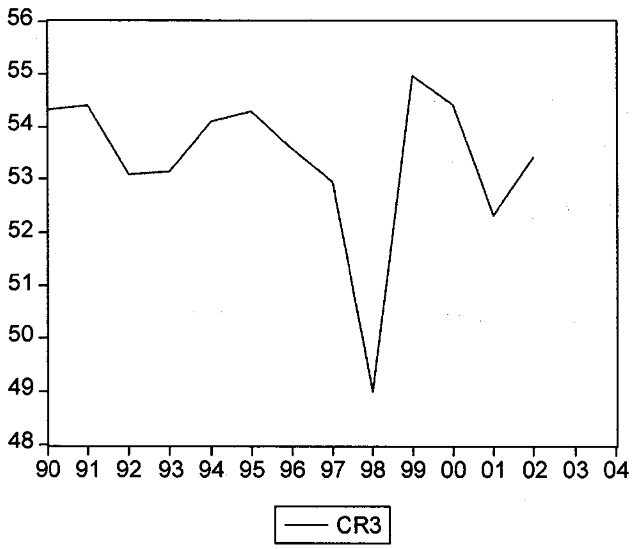
L: labor supply

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 International trade and new growth theory

Nowadays, many analyses of international trade have considered alternative explanations of trade flows to the traditional (Hecksher-Ohlin) factor endowment approach. These have included extensions of the latter theory to include human capital(the neofactor endowment theories) and then development of the neotechnology theories of trade which stress the role of changes in technology and innovation.

Some have suggested that the role of technological knowledge can be incorporated into the factor endowment theories because R&D acts as a proxy for human skills.

If we proxied the endowment of technological knowledge by R&D expenditures, industries could be ranked by the input of R&D required.

We try some empirical analyses to highlight the relation between competitiveness and technology by regressing export performance on a technology variable and other variables.

$$X = X(T, O)$$

X: export performance, T: technology proxy O: other variables

While there are not given R&D input coefficients for each industry, there may be some minimum point of R&D expenditure which must be spent over time.

The technological opportunity level(T) of an industry, the deviation of actual R&D from the technological opportunity level(RD-T) and the technological gap between countries(RD*-RD) can affect exports.

This can be expressed as follows:

$$X = \alpha T + \gamma(RD-T) + \delta(RD-RD^*)$$

RD: domestic R&D investment

RD*: foreign R&D investment

Exports depend on actual R&D expenditure and the gap between foreign country and Korea's R&D.

Grossman and Helpman(1991) derived predictions about the long-run patters of commodity trade from a fully specified dynamic model in which technological capabilities are the outgrowth of investments by entrepreneurs. They found the implications of international technological competition for long-run patterns of specialization and trade. In the two-sector(X, Z), two factor models(H, L), innovation in a country (i=C, D) contributes to endogeneous comparative advantage(c_x / c_Y) in a high-technology sector(X).

In so analysing, they extended to a dynamic setting the static analyses of intraindustry trade of Krugman(1981). The pattern of trade is determined by the number of blueprints in the hand's of each country's firms. Over the time the number of new discoveries depends on the R&D investments.

$\gamma = \gamma^i(H, L)$: research sector

$x = x^i(H, L)$: (differentiated) innovative product sector

$Z = Z^i(H, L)$ (i = C, D) : traditional good sector

$K_A(C) = K_A(D) = K_A = n$ $(n = n^C + n^D)$: stock of general knowledge capital

γ: rate of product innovation, x: output of innovative products, c: unit cost, H: human capital, L: unskilled labor

Since all intermediates bear the same price, all are demanded to the same extent by final good producers. As in section 2.1, we can express the indexes of intermediate inputs as

$$D_i=A_D X_i \qquad (2.6)$$

where X_i denotes the aggregate quantity of intermediate inputs used in the production of final good i and A_D represents the productivity of intermediates. The productivity parameter refelcts the available variety of differentiated intermediates. By familiar arguments,

$$A_D(t)=n(t)^{(1-\alpha)/\alpha}$$

In this case, (2.6) implies that[2)]

$$p_D = p_x / A_D$$

p_x : equilibrium price for every component

For an economy that is incompletely specialized in its production of final goods, the above equations allow us to solve for the prices of the primary and produced inputs as functions of the state of technology A_D and the prices of the final goods. If world prices remain constant, then the price of the typical intermediate good and the rewards to the two primary inputs(H, L) all grow at a common rate. This rate equals the product of the cost share of intermediates and the rate of productivity growth $\Delta A_D/A_D$.

In the free-trade equilibrium with FPE, each country introduces new innovative products at the same steady-state rate; that is,

$$g=g^C=g^D$$

The equality of the rates of product innovation notwithstanding, the country with a relative abundance of human capital conducts relatively more R&D in the steady state than its trade partner, compared to its relative output of the traditional good.

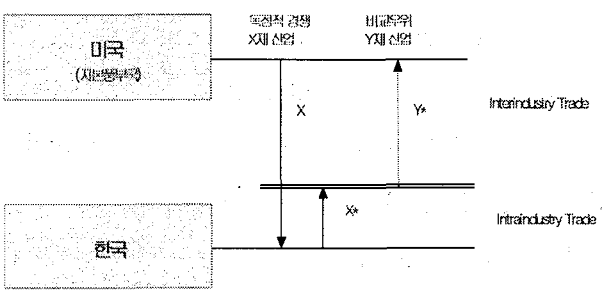
2) Note that p_D represents a price index, reflecting both the prices of the underlying intermediates and the state of technology.

By dint of relative specialization in research, this country acquires the know-how to produce a relatively wider range of innovative goods.($n^C/Z^C > n^D/Z^D$) Outputs of the representative differentiated product are the same in both countries, so ($X^C/Z^C > X^D/Z^D$).

What does the predicted pattern of specialization imply about the long-run pattern of international trade? We note that their model predicts the practice of intraindustry trade, with firms in each country exporting the unique brands that they have developed.(See example between Korea and US <Fig. 4>) The basis for this type of trade is the same here as in the static models with differentiated products of Krugman(1981). Households demand diversity in consumption, which firms can supply only by bearing fixed costs. Each partner to trade will have an incentive to import the unique varieties produced abroad rather than incur a second fixed cost to produce these goods locally.

Their model predicts equal rates of productivity growth in the sectors that manufacture innovative goods in each country. But high technology comprises a larger share of the national economy in the human-capital-rich country than it does in the unskilled-labor-rich country. It follows that real output growth is faster in the former country than in the latter.

<Fig. 4> Pattern of trade due to product differentiation



2.3 Small open economy: technology policies and trade 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-α)α. 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

$$\Delta v = \rho v - (1-\alpha)/n \qquad (2.7)$$

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

$$ag + X = L \qquad (2.8)$$

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

$$(1-\alpha)X/(\alpha a) = g + \rho \qquad (2.9)$$

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

$$(1-\alpha)X/[(\alpha a)(1-\Phi)] = g + \rho \qquad (2.9)'$$

From (2.9)′, 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.

We study a small country that trades two final goods at exogeneously given world prices. Local producers manufacture these goods using primary and intermediate inputs. The sector that produces good H_Y employs human capital in amount H and the sector that produces good Z employs unskilled labbor in amount L_Z.

Each final good is manufactured according to a CD technology with CRS.

$$Y=A_Y D_Y{}^{\beta} H_Y{}^{1-\beta} \qquad (2.10)$$

$$Z=A_Z D_Z{}^{\beta} H_Z{}^{1-\beta} \qquad (2.11)$$

In (2.10) and (2.11), D represents an index of the intermediate inputs used in sector i, i = Y,Z.

If both final goods are manufactured in positive quantities, then each must have a unit cost equal to its world price. With appropriate choices of the constants A_i, i = Y,Z, incomplete specialization in the production of final goods implies that

$$p_Y=p_D{}^{\beta} w_H{}^{1-\beta} \qquad (2.12)$$

$$p_Z=p_D{}^{\beta} w_L{}^{1-\beta} \qquad (2.13)$$

In the formulation with endogeneous product variety, we recall that

$$D_i=[\int_0^n x(j)^{\alpha} dj]^{(1/\alpha)} \qquad (2.14)$$

where x(j) denotes the input of intermediate j in the production of final good i.

Let $c_x(w_L,w_H)$ denote the marginal and average cost of producing any known intermediate. Then an equilibrium price for every component is

$$p_x = (1/\delta)c_x(w_L,w_H)$$

where $\delta=\alpha$.

For an economy that is incompletely specialized in its production of final goods, the above equations aloow us to solve for the prices of the primary and produced inputs as functions of the state of technology A_D and the prices of the final goods. the price of the typical intermediate good grow at a constant rate. This rate equals the product of the cost share of intermediates β and the rate of productivity growth $\Delta A_D/A_D$.

We assume now that R&D requires the input of human capital, but not unskilled labor. The usual free-entry condition $v=w_H a/n$ equates the value of a firm in the nontradables sector to the cost of market entry.

We adopt the by now familiar specification of the demand side. Households maximize an intertemporal utility function of the form

$$U(t)=\int_t^{\infty} e^{-\rho(\tau-t)}[\log u[C_Y(\tau), C_Z(\tau)]d\tau$$

where $C_i(\tau)$ is the consumption of final good i at time τ.

Thus the maximization of utility subject to an intertemporal budget constraint requires that spending evolve according to

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

as usual.

The absence of international capital flows implies that the small country's trade must be balanced at every moment in time.

$$E=p_Y Y+p_Z Z$$

The equilibrium conditions reflect the clearing of factor markets. Each primary factor is used to manufacture components and one of the final goods. In addition human capital is employed in research labs. Market clearing implies that

$$a\gamma + (a_{HY} + a_{Hx}a_{XY})Y + (a_{Hx}a_{XZ})Z = H$$

$$a_{Lx}a_{XY}Y + (a_{LZ} + a_{Lx}a_{XZ})Z = L$$

Let us define now the productivity-adjusted value of the national product $Q^* = p_Y Y^* + p_Z Z^*$. The terms Y^* and Z^* represent output levels adjusted for changes in TFP.

Through some calculation, we can obtain an aggregate constraint on resource use.

$$w_H^* a\gamma + [1-(1-\delta)\beta]Q^* = w_H^* H + w_L^* L$$

where w^* means productivity-adjusted primary input prices and Q^* the productivity -adjusted value of the national product, respectively.

Finally, we can use the definitions of productivity-adjusted primary input prices and output levels, to derive

$$(1-\delta)\beta Q^*/a w_H^* = \gamma + \delta$$

The above equations can be solved for the steady-state growth rate

$$\gamma = (1-\upsilon)(h/a) - \upsilon\rho \qquad 0<\upsilon<1,\ h = H + w_L^* L / w_H^*$$

Using the expression for indirect utility and noting the trade balance condition, we can express the maximization for the first-best allocation problem as

$$U(t) = \int_t^{\infty} e^{-\rho(\tau-t)}[\log Q^* + \log A_D(\tau)^{\beta} - \log\Phi(p_Y, p_Z)]d\tau$$

The social planner maximizes the utility by choosing Q^* and γ subject to a resource constraint.

Now let us suppose that the market equilibrium is characterized by incomplete specialization in the production of final goods. We can derive the following equation

$$\gamma' = (h/a) - (\rho/\beta\mu)$$

The government requires two policy instruments in order to achieve the first-best allocation in a decentralized equilibrium. An appropriate subsidy to final good producers in proportion to the cost of their components could be used to eliminate the static distortion associated with monopoly pricing. Then a policy directed at R&D can be used in combination with the input subsidy to ensure an efficient rate of innovation.

Some difficult problem arises as to whether the same prescriptions for R&D policy apply when the government cannot implement the first-best subsidy. We consider the welfare implications of a policy whereby the government bears a fraction ϕ of the private cost of R&D. The solution gives the second-best rate of innovation,

$$\gamma'' = (h/a) - (\rho/\beta\mu)$$

What are the implication of trade policy? We introduce T, i = Y,Z, to represent one plus the rate of trade protection provided to sector i, where protection takes the form of an import tariff. We assume the economy to be incompletely specialized in its production of final goods.

Trade balance now implies that aggregate spending is equal to the value of output at domestic prices plus government transfers, or

$$E = Q + \sum_i (T_i - 1) p_i{*} M_i$$

where p_i* stands for the international price and M_i the volume of imports of good i and M_i the volume of imports of good i.

Finally, we can derive the expression for the change in welfare, which yields

$$(1-\beta)\rho dU = \{(1-\delta)\beta\theta_{Lx} - [\beta\mu(\gamma + \rho)[\delta\beta\theta_{Lx} + (1-\beta)\theta_Z]/\rho\}(T_Y{*} - T_Z{*})$$

letting a "star" over a variable denote a proportional rate of change.

Consider an economy that is poorly endowed with unskilled labor and relatively unproductive in the research lab. When research productivity is low, R&D is not very sensitive to changes in factor prices. And when unskilled labor is scarce, there is little scope for one final goods industry to expand at the expense of the other. This in turn implies that relatively little human capital will move between the R&D labs and the plants that produce good Y in response to trade initiatives. In these circumstances, the effects of trade policy on growth are relatively muted and are dominated in the welfare calculus by the induced changes in the output of intermediates.

2.4 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. Data for average applied tariff(%) in Korea were obtained from UNCTAD TRAINS database.

We examined a simple model for the technology for product innovation of 5 industries in manufacturing sector:[3)]

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

n: the number of firms in each industry[4)]

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

The fixed effects approach takes α_i to be a group(industry) specific constant term in the regression model. The random effects approach specifies that takes α_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.

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3) 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)

4) 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(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:[5)]

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

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).

5) 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[6]

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.

$$(\Delta V/V)_{it} = \alpha_i + \beta' n_{it} + \gamma TARIFF_t + \varepsilon_{it}$$

V: Value added by industry, TARIFF: rate of import tariff(%)

Significantly estimated elasticity of product innovation to the rate of growth in each industry is 1.51. It means that if firms increase product innovation by 1%, then the rate of growth is increased by 1.51%.

As for import tariff, we see that 1% increase in the rate of tariff that protect domestic market causes the rate of growth g_D to increase by 0.87%. An imprort tariff to final product significantly spurs product development and faster growth come as a result. But, we should note that the effects of trade policy are muted by the induced changes in the output of intermediates in an economy that is relatively unproductive in the research lab.

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

Trade policies affect the division of resources between R&D and manufacturing. This is one channel through which these policies influence social welfare. Trade policies also drive a wedge between domestic consumer prices and world prices, and so distort household purchase decisions.

Finally, trade policies influence the efficiency of resource allocation within the manufacturing sector. When research productivity is low, R&D is not very sensitive to changes in factor prices. And when unskilled labor is scarce, there is little scope for one final goods industry to expand at the expense of the other. This in turn implies that relatively little human capital will move between the R&D labs and the plants that produce good Y in response to trade initiatives. In this economy, the effects of trade policy on growth are relatively muted.[7)]

<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	-3.584296	1.335017	-2.684832	0.0095*
LOG(N?(0))	1.509591	0.105951	14.24798	0.0000*
LOG(TARIFF(0))	0.868957	0.275197	3.157581	0.0025*
Random Effects (Cross)				
_FOOD--C	0.405192			
_CLOTH--C	-1.439539			
_CHEMICAL--C	-0.523819			
_METAL--C	1.792377			
_MACHINE--C	-0.234210			

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

7) Where the production of intermediates requires only the input of human capital, this economy always gains from a trade policy that promotes growth.

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. That is, 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, to see the implication of trade policy in endogeneous growth model, we introduce trade protection that takes the form of an import tariff and represents one plus the rate of protection provided to industry sector. Government can consider both technology policies that directly augment the incentives for research and industrial (trade) policies that do so indirectly by encouraging production of technology-intensive goods. Among two policies, we analyzed what the trade policies have effects on the growth rate in the one-sector economy.

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 trade policies as the instrument spurring economic growth. As for import tariff, we see that 1% increase in the rate of tariff that protect domestic market causes the rate of growth to increase by 0.87%. An imprort tariff to final product significantly spurs product development and faster growth come as a result. But, we should note that the effects of trade policy are muted by the induced changes in the output of intermediates in an economy that is relatively unproductive in the research lab.

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

<Table 6> Panel analysis summary: Estimated elasticity

<table>
<tr><th>Causal relationship</th><th>Innovation</th><th>(Elasticity)</th><th>Industry structure</th><th>(Elasticity)</th><th>Growth</th></tr>
<tr><td rowspan="2">Innovation and growth in monopolistic competition</td><td>R&D investment(X)</td><td>⇒(0.14)</td><td>Product innovation(n)</td><td>⇒(1.51)</td><td rowspan="2">Economic growth in industry(ΔV/V)</td></tr>
<tr><td>Import tariff(TARIFF)</td><td colspan="3">⇒(0.87)</td></tr>
</table>

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