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THE DIVISION OF LABOR, PRODUCT QUALITY, AND THE PATTERN & THE DYNAMIC EFFECT OF INTERNATIONAL TRADE

by

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The Division of Labor, Product Quality, and the Pattern & the Dynamic Effect of International Trade*

C. Simon Fan

Abstract

Emphasizing the role of product quality in industrial specialization and in consumption, this paper shows that the degree of the division of labor is limited by the heterogeneity of individuals' human capital, as well as by the extent of the market as argued by Adam Smith. In the international context, it explores the role of product quality in international trade and helps explain the observation that the bulk of the volume of international trade is among developed countries with similar endowments. Meanwhile, the model formalizes Linder's (1961) hypothesis that the similarity of demand for quality, which is largely determined by the similarity of per capita income, plays a very important role in the international trade of manufactured goods. The extension of the model examines the dynamic effects of international trade and sheds light on the patterns of cross country growth. In particular, it provides an explanation for the trade induced rapid economic growth observed in some Asian countries.

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1 Introduction

The traditional theory of international trade is based on David Ricardo's idea of comparative advantage. According to the Heckscher-Ohlin model, comparative advantage is explained in terms of differences of factor endowments among countries. Each country has comparative advantage in and consequently exports the good that uses more intensively its relatively more abundant primary factor endowment.

A prediction of this theory is that we should observe the largest volume of trade between countries that are most different in their endowments, namely between developed and developing countries. However, the empirical evidence (e.g. see the survey by Deardoff (1984)) after World War Two is almost opposite to the prediction: the largest part of world trade is that among the developed countries themselves, rather than between the developed and the developing countries.

This empirical puzzle motivated the emergence of the "new" trade theory. Based on Adam Smith (1776) and Allyn Young's (1928) argument, Krugman (1979), Lancaster (1980), Ethier (1982), and Helpman (1981), among others, formalize the idea that scale economies due to the increase of the division of labor are a cause of international trade. Therefore, they provide an explanation for the existence of trade, which is usually in the form of intra-industry trade, among the developed countries with similar factor endowments. Later, based on these models and an additional assumption of nonhomothetic preferences, Markusen (1986) extends this approach to explain the patterns and the volume of trade between developed and developing countries as well as among developed countries.

However, partly because the motivation of the "new" trade theory was to explain the pattern of trade among developed countries, the above models yield a rather unrealistic implication when they are applied to explain the trade and consumption pattern of manufactured goods between developed and developing countries.\(^1\) Specifically, these models only confirm Smith's idea that the degree of specialization is limited by the extent of market.

\(^1\)Similar criticism and other criticisms of the applicability of the "new" trade theory to the North-South trade are made in Stewart (1984).
Thus, they imply that the manufacturing industry in any individual country should be part of the global industrial specialization. Consequently, these models (including the Markusen model) indicate that individuals in the poorest countries consume the same of varieties of goods with the same quality as individuals in the richest country, although an individual in poorer countries will consume a smaller quantity of each variety. This implication, however, is against empirical observations. As emphasized by many growth economists (e.g. Stokey 1988, Matsuyama 1993), economic development is more associated with a process of quality improvement and variety increase of the products, than with the quantity increase of the same goods. Thus, a representative individual in a richer country usually consumes the goods with higher quality and more varieties, rather than larger quantities of each variety.

This empirical observation motivated several important contributions on the role of product quality in international trade. For example, Flam and Helpman (1987) develop a model of North-South trade based on vertical product (i.e. quality) differentiation. Assuming that richer countries have comparative advantage in producing higher quality goods, the model explores the overlap of income distribution\(^2\) between poor and rich countries as the source of trade. More recently, based on the characteristics model of Lancaster (1966) and Stokey (1988), Stokey (1991a) also develops a model of North-South trade based on product quality.

Each of these interesting pioneering efforts, however, contains at least one unsatisfactory element. For example, the Flam-Helpman model, emphasizing the difference of production technology in quality as the source of international trade, has the counterfactual implication that there is little trade among developed countries that have similar production technologies. In fact, Hansson (1994) provides formal evidence that questions the empirical significance of the Flam-Helpman model. While the Stokey model indicates that the North imports and consumes all kinds of the goods produced and consumed in the South, which is inconsistent with the observed trade patterns. Also, this implication is contrary to the consumption pattern in the North. As emphasized by Stokey (1988), a stylized fact of eco-

\(^2\)In an interesting application and extension of the Flam-Helpman model, Murphy and Shleifer (1991) show that when the overlap does not exist, namely when every individual in one country has higher income than any individual in the other country, trade will not exist.
onomic development is that many low quality goods are no longer consumed when people’s income increases.

This analysis tries to explore the role of product quality in international trade from a different angle. It attempts to provide a model that will complement the existing literature to explain the observed trade patterns between developed and developing countries. Then, the model is extended to explore the dynamic implications of international trade.

The basic idea of this paper dates back to the seminal contribution of Linder (1961), who argues that trade in manufactured products arises not so much from differences in supply as from similarities in demand of individuals in different countries. Since the major determinant of what he called the “representative demand” (p. 95) for the quality of the commodities of a country is the income of the representative individual of the economy, he (p. 94, p.98, p. 99) claims that

"....The higher the per capita income, the higher will be the degree of quality characterizing the demand structure as a whole.... (so), similarity of average income level could be used as an index of similarity of demand structures.... (therefore), per capita income differences are a potential obstacle to trade (in manufactured goods)."

This paper attempts to provide a model that formalizes Linder’s hypothesis. The result will be derived by emphasizing the role of product quality in the modern production of industrial specialization in the context of international trade.

In industrial specialization, we assume that the qualities of different intermediate goods are highly complementary in producing the quality of the final consumption good.\(^3\) This point can be illustrated by the example that a computer will not work even if only one out of the thousands of its components goes wrong. Based on this assumption, this paper develops

\(^3\)Similar assumption is made in Kremer (1993), who provides a survey of much empirical evidence for the assumption. Both the Kremer model and the current model discuss the relationship between product quality and economic development. However, as will be apparent, the emphasis and the application (as well as the formulation) of the current paper are very different from those in Kremer, who only analyzes the complementarity of the qualities of the workers within a firm and consequently the issue of the matches of workers with different skills within a firm.
an analytic framework that formalizes the mechanism of industrial specialization. As much literature in the "new" trade theory (e.g. Krugman 1979, 1980, 1981; Ethier 1982) and the "new" growth theory (e.g. Romer 1987, Grossman and Helpman 1992) that involves scale economies, the first part of this model will build on the seminal contribution of Dixit-Stiglitz (1977), who models the situations where individuals value variety and where the production side of the economy is characterized by monopolistic competition. There are three slight modifications to the Dixit-Stiglitz model in this model. First, following Ethier (1982) and many others, we interpret each variety of consumption goods as an intermediate good and the total utility as the quantity of the final consumption good. Second, the input to the production of intermediate goods is individuals' human capital (or efficiency labor). The "human capital" here, however, can be interpreted as an index of the combination of an individual's educational attainment ("general human capital" in terms of Becker (1975)) and the technology of the firm that he has access to ("firm specific human capital" in terms of Becker (1975)). Thus, according to this interpretation, an individual in a country with advanced industrial technology has higher level of human capital than an individual in a country with backward industrial technology even if they have the same level of educational attainment. As we will see, the advantage of this interpretation is that it will make it innocuous to assume that all countries have the same production functions for intermediate and final goods. Third, we assume that the efficiency labor input necessary to produce any quantity of intermediate goods increases as the quality of the goods increases.

The product quality in industrial specialization is endogenously determined in the model. Under some reasonable assumptions, we show that the quality as well as the quantity of the consumption goods produced and consumed will increase as the scale of the economy or the level of a representative individual's human capital increases. In the international context, if the representative individual's human capital in different countries is similar, the individuals in these economies will demand goods with similar quality. In this case, consistent with the

4The importance of on the job training in individuals' productivity is stressed in the literature of human capital theory (e.g. Becker, 1976) and the "new" growth theory (e.g. Lucas, 1988, 1993). More recently, Javorovic and Nyarko (1994) and Kremer and Thomson (1994) analyze this point formally and discuss its growth implications.
previous studies, we reconfirm Smith’s insight that the degree of specialization is only limited by the extent of the market. Moreover, because the enlargement of the market increases the productivity of the economy, international trade increases the quality as well as the quantity of every individual’s consumption.

If, however, the representative individual’s human capital (and hence income) of a country is sufficiently low relative to that of the rest of (industrial) world, the individuals of this country will have less demand for quality. Consequently, despite the higher efficiency of international specialization in the production of the goods of any quality, this country may choose an “inferior” domestic production technology to produce more quantity, rather than join the global markets, specializing in producing some intermediate goods of the high quality of international standard. Thus, the model indicates that the degree of the division of labor is also limited by the heterogeneity of individuals’ human capital, as well as by the extent of the market.\footnote{Becker and Murphy (1991) also note that the extent of market is not the only constraint in specialization. In fact, they argue that other factors, such as “coordination cost” in their model, have far more significant influence on the division of labor.} In the international context, trade in manufactured goods may not occur between countries with very different level of per capita human capital or income.

Thus, this model formalizes Linder’s (1961) hypothesis that emphasizes the role of similar demand as the major source of international trade (in manufactured goods). It also complements the previous studies to explain the observed trade patterns (see Deardorff, 1984) that the bulk of the volume of international trade is between developed countries with similar endowments and trade is largely intra-industrial trade.

Based on the above results, we extend the model to a dynamic framework, which yields some interesting growth implications of international trade. The close relationship between a country’s trade pattern and its growth performance has long been recognized (see the survey by Findlay (1984)). However, until very recently, the formal analysis of the dynamic effects of international trade had been largely ignored in the literature. Recent important contributions, notably Stokey (1991a, 1991b), Grossman and Helpman (1991), Young (1991), and Matsuyama (1992), improve our understanding the effects of international trade
on a country's economic growth. However, as critically examined and commented on by Lucas (1993), the available models of north-south trade do not provide a fully satisfactory explanation for the observed correlation between trade and growth. In particular, Lucas comments that the existing literature does not predict the trade-induced miraculous growth observed in some East Asian countries.

The analysis provides an explanation for the trade-induced rapid growth in a country's economic development. By assuming that the externality effect of technology diffusion from the industrial world is positively correlated with the degree of a country's participation in international industrial specialization, this study suggests the existence of a threshold in economic development. Because when a country is too poor, it will not join the global industrial specialization. So it will benefit little from the technology spillover from industrialized countries. The middle income countries may benefit from the technological spillover most because they are likely to be the poorest in the countries engaging in global industrial specialization. So, the model provides an explanation for the phenomenon of "take-off" in economic development or why middle income countries tend to grow fastest. It also explains why the newly industrialized countries, which have the highest economic growth rates, also have the fastest growth in exports (e.g. Ethier 1988). Finally, the growth implication of this analysis justifies the promotion of a fraction of leading export industries as a development strategy, based on the externality effect of technological spillover in an open economy.

In what follows, Section 2 sets up the basic analytical framework; section 3 investigates the endogenous determination of product quality in a closed economy; Section 4 analyzes the patterns and the static effects of trade; section 5 extends the basic model to explore the dynamic effects of international trade; section 6 offers the conclusion.

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[6] In an extended model (Fan, 1994) that incorporates both manufactured goods and agricultural goods, whose quality is fixed by nature, I show that when the representative individual's human capital of an economy is below a certain threshold level, it will either export agricultural good or isolate itself from the rest of the world. In either case, it confirms the conclusion in this model that when a country is too poor, it will not export manufactured goods to participate the international industrial specialization.
2 The Basic Analytical Framework

2.1 Production

As we discussed in the introduction, this subsection will build on Dixit-Stiglitz-Ethier model of monopolistic competition with some modifications to formalize the production of industrial specialization. In this model, we assume that there is only one final consumption good. The production of the final good is through the costless combination of a variety of differentiated intermediate goods. The economy is assumed to be able to choose to produce any of a large number of intermediate goods with any level of quality. The technology satisfies the property of constant returns to scale for a given set of inputs. Specifically, the production function of the quantity is defined as,

$$X = \left( \sum_{i=1}^{n} x_i^\theta \right)^{\frac{1}{\theta}}$$  \hspace{1cm} (1)

where $X$ denotes the quantity of the final output; $x_i$ denotes the output of the $i$th intermediate product of the industry, $n$ denotes the number of the intermediate products, and $\theta$ ($0 < \theta < 1$) measures the degree of substitution between different intermediate products.

As we discussed in the introduction, we assume that the qualities of different intermediate goods are highly complementary in producing the quality of the final consumption good. Although we can get qualitatively the same result with less stringent functional forms, the simplest formulation that can capture this property is that we assume that the qualities of the intermediate goods are perfectly complementary in producing the quality of the final good, namely

$$Q = \min(Q_1, Q_2, ..., Q_n)$$  \hspace{1cm} (2)

where $Q_i$ denotes the quality of the $i$th product of the industry, $Q$ denotes the quality of the final consumption good.

From the above formulation, obviously, all producers of different products will produce goods with the same quality in equilibrium.\footnote{This formulation also implies that the number of the intermediate goods (or processes) may only affect the quantity of the final good (as we will see), but it does not (directly) affect the quality of the final good.} So we might as well denote the quality of any intermediate goods by $Q$, as that of the final good.
We assume that there is only one factor of production, which is efficiency labor (or human capital) in intermediate goods. As we discussed in the introduction, the human capital here can be interpreted as an index of the combination of the level of industrial technology of the firms and the level of workers' educational attainment in the economy. For any intermediate good that is produced, the efficiency labor employed is

\[ h_i = \alpha + \beta Q x_i \]  \hspace{1cm} (3)

where \( \alpha, \beta \) are both positive constants. It should be noted that the only difference here from the Dixit-Stiglitz model is that we assume that the higher the quality of the product is, the more costly it is to produce it. Specifically, we assume that the quantity and the quality of a product enter symmetrically into its cost function. However, it is easy to verify that other kinds of functional forms can give us similar results as long as they have the property that quality is "costly" to produce. The presence of the fixed cost \( \alpha \) introduces economies of scale into the model. As we will see, this fixed cost limits the number of intermediate goods that any economy actually produces, and therefore leads to both trade and gains from trade.

### 2.2 A Closed Economy

First, we consider equilibrium in a single economy. Let \( N \) be the total number of individuals of this economy. For now, we assume that every individual in this economy is endowed with \( h \) amount of human capital. Then, the total amount of human capital in the economy is

\[ H = N h \]

Then full employment requires that

\[ H = \sum_{i=1}^{n}(\alpha + \beta Q x_i) \]  \hspace{1cm} (4)

We assume that the market for the final good is perfectly competitive. Let \( P(Q) \) be the price of the final good with quality \( Q \); \( p_i(Q) \) for \( i = 1, 2, \ldots, n \) be the prices of intermediate
goods with quality $Q$. Then taking $P(Q)$ and $p_i(Q)$ (for $i = 1, 2, \ldots, n$) as given, final goods producers seek to maximize their profit, $\pi$, by choosing the optimal input combination,

$$
\pi = P(Q)X - \sum_{i=1}^{n} p_i(Q)x_i
= P(Q)(\sum_{i=1}^{n} x_i^{\delta})^{\frac{1}{\delta}} - \sum_{i=1}^{n} p_i(Q)x_i
$$

(5)

The first order condition yields,

$$
x_i = (\frac{p_i(Q)}{P(Q)})^{\frac{1}{\delta}}(\sum_{i=1}^{n} x_i^{\delta})^{\frac{\delta - 1}{\delta}}
$$

(6)

Plugging (6) into (5), then the zero profit condition of perfect competition in the final good market implies

$$
P(Q) = \left[\sum_{i=1}^{n} (p_i(Q))^{\frac{1}{\delta}}\right]^{\frac{\delta - 1}{\delta}}
$$

(7)

Now we turn to the problems of the firms producing intermediate goods. We begin by noting that as long as there are more potential varieties of intermediate goods than are actually produced, there will be no reason for more than one firm to produce any given intermediate good in equilibrium; since the varieties of intermediate goods are symmetrical, a firm will always prefer to switch to a different intermediate good rather than compete with another firm head to head. Thus each intermediate good will be produced by a monopolist.

Based on the above analysis, let us consider profit-maximizing pricing behavior of firms. Each individual firm, being small relative to the economy, can ignore the effects of its decisions on the decision of other firms and the total final outputs. Thus, the $i$th firm will choose its price to maximize its profits, $\pi_i$. Noticing (6) and (1), we have,

$$
\pi_i = p_i x_i - (\alpha + \beta Q x_i)w
= [p_i^{\frac{\delta}{\delta - 1}} - \beta Q wp_i^{\frac{\delta}{\delta - 1}}]XP^{1/\delta} - \alpha w
$$

(8)

subject to (7), where $w$ is the cost of one unit of human capital, or the wage rate (of efficiency labor). It should be noted that labor market is perfectly competitive in this model. Consistent with the original Dixit-Stiglitz (1977) model and many followers, we assume that any single individual firm is sufficiently small such that its decision on pricing
its own product will not affect either the total output \( X \) or the price of the final good \( P \). So, from the first order condition, we get

\[
p_i(Q) = \frac{\beta Q}{\theta}w
\]  

(9)

Clearly, the price of a product increases as its quality rises.

Next we introduce the possibility of entry and exit. If firms are free to enter to produce new intermediate goods and exit, then profits in the production of \( i \)th intermediate good will be driven to zero. Thus,

\[
\pi_i = p_i x_i - (\alpha + \beta Q x_i)w
\]

\[
= \frac{\beta Q}{\theta}wx_i - (\alpha + \beta Q x_i)w = 0
\]  

(10)

This implies that the output of any intermediate good is

\[
x_i = \frac{\alpha \theta}{\beta Q(1 - \theta)}
\]  

(11)

It indicates that the output of any intermediate good that is actually produced decreases as the level of its quality rises.

We assume that the labor market is perfectly competitive. So using the full-employment condition, we can then conclude that the number of firms, which is also the number of intermediate goods actually produced, is

\[
n = \frac{H}{\alpha + \beta Q x_i} = \frac{H(1 - \theta)}{\alpha}
\]  

(12)

(12) indicates that the fixed cost \( \alpha \) limits the number of goods produced. Finally, the total output of the final good is,

\[
X = (\sum_{i=1}^{n} x_i^\theta)^{\frac{1}{b}} = (n x_i^\theta)^{\frac{1}{b}} = \left[\left(\frac{\alpha}{1 - \theta}\right)^{1-b}\frac{\theta}{\beta}\right]^{\frac{1}{b}}\frac{H^b}{Q}
\]  

(13)

For the simplicity of notation, we define

\[
A \equiv \left(\frac{\alpha}{1 - \theta}\right)^{1-b}\frac{\theta}{\beta}
\]
Thus, we can express (13) in the following simpler form

$$X = A \frac{H^2}{Q}$$

(14) characterizes the "quantity-quality" possibility frontier of the production of the economy. Clearly, the quantity of the total final output decreases as its quality increases. (14) can also be illustrated by the following graph:

Figure 1 is about here

Clearly, the frontier expands as $H$ increases. From (14) or Figure 1, it is easy to see that the "quantity-quality" possibility frontier is convex. This result is not surprising if we refer to (3) (imagining that only one intermediate good is produced), which introduces the formulation of scale economies into the model. The advantage of this particular choice of the functional form (3) is that it makes our model most ready to utilize the Dixit-Stiglitz model, which serves as the standard tool in the formulation of scale economies in the literature. So, this particular choice makes our models most easily related to other models in the literature for the comparison of relevant results. Other choices of functional forms may give rise to more concave "quantity-quality" possibility frontier. However, as will be apparent, the more concave the frontier is, the less stringent will be the assumption of individuals' utility function that we need to make, and therefore the more easily we will get our results. Thus, the particular choice of the functional form (3) makes the results that we will get very robust.

3 The Determination of Quality

Since the market for the final good is perfectly competitive, the quality of the final good will be ultimately determined by a representative consumer. Thus, we can derive the quality of the final good (and hence the intermediate goods) by solving the problem of a representative individual's utility maximization subject to his budget constraint.
3.1 The Budget Constraint

To derive a representative individual’s budget constraint, we first try to get the expression of his wage rate and income. Plugging (11) into (6), and rearranging, we get,

\[ p_t = \left( \frac{H(1 - \theta)}{\alpha} \right)^{\frac{1}{\lambda}} P(Q) \]  

(15)

Plugging (15) into (9), we then get,

\[ w = A \frac{H^{1-\frac{\theta}{\sigma}}}{Q} P(Q) \]  

(16)

Since a representative individual is endowed with \( h \) amount of human capital, his income is,

\[ I = wh = AN^{1-\frac{\theta}{\sigma}} \frac{h^{\frac{1}{\sigma}}}{Q} P(Q) \]  

(17)

We assume that a consumer only consumes the final good with the same quality.\(^8\) Let \( M \) denote the quantity of an individual’s consumption, then his budget constraint is,

\[ P(Q)M = I = AN^{1-\frac{\theta}{\sigma}} \frac{h^{\frac{1}{\sigma}}}{Q} P(Q) \]  

(18)

Namely,

\[ M = AN^{1-\frac{\theta}{\sigma}} \frac{h^{\frac{1}{\sigma}}}{Q}, \text{ or } MQ = AN^{1-\frac{\theta}{\sigma}} h^{\frac{1}{\sigma}} \]  

(19)

Obviously, (19) is identical to

\[ \ln M + \ln Q = \ln(AN^{1-\frac{\theta}{\sigma}} h^{\frac{1}{\sigma}}) \]  

(20)

This log-linear relationship between the quantity and the quality of an individual’s consumption can also be illustrated in Figure 2,

Figure 2 is about here

Figure 2 depicts a representative individual’s “budget line”. Clearly, the “budget line” shifts out (or expands) as \( N \) or \( h \) increases.

\(^8\)Namely, we assume that consumers smooth their consumption on the quality of the goods perfectly across time and space. This assumption can be justified by a more fundamental assumption that individuals’ utility function of the quality of the consumption good across time and space is strictly increasing and strictly concave. In fact, similar assumption is also made in Flam and Helpman (1987) and Murphy and Shleifer (1991).
3.2 The Preferences

Now, we turn to discuss an individual’s preferences. As we have described, there is only one final consumption good in the model. Individuals are assumed to obtain utility from the quality\(^9\) as well as from the quantity of this good consumed.

Based on the observation that economic development is associated with the quality improvement as well as the quantity increase of individuals’ consumption, we will seek a utility function that can generate the “interior” solutions of an individual’s consumption on both quantity and quality. To avoid any “corner” solution, it entails that the indifference curves are more convex than the “budget line (or curve)”. In this model, specifically, generating the “interior” solutions (see Figure 2) entails that the utility function is more concave than a log-liner, or equivalently, a symmetric Cobb-Douglas utility function.

Therefore, we will assume that the quality and the quantity are highly complementary in an individual’s utility function. This assumption can be explained as follows: In some textbooks of Microeconomics (e.g. Varian 1993), a simple criterion for judging whether two goods are substitute or complementary in individuals’ utility function is to see whether they are consumed separately or together. For example, blue pen and black pen are highly substitute because they cannot be used at the same time by an individual; left shoe and right shoe are highly complementary because they are consumed together. Since the quantity and the quality of any good are always consumed at the same time,\(^{10}\) it is reasonable to assume that they are highly complementary in individuals’ utility function.

Since a Cobb-Douglas preference is the intermediate case between the perfect substitute preference and the perfect complement preference, a reasonable benchmark of the high complementarity between the quantity and the quality in an individual’s consumption is that the utility function of the quantity and the quality is more concave than the symmetric Cobb-Douglas case.

\(^9\)We may follow Lancaster (1966) to explain that consumers value quality because the quality of a good can be interpreted as the combination of the characteristics the good contains. Thus, we may interprete \(Q\) as an index of the combination of the characteristics of the good.

\(^{10}\)In other words, when one consumes a commodity, he is always consuming certain quantity of the good with certain quality.
Based on the above description, an individual's utility function is defined as follows,

\[ u(Q, M) = \min[\ln Q + \xi \ln M, \ln M + \xi \ln Q] \]  
(21)

where \(\xi (0 \leq \xi < 1)\) is a coefficient. The indifference curves from the utility function defined in (21) are illustrated in Figure 3:

Figure 3 is about here

From Figure 3, we can see that the utility function (21) and the corresponding indifference curves are very well behaved. In particular, the indifference curves are more convex than the symmetric Cobb-Douglas case for any \(\xi (0 \leq \xi < 1)\). Moreover, \(\xi\) measures the degree of complementarity between quantity and quality in individuals' utility maximization: the greater \(\xi\) is, the less complementary they are. In particular, when \(\xi = 0\), it will be the perfect complementary case, namely, the Leontief utility function; when \(\xi = 1\), it is equivalent to a symmetric Cobb-Douglas (or log-linear) utility function. So, as \(\xi\) varies from 1 (\(\xi < 1\)) to 0, the indifference curves corresponding to the utility functions with different values of \(\xi\) will cover the whole area above the "budget line" (see Figure 3). Thus, with different possible choices of the value of \(\xi\), (21) represents a very general formulation.

Also, as we will see, this formulation of the utility function (21) will enable us to analyze conveniently the response of our results to the change of the degree of complementarity between quality and quantity in the utility function by varying \(\xi\).

### 3.3 The Derterminants of Quality

Now, given the utility function (21) and the budget constraint (20), we can solve the problem of an individual's utility maximization. A simple way of solving this problem is illustrated by Figure 4:

Figure 4 is about here

Since the indifference curve is more convex than the budget line, a (representative) consumer will choose \(Q\) and \(M\) such that,

\[ \ln Q + \xi \ln M = \ln M + \xi \ln Q \]  
(22)
Noticing that $\xi \neq 1$, from (22), we get

$$M = Q$$  \hspace{1cm} (23)

From (23) and the budget constraint (20), we then get

$$M^* = Q^* = A^{\frac{1}{2}}N^{\frac{1}{2(h+g)}}h^{\frac{1}{h}}$$  \hspace{1cm} (24)

From (24), it is clear that the quality as well as the quantity that an individual consumes increases as either $N$ or $h$ increases. So, the model predicts that economic development (e.g. due to the increase of individuals' human capital, $h$) will result in the quality improvement as well as the quantity increase of an individual's consumption.

4 The Effect and the Pattern of Trade

4.1 Countries with homogeneous individual human capital

The focus of this paper is to analyze the trade pattern between two economies with different levels of individual human capital and economic development. However, to make a comparison with the next subsection, it is useful to first consider two economies with similar level of individual human capital and economic development.\textsuperscript{11} We consider two economies in the subsection: One is home country, with population $N$; the other is foreign country, with population $N^*$. Each individual in either of the two economies is endowed with $h$ amount of human capital.

Now, suppose that trade is opened between these two economies and at zero transportation cost. Also, the model assumes international identity of production functions, namely, every firm in every country (poor or rich) has access to the same production function of producing any intermediate or final goods. As we discussed in the introduction, since we already incorporate the industrial technology of an economy as part of the individuals' human capital of the economy and assume that a representative individual in a richer country has higher human capital, it is no longer necessary to assume that the firms in richer countries

\textsuperscript{11}The analysis in this subsection follows closely some models in the "new" trade theory (e.g. Krugman, 1979).
can get access to superior production function. So, this assumption is innocuous, while it makes the presentation of the model simpler.

Free labor mobility within either economy ensures that the wage rate is the same across different firms in the same economy. Meanwhile, the above assumption of the symmetry of production technology in the two economies will ensure that wage rates in the two countries will be equal and that the price of any intermediate good produced in either country will be the same. Otherwise, suppose the wage rate in country A is lower than that in country B, by (9), the price of the intermediate goods produced in country A will be lower than that in country B. So, by (6), the demand for any single intermediate good produced in country A will be more than that in country B. However, zero profit condition ensures that in equilibrium, the quantity of any intermediate good will be at fixed level described by (11). Thus, the wage rate and the price of any intermediate good produced in country A have to increase to be equal to those in country B to reach the equilibrium in both labor and good markets.

Finally, free trade in goods ensures that the same set of intermediate inputs is available everywhere, so that the final good sector in both economies achieve the same level of production efficiency (since they can get access to the same production functions described in Section 2), while the number of the intermediate goods produced in each region are determined by the efficiency labor (or human capital) resource constraint.

From the above description and analysis, since every individual in both economies is endowed with the same amount of efficiency labor and hence income, all individuals face the same budget constraint. Also, we assume that all individuals in both economies have the same preference as described in (21), so their demand structure will be the same. In particular, every individual in either country will have the same demand for quality. So the effect of trade is the same as if each country had experienced an increase in its labor force with homogeneous individual human capital. Thus, similar to the analysis in the previous sections, we can get the *per capita* income as

\[
I = A(N + N^*)^{1+\varepsilon} \frac{h^\frac{1}{\varepsilon}}{Q} P(Q)
\]  

(25)
Every individual's budget constraint becomes,

\[ M = A(N + N^*)^{1-s} \frac{h^{\frac{s}{2}}}{Q} \tag{26} \]

As illustrated in Figure 5,

Figure 5 is about here

the budget constraint expands outward because of the larger scale of the economy due to the further division of labor from international industrial specialization and international trade.

Consequently, the *per capita* consumption of the final good increases to

\[ M^* = Q^* = A^{\frac{1}{2}}(N + N^*)^{1-s} h^{\frac{1}{2s}} \tag{27} \]

From above, it is clear to see that the *per capita* consumption of the quality as well as the quantity of the final good increases as a result of international trade. If we interpret the intermediate goods as varieties of consumption goods, as in Krugman (1979), then this model shows that international trade increases individuals' consumption of "quality" as well as "quantity" or "variety". In this case, consistent with the results in most previous studies, the division of labor is only constrained by the extent of the market.

### 4.2 Countries with heterogeneous individual human capital

In this subsection, we will analyze the possibility of trade (in manufactured goods) between two economies with different levels of individual human capital and economic development. We may regard the richer economy as the whole industrial world, where every individual is assumed to be endowed with \( h \) amount of human capital (to be consistent with the previous (sub)sections). So, it is both realistic and convenient to treat the poorer economy (or country) as a small economy. We assume each individual in this small economy is endowed with \( h^* \) amount of efficiency labor (or human capital), and

\[ h^* < h \]
Namely, the level of a representative individual's human capital of this small economy is lower than that of the industrial world. We assume that individuals in this small economy differ from those in the industrial world only in the endowment of human capital. They share the preferences with those of the rest of the world, which is described by (21) and Figure 3.

Individuals in this economy face two choices of obtaining the single final good to consume. One is to produce the good together with the industrial world by joining the global industrial specialization. The other is to produce the good in autarky.

First, if individuals in the small economy join the global industrial specialization, they will specialize in some intermediate goods. However, in order to sell their intermediate products in the international markets, as we analyzed in Section 2, they must produce the goods with quality $Q^*$ that meets the "international standard" (because of the high complementarity of the qualities of intermediate goods in producing the quality of the final good in the modern production of specialization). As in the last subsection, we assume that there is neither any trade barrier nor transportation cost. Also, as we discussed in second paragraph of the last subsection, we assume that the firms in this economy have access to the same production functions of any goods as those in the rest of the world. So, in this case, the (real) wage rate in terms of the final good with quality $Q^*$ is,

$$w(Q^*) = \frac{w}{P(Q^*)} = A\frac{H^{1-\theta}}{Q^*}$$

(28)

It should be noted that our assumption that the economy is "small" implies that we can ignore the impact of its participation in the global industrial specialization on the determination of the product quality, $Q^*$, and on the real wage rate in the industrial countries.

Consequently, the real income or the quantity of the final good that an individual in the economy can consume is

$$I^1 \equiv w(Q^*)h^* = A\frac{H^{1-\theta}}{Q^*}h^*$$

(29)

Since $Q^*$ is optimally chosen by a representative individual in the industrial world, by the analysis in Section 2, noticing that $w(Q^*)h$ is the individual's real income or the quantity of the good that he consumes, we have
\[ w(Q^*)h = Q^* \]

Also, since \( h^* < h \), clearly, we have \( I^1 < w(Q^*)h = Q^* \).

Thus, if this economy participates the global industrial specialization, an individual's utility in the economy, which is denoted by \( u^1 \), is,

\[
u^1 \equiv \min(\ln Q^* + \xi \ln I^1, \ln I^1 + \xi \ln Q^*)
\]
\[
= \ln I^1 + \xi \ln Q^*
\]
\[
= \ln[A \frac{H^{1-\frac{\xi}{\delta}}}{Q^* - h^*}] + \xi \ln Q^*
\]
\[
= \ln[A H^{1-\frac{\xi}{\delta} h^*} - (1 - \xi) \ln Q^*] \quad (30)
\]

Second, individuals in this economy can also produce the consumption good domestically in autarky. In this case, they can produce the good with the quality that they optimally choose. However, by giving up the benefit of taking advantage of the international increasing returns (due to specialization) and other benefits from trade, individuals in the economy face a less efficient, or "inferior" domestic production technology. This "inferior" constant return to scale technology, whose only input is also efficiency labor, is described as,

\[ Y = \phi(Q)H \quad (31) \]

where \( Y \) and \( H \) denote the quantity of the output of the final consumption good\(^{12}\) with quality \( Q \) and the efficiency labor input respectively, \( \phi(Q) \) is the marginal product of the output with quality \( Q \). We assume that the labor market in this economy is also perfectly competitive. So, the wage rate (in terms of the final good with quality \( Q \)) that an individual receives by engaging in this production process is,

\[ \phi(Q) \]

\(^{12}\)As will be clear, the exact (intermediate) processes of producing the final consumption good in the small economy will not affect any result of the paper.
To describe the "inferiority" of the above autarkic production technology relative to the production technology of global industrial specialization, we define

\[ f(Q) = \frac{\phi(Q)}{w(Q)} \]

where \( f(Q) \) satisfies the following property.

Assumption 1

\[ f'(Q) < 0, \quad f(0) = 1, \quad \lim_{Q \to \infty} f(Q) = 0 \]

**Remark:** This assumption implies that for any quality between zero and infinity, we have

\[ 0 < f(Q) < 1 \]  \hspace{1cm} (32)

This assumption characterizes the "inferiority" of the production technology described by (31) because the real wage rate a worker receives from this autarkic technology, \( \phi(Q) \), is less than the real wage rate by being part of the global specialization, \( w(Q) \), in terms of the final good with any certain quality (except with zero quality). Meanwhile, this assumption also captures the intuitive observation that the higher the quality of the good they produce, the more inferior the domestic (autarkic) technology (of a developing economy) is. Finally, the assumption implies that the small economy can also produce a large quantity of the good if it chooses a very low quality.

Since every individual in this economy is endowed with \( h^* \) amount of efficiency labor, the quantity he consumes, namely, his real income in terms of the (final) good with quality \( Q \) is

\[ \phi(Q)h^*, \quad \text{or,} \quad f(Q)w(Q)h^* \]  \hspace{1cm} (33)

Consistent with the previous analysis, we assume individuals in this economy also consume the goods with the same quality. So, an individual's budget constraint in this case can be expressed as

\[ M = f(Q)w(Q)h^* \]  \hspace{1cm} (34)
where $M$, the same notation as in the previous sections, denotes the quantity that an
individual consumes. (34) can be illustrated in the following graph:

Figure 6 is about here

From Figure 6, we can see that the budget curve is clearly downward sloping. Thus, we
can choose small enough $\zeta$ such that the indifference curve is more convex than this budget
curve.\(^{13}\) Therefore, similar to analysis in Subsection 3, to maximize his utility, an individual
will choose to the good with the quantity $M^*$ and the quality $Q^*$ that satisfies,

$$M^* = Q^* = f(Q^*)w(Q^*)h^*$$

(35)

From the above equation, we have the following lemma.

**Lemma 1** When Assumption 1 is satisfied, for any $h^*$, there exists a unique $Q^*$ that satisfies
(35). Besides,

$$\frac{dQ^*}{dh^*} > 0$$

**Proof:** See Appendix.

**Remark:** This lemma indicates that when individuals engage in the autarkic production,
the quality of the good they consume also increases as their (per capita) efficiency labor
increases.

From (35) and Lemma 1, we can express an individual's utility in Autarky, which is
denoted by $u^2$, as

$$u^2 = \min[\ln Q^* + \xi \ln M^*, \ln M^* + \xi \ln Q^*]$$

$$= \ln M^* + \xi \ln Q^*$$

$$= \ln f(Q^*) + \ln[A \frac{H^{1/\theta}}{Q^*} - h^*] + \xi \ln Q^*$$

$$= \ln f(Q^*) + \ln[A H^{1/\theta} h^*] - (1 - \xi) \ln Q^*$$

(36)

\(^{13}\)In particular, when $\xi = 0$, the utility function will be the Leontief utility function, whose indifference
curves is clearly more convex than any downward sloping curve. However, it is easy to construct a numerical
example in which $\xi > 0$ and the indifference curves are more convex than the budget curve. It is even clearer
to see the point if we use the horizontal axis to denote $\ln M$ and the vertical axis to denote $\ln Q$. In this
case, the graphical representation of (34) is clearly still downward sloping.
Clearly, individuals in this small economy will participate in global industrial specialization if and only if\textsuperscript{14}

\[ u^1 \geq u^2 \]

namely,

\[ \ln[AH^{1-\varphi} h^\alpha] - (1 - \xi) \ln Q^* \geq \ln f(Q^*) + \ln[AH^{1-\varphi} h^\alpha] - (1 - \xi) \ln Q^* \]  
(37)

Rearranging it, we get

\[ f(Q^*) \leq \left( \frac{Q^*}{Q^c} \right)^{1-\xi} \]  
(38)

In the appendix, we show that there exists a unique \( Q^c \), such that (38) is satisfied if and only if \( Q^* \geq Q^c \). Also, by Lemma 1, we then have the following theorem,

**Theorem 1** (1) When Assumption 1 is satisfied, there exists a unique critical level of human capital, \( h^c \), such that an economy will participate in the international industrial specialization if and only if the level of its representative individual's human capital, \( h^\alpha \), satisfies

\[ h^\alpha \geq h^c \]

(2) \( h > h^c \)

(3) \( h^c \) is a strictly decreasing function of \( \xi \).

**Proof:** See Appendix.

The first result of the theorem formalizes the proposition that the division of labor is also limited by the heterogeneity of individuals' human capital. When the level of per capita human capital in an economy is too low relative to that in the rest of the world, individuals in the economy would choose to remain autarkic to produce more quantity rather than to join the international industrial specialization to produce high quality goods. The analysis helps explain the observed trade patterns. Meanwhile, we have provided a model that is consistent with Linder’s hypothesis that the similarity in the demand for quality, which is

\textsuperscript{14}For simplicity of exposition, we might as well assume that the individuals will take part in the international industrial specialization if and only if they can be \textit{weakly} better off by doing so.
largely determined by the similarity of per capita income, plays a very important role in the international trade of manufactured goods.

The second result of the theorem confirms that an economy (in the industrial world) whose representative individual is at the level, \( h \), will join the international industrial specialization. Therefore, it justifies that we need not consider the autarkic production technology in the last subsection.

The last result of the theorem shows that \( h^c \) is a strictly decreasing function of \( \xi \). From (21), as we discussed earlier, the greater \( \xi \) is, the less complementary the quality and the quantity of the consumption good are in individuals' utility maximization. Thus, this result implies that the more complementary the quality and the quantity are in individuals' consumption, the less likely the individuals of a developing economy are to participate the global industrial specialization to produce and consume high quality good. The intuition behind this result is that for the individuals in a poor economy who have little quantity of goods to consume, the more complementary the quality and the quantity are, the less benefit they will get from consuming high quality goods. Thus, the less likely they are to join the international industrial specialization.

This result also indicates that some developing countries may benefit more from seeking opportunities of trade among themselves than from trading with the industrial countries in their early stage of development.\(^{15}\) This prediction seems to be empirically supported by the observation of some free-trade areas and customs unions among some developing countries such as the Latin American Free Trade Association (LAFTA). However, the economic scale of these developing countries is clearly much smaller than that of the developed countries. So, we may still observe that these countries are still poorer than the industrial world.

There are two further comments for this section. First, for simplicity, the analysis abstracts from the consideration of the overlap of income distribution between rich and poor economies. This phenomenon may occur if, for example, there exists a rent-seeking (dictatorial) class in the poor economy. This consideration, however, does not affect the qualitative

\(^{15}\)This view is also emphasized by Stewart (1984).

23
result of the model. Although trade in (final) manufactured goods may occur between rich and poor economies in this case, as can be explained by the Flam-Helpman (1987) model, the poor economy will still choose to produce manufactured goods (of low quality) in autarky, rather than join the international industrial specialization if its industrial technology or the educational attainments of its workforce is too low. Namely, the production patterns of manufactured goods in the two economies will remain the same (and hence there will be no intra-industry trade of intermediate goods between the two economies), even though the extraordinary rich people in the poor economy can consume high quality goods through international trade.\(^\text{16}\) Thus, this model complements the Flam-Helpman model and other relevant models in explaining the role of product quality in the patterns of trade.

Second, in this model, we have only considered the trade in manufactured goods. In an extended model (Fan, 1994) that incorporates both manufactured goods and agricultural goods, where the quality of the agricultural goods is fixed by nature, I show that when the representative individual's human capital of an economy is below a certain threshold level, it will either export agricultural goods or isolate itself from the rest of the world. In either case, it confirms the conclusion in this model that when a country is too poor, it will not export manufactured goods to participate in the international industrial specialization. In other words, the extended model confirms that the international industrial specialization is only confined to those countries with sufficiently high level of per capita human capital.

\(^{16}\)Besides, some evidence (e.g. Hansson, 1994) suggests that the volume of trade (based on quality differentiation) that is due to the overlap of income distribution between different countries seems not to be empirically significant.
5 The Dynamic Effect of Trade

The purpose of this section will be to examine the dynamic effect of international trade. In particular, we attempt to provide an analysis that will shed light on the following stylized facts of economic growth.¹⁷

1. Middle income economies tend to grow fastest. Namely, there is the phenomenon of "take off" (or Miracle) in a country's economic development.

2. Economies growing the fastest have increased exports of new manufactured goods not exported by them before.

In short, we will try to provide an explanation for the observed trade-induced rapid economic growth. To extend the previous analysis into a dynamic setting, we consider a small economy, where every individual lives for one period. At the end of the period, every individual gives birth to a child. So the economy lasts indefinitely.

The analysis of individuals' behavior in each period in this section will be based on the previous analysis, except that we will no longer assume that an individual's human capital is exogenously given. In this model, we will emphasize that human capital, which can be generally interpreted to include industrial technology, is the engine of growth.¹⁸ The analysis of the endogenous formation and evolution of individuals' human capital in this section will build on Lucas (1988, 1993) with some simplification and modifications.

An individual's human capital is assumed to be determined by two (general) factors: One is the time he devotes to accumulate human capital, which is denoted by \( e \). The other is his learning environment, which is denoted by \( \Phi \). Specifically, we assume that the human formation function takes the following Cobb-Douglas form,

\[
h_t = b e_i^{1-a} \Phi_i^a
\]

(39)

¹⁷These stylized facts are pointed out by Lucas (1988, 1993). They are also supported by more and more recent empirical evidence (e.g. Lau and Wan (1991), Espana (1992), Sengupta and Espana (1992), and Pack and Page (1994)).

¹⁸This emphasis is in consistent with much recent growth literature (see an excellent recent survey article by Fagerberg (1994)).
where $a$, $b$ are both positive constants, $a < 1$; the subscript $t$ refers to generation $t$ (or period $t$). For example, $h_t$ refers to the level of human capital of an individual of generation $t$.

We assume that there are three elements that influence an individual’s (of the small economy) learning environment: The first is the average human capital of his last generation\(^{19}\) (of the small economy); the second is the average human capital of the industrial (or developed) world; the third is the closeness of the contact of the small economy with the rest of the world (when the individual accumulates his human capital), which is denoted by $\lambda$. This consideration is very similar to Lucas (1993, 1988) if we interpret the first factor as the internal effect and the second factor as the external effect. The essential difference is the third factor $\lambda$. In the Lucas model, every individual (or country) benefits the same from the external effect. In the current model, however, what a (small developing) economy benefits from the industrial world will depend on the closeness of its contact with the industrial world.

Formally, the learning environment of an individual of generation $t$ is described as

$$\Phi_t = g(h_{t-1}, h^*, \lambda_t)$$

(40)

where $g()$ is a function that is non-decreasing of any of its variables; $h^*$ denotes the average human capital of the industrial world. Since the focus of the analysis is on the economies that is in the process of economic development, for simplicity, we assume that $h^*$ is constant over time.

In this model, the degree that an economy interacts with the rest of the world is measured by the degree of its participation in international industrial specialization. If an economy is autarkic in producing manufactured goods, the economy will have no contact with the advanced technology in the industrial countries. Thus, it will benefit little from the technological spillover from the rest of the world. On the other hand, if an economy joins the

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\(^{19}\)The importance of on the job training in individuals' productivity is stressed in the literature of human capital theory (e.g. Becker, 1975) and the “new” growth theory (e.g. Lucas, 1988, 1993). For more recent theoretical analysis on this issue, see Jovanovic and Nyarko (1994) and Kremer and Thomson (1994).
global industrial specialization, as a large body of literature shows, it will benefit much from the technological spillover from industrial nations. For example, as put by Haberler (1959):

"...trade (in manufactured goods) is the means and vehicle for the dissemination of technological knowledge, the transmission of ideas, for the importation of know-how, skills, managerial talents and entrepreneurship...."

Also, the modelling strategy of a small economy abstracts from the consideration of the heterogeneity of individuals' human capital (or firms' technology) within an economy. So, as shown in the last section, a small economy will either fully participate in the global industrial specialization or be fully autarkic in producing manufactured goods. Thus, $\lambda_t$ only takes two values and it is defined as

$$\lambda_t = \begin{cases} 0 & \text{if the economy is autarkic at period } t - 1 \\ \delta & \text{if the economy exports manufactured good at period } t - 1 \end{cases}$$

where $\delta$ is a positive constant. Also, it should be noted that an individual's learning environment is created by his last generation (of the small economy), and in particular, by the interaction of his last generation with the industrial world.

We normalize an individual's life span to be one unit of time, and we assume individuals do not consume leisure. Therefore, if an individual devotes $\varepsilon_t$ amount of time in accumulating human capital, he will devote $1 - \varepsilon_t$ amount of time in working. Suppose that the wage rate (of human capital) is denoted by $w_j$ ($j = 1, 2$), where $w_j$ denotes the international wage rate when $j = 1$; the autarkic wage rate when $j = 2$. Then, an individual's total (life-time) income can be expressed as

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21In an extended model (Fan, 1994) that incorporates both manufactured goods and agricultural goods, where the quality of the agricultural goods is fixed by nature, I show that when the representative individual's human capital of an economy is below a certain threshold level, it will either export agricultural good or isolate itself from the rest of the world. Since little industrial technology is used in the agricultural sector, an economy will benefit little from the technological spillover from the industrial countries by specializing in agricultural goods. In fact, Matsuyama (1992) shows that this type of specialization may even retard a country's economic growth. So, in either case (that an economy does not join the global industrial specialization), it will benefits little from the technological spillover from the industrial world.
\[(1 - e_t)h_t w_j\]

Namely

\[(1 - e_t)e_t^{1-a}g(h_{t-1}, h^*, \lambda_t)w_j\]  \hspace{1cm} (41)

From the previous analysis, it is easy to see that an individual's maximizing his utility entails his maximizing his income. From (41), we can see that \(e_t\) is the only choice variable of a (single) individual of generation \(t\). Also, noticing that neither \(g(h_{t-1}, h^*, \lambda_t)\) nor \(w_j\) depends on an individual's time in accumulating human capital, \(e_t\), then, from the first order condition of maximizing the income (41) with respect to \(e_t\), we have

\[e_t = \frac{1 - a}{2 - a}\]  \hspace{1cm} (42)

Plugging (42) into (39), we get

\[h_t = b(\frac{1 - a}{2 - a})^{1-a} \Phi_t^a\]  \hspace{1cm} (43)

For simplicity of notation, we define

\[
\gamma \equiv b(\frac{1 - a}{2 - a})^{1-a}
\]

Therefore, we can rewrite (43) as

\[h_t = \gamma \Phi_t^a\]  \hspace{1cm} (44)

To illustrate the dynamics of the evolution of individuals' human capital graphically, we will assume the formulation of an individual's learning environment to have the following Cobb-Douglas form,

\[
\Phi_t = B(\lambda_t)h_t^{1-\lambda_t}(h^*)^{\lambda_t}
\]  \hspace{1cm} (45)

where \(B()\) is a non-decreasing function of \(\lambda\). In particular, since \(\lambda\) only takes two values in the model, \(B(\lambda)\) also only takes two values, and \(B(\delta) \geq B(0)\). Also, since a representative individual's human capital in a developing country is less than that in the industrial world,
namely, \( h_t < h^* \), (45) implies that the greater \( \lambda_t \) is, the greater \( \Phi_t \) will be. Namely, the more closely the economy interacts with the industrial world, the better learning environment the next generation of the economy will have. Plugging (45) into (44), we have

\[
h_t = \gamma B^a(\lambda_t)h_t^{1-\lambda_t}(h^*)^{\lambda_t(1-\lambda_t)} \tag{46}
\]

Namely

\[
h_t = \begin{cases} 
\gamma B^a(0)h_t^a & \text{if the economy is autarkic at period } t - 1 \\
\gamma B^a(\delta)h_t^{\alpha(1-\delta)}(h^*)^{\alpha(1-\delta)} & \text{if the economy exports manufactured good at period } t - 1
\end{cases} \tag{47}
\]

Now, we will first discuss the steady states of the above dynamic system. Based on the large body of evidence\(^{22}\) showing that there exists at least local convergence (i.e. excluding some very poor countries), for simplicity, we might as well assume that a representative individual’s human capital of an economy will converge to the steady state \( h^* \) as long as the economy participates in international industrial specialization. Thus, we must have

\[
h^* = \gamma B^a(\delta)(h^*)^{\alpha(1-\delta)} \tag{48}
\]

(48) yields

\[
h^* = [\gamma B^a(\delta)]^{\frac{1}{1-\alpha}} \tag{49}
\]

On the other hand, if an economy chooses to be autarkic in the initial period, its representative individual’s human capital may converge to a different steady state. Let \( h' \) denote this steady state, then it must satisfy

\[
h' = \gamma B^a(0)(h')^a \tag{50}
\]

(50) yields

\[
h' = [\gamma B^a(0)]^{\frac{1}{1-\alpha}} \tag{51}
\]

Based on the above description and analyses, we have the following theorem.

\(^{22}\)see Barro (1991), Mankiw, Romer and Weil (1992), Durlauf and Johnson (1992), among others.
Theorem 2 (1) There exists a critical level of human capital \( h^{cc} \), such that individuals of generation \( t \) in an economy will participate the international industrial specialization if and only if

\[
h_t \geq h^{cc}
\]

(2) \( h^* \) is the only stable steady state if and only if

\[
h^{cc} \leq h'
\]

(3) \( h^* \) and \( h' \) will be the two stable steady states if

\[
h^{cc} > h'
\]

Proof: See Appendix.

The first result of the theorem is a simple extension of Theorem 1 in the dynamic setting. It immediately implies that we can express (47) as

\[
h_t = \begin{cases} 
\gamma B^a(0)h_t^a & \text{if } h_{t-1} < h^{cc} \\
\gamma B^a(\delta)h_t^a h^{\alpha}(h^*)^{a(1-\delta)} & \text{if } h_{t-1} \geq h^{cc}
\end{cases}
\]

(52)

Furthermore, plugging (49) into (52), we get

\[
h_t = \begin{cases} 
\gamma B^a(0)h_t^a & \text{if } h_{t-1} < h^{cc} \\
[\gamma B^a(\delta)]^{\frac{1-\alpha}{\alpha}} h_t^\delta & \text{if } h_{t-1} \geq h^{cc}
\end{cases}
\]

(53)

Depending on the value of the parameters, the dynamics of the evolution of an individual's (of different generations) human capital in the economy which is characterized by (52) or (53) can be illustrated by one of the following graphs.

Figure 7-8 are about here

From either of these graphs, we can see that the evolution of human capital of the economy when \( h_{t-1} < h^{cc} \) and when \( h_{t-1} \geq h^{cc} \) follow two different paths. Namely, there is a discrete "jump" in the evolution of an individual's human capital when the level of an individual's human capital of the previous generation reaches \( h^{cc} \). Thus, the essence of this result implies that there exists a threshold level of human capital accumulation and economic development.
However, in reality, the transition may be more gradual than the discrete "jump" (within one generation or period) in Figure 7 or 8, since there might be some adjustment cost of technology adoption or absorption or there might be some heterogeneity of technology across different firms (or industries) within an economy. But these considerations clearly do not affect the insight or essence of the result.

Therefore, the model sheds light on the two stylized facts that are listed at the beginning of this section. First, that middle-income countries grow fastest can be explained that they are likely the poorest of those countries that engage in global industrial specialization. Thus, (the essence of) the first result of the theorem indicate that these countries may experience very fast economic growth (or "miracle") when they just begin to join the international industrial specialization. Second, the analyses in the previous sections indicate that a developing economy will choose to produce low quality manufactured goods in autarky. So, the economy which just begins to join the global industrial specialization will also just begin to produce and export high quality manufactured goods (that it did not produce before). Thus, in short, we provide an explanation for the observed trade-induced rapid economic growth.

In a recent contribution, Parente and Prescott (1994) argue that the size of the barriers to technological adoption, which is taken to be exogenous in their model, may be an explanation why some countries experience fast economic growth, while others stagnate. This paper extends the Parente-Prescott model by offering an endogenous explanation that the size of these barrier may differ across countries because these countries may choose to have different patterns of production and trade in manufactured goods.

The last two results of Theorem 2 indicate that countries may converge in the long run either globally (see Figure 7), or only locally (see Figure 8), depending on the value of the parameters of the model. So, this model does not intend to resolve the controversy\textsuperscript{23} of "convergence". However, an interesting point of the theorem is that middle-income countries may have the highest economic growth rates even though all economies will converge to the

\textsuperscript{23}For example, see Mankiw, Romer and Weil (1992) and Barro (1991) for the empirical studies on global convergence, and Durlauf and Johnson (1992) for the empirical work on local convergence.
same steady state in the long run (see Figure 7).

There is also a policy implication in the model: The consideration that technological spillover from industrial countries may occur through trade suggests that there might be a disparity between the social return and private return from individual firms' participating the global industrial specialization. So, to promote a country's growth (in particular, to avoid the possible "poverty trap" (see Figure 8)), the government of the economy may choose to subsidize certain leading exporting industries to overcome the externality effects of exporting manufactured goods that are not taken into account by individual firms. Thus, this analysis justifies the promotion of a fraction of leading export industries as a development strategy, as has been successfully adopted in several East Asian countries.\textsuperscript{24}

Finally, the model (with slight extension) may also help explain the puzzle put forward by Lucas (1993) that the Philippines and South Korea have had very different economic growth rates in the last few decades although they had similar initial conditions in individual educational attainment. There are several suggestive answers to this puzzle: First, South Korea might have better industrial technology: According to Lucas (1993), in 1960, the export of manufactured goods only account for 4 percent in the Philippines but 14 (of which 8 were textiles) percent in Korea of the total export. Thus, the textile industry in Korea might choose to produce high quality products to be part of the international industrial specialization. Dynamically, the technological spillover effect from trading manufactured goods with the industrial countries might make the textile industry develop very quickly. Meanwhile, some other domestic industries might also benefit from the technological spillover from the textile industry and might later be induced to join the international specialization, and so on. Second, the Korean governmental policy of promoting some leading exporting industries might also facilitate the above process of its industries' (gradual) participating the international industrial specialization. Finally, Korea had better transportation structure (e.g. railways, harbour) that had been left by the Japanese occupation, which might reduce their costs of international trade.

\textsuperscript{24}For example, see Amesden (1989) for the discussion on the experience of Korea, and Wade (1990) for the discussion on the experience of Taiwan.
6 Conclusion

Assuming that the qualities of different intermediate goods are highly complementary in producing the quality of the final good, this paper explores the role of product quality in industrial specialization. Also, assuming the high complementarity between quantity and quality in consumption, the model implies that the individuals of an economy will demand higher quality as well as more quantity of commodities as the per capita income (or human capital) of the economy rises.

In the context of international trade, if the representative individual's human capital in different countries is similar, the individuals in these economies will demand goods with similar quality. In this case, consistent with the previous studies, we reconfirm Smith's insight that the degree of the division of labor is only limited by the extent of the market. Moreover, because the enlargement of the market increases the productivity of the economy, international trade increases the quality as well as the quantity of every individual's consumption.

If, however, the representative individual's human capital (and hence income) of a country is sufficiently low relative to that of the rest of the (industrial) world, the individuals of this country will have less demand for quality. Consequently, despite the higher efficiency of international specialization in the production of the goods of any quality, this country may choose an "inferior" domestic production technology to produce more quantity, rather than join the global markets, specializing in producing some intermediate goods of the high quality of international standard. Thus, the model indicates that the degree of the division of labor is also limited by the heterogeneity of individuals' human capital, as well as by the extent of the market. In the international context, trade in manufactured goods may not occur between countries with very different levels of per capita human capital or income. Thus, this model formalizes Linder's (1961) hypothesis that the similarity in the demand for quality, which is largely determined by the similarity of per capita income, plays a very important role in the international trade of manufactured goods.

This model is also extended to examine the dynamic effects of international trade, which
sheds light on the patterns of cross country growth. By assuming that the externality effect of technology diffusion from the industrial world is positively correlated with the degree of a country's participation in international industrial specialization, this study suggests the existence of a threshold in economic development. Because when a country is too poor, it will not join the global industrial specialization. So it will benefit little from the technology spillover from industrialized countries. The middle-income countries may benefit from the technological spillover most because they are likely to be the poorest among the countries engaging in global industrial specialization. So, the model provides an explanation for the phenomenon of "take-off" in economic development or why middle-income countries tend to grow the fastest. It also explains why the newly industrialized countries, which have the highest economic growth rates, also have the fastest growth in exports. Thus, this analysis also provides an explanation for the trade-induced rapid economic growth observed in some Asian countries.
References


35


Appendix

Proof of Lemma 1: First, we define

\[ Z(Q) \equiv Q - f(Q)w(Q)h^* \]

From (28), we have \( w(0) = \infty \) and \( w(\infty) = 0 \). Also, by Assumption 1, we have

\[ Z(0) < 0, \quad Z(\infty) > 0 \]

Thus, by the continuity of \( Z(Q) \), for any \( h^* \), there exists a unique \( Q^* \) such that \( Z(Q^*) = 0 \), namely, \( Q^* \) satisfies (35).

Now, totally differentiating (35) w.r.t. \( Q^* \) and \( h^* \), and rearranging, we then get

\[ \frac{dQ^*}{dh^*} = \frac{f(Q^*)w(Q^*)}{1 - h^*f(Q^*)w'(Q^*) - h^*f(Q^*)w(Q^*)} > 0 \]

So, \( Q^* \) is unique for every \( h^* \).

Proof of Theorem 1: (1) First, we try to prove that there exist a unique \( Q^c \), such that

\[ f(Q^c) = \left( \frac{Q^c}{Q^*} \right)^{1-\xi} \]

To do this, we define

\[ G(Q) \equiv f(Q) - \left( \frac{Q}{Q^*} \right)^{1-\xi} \]

Because

\[ G(0) = 1 > 0, \quad G(2Q^*) = f(2Q^*) - 2^{1-\xi} < 1 - 2^{1-\xi} < 0 \]

by the continuity of \( G(Q) \), there exists a \( Q^c \), such that

\[ G(Q^c) = 0 \]

Besides,

\[ G'(Q) = f'(Q) - \frac{1 - \xi}{Q} \left( \frac{Q}{Q^*} \right)^{1-\xi} < 0 \]

So \( Q^c \) is unique. Thus, (38) is satisfied if and only if

\[ Q' \geq Q^c \]
Second, by Lemma 1, there is a strictly monotonically positive relationship between $Q^*$ and $h^*$. Thus, there exists a unique $h^c$, such that

$$Q^* \geq Q^c$$

if and only if

$$h^* \geq h^c$$

Thus, (38) is satisfied if and only if

$$h^* \geq h^c$$

(2) When the level of a representative individual’s human capital of an economy is $h$, by the analysis in Section 3, the utility that an individual obtains if the economy engages in trade is equal to $(1 + \xi)Q^*$. where $Q^*$ satisfies

$$Q^* = w(Q^*)h$$  \hspace{1cm} (54)

On the other hand, if the economy is in autarky, by the analysis in Subsection 4.2, the economy will choose the product quality, $Q'$, which satisfies

$$Q' = f(Q')w(Q')h$$  \hspace{1cm} (55)

From the utility function (21), we know the utility that its representative individual obtains in this case is equal to $(1 + \xi)Q'$. Thus, the economy (whose representative’s human capital is $h$) will join the global industrial specialization if and only if

$$(1 + \xi)Q^* > (1 + \xi)Q'$$

Namely,

$$Q^* > Q'$$  \hspace{1cm} (56)

Now, we claim that (56) is true.
Suppose not, namely, \( Q^* \leq Q' \), then \( w(Q^*) \geq w(Q') \). Also, by Assumption 1, we have \( f(Q') < 1 \). Thus,

\[
f(Q')w(Q')h < w(Q')h \leq w(Q^*)h
\]  \hspace{1cm} (57)

By (54) and (55), (57) implies \( Q^* > Q' \), which results in contradiction.

Thus, (56) is satisfied and an economy whose representative individual's human capital is \( h \) will join the international industrial specialization.

(3) From the proof of the first part of the theorem, we get

\[
G(Q^c) = f(Q^c) - \left( \frac{Q^c}{Q^*} \right)^{1-\xi} = 0 \]  \hspace{1cm} (58)

Totally differentiating (58) w.r.t. \( Q^c \) and \( \xi \), and rearranging, we then get

\[
\frac{dQ^c}{d\xi} = \frac{(\frac{Q^c}{Q^*})^{1-\xi} \ln(\frac{Q^c}{Q^*})}{\frac{1-\xi}{Q^*} - f'(Q^c)} \]  \hspace{1cm} (59)

Since \( Q^* > Q^c \) (by the proof in Part 2 of the theorem) and \( f' < 0 \), the numerator of the right hand side (59) is negative and the denominator is positive. So

\[
\frac{dQ^c}{d\xi} < 0
\]

Also, by Lemma 1, we know \( \frac{dh^c}{dh^c} > 0 \). Thus,

\[
\frac{dh^c}{d\xi} < 0
\]

Namely, \( h^c \) is a strictly decreasing function of \( \xi \).

**Proof of Theorem 2:** Since an individual devotes \( 1 - \epsilon \) amount of time in working, then, if his human capital is \( h \), his effective efficiency labor in working will be \( (1 - \epsilon)h \). Now, (noticing (42)), let

\[
h^{\epsilon} = \frac{h^c}{1 - \epsilon} = \frac{h^c}{1 - \frac{1-a}{2-a}} = (2 - a)h^c \]  \hspace{1cm} (60)

Then, an individual's efficiency labor in working is greater (equal to) (less) than \( h^c \) if and only if the level of his human capital is greater (equal to) (less) than \( h^{\epsilon} \). By Theorem 1, we have proved the first part of the theorem.

By the first part of theorem 1, we can get (53), which can be illustrated by either Figure 7 or Figure 8. The proofs of the second and the last results are trivial by Figure 7 and 8.
The "Quantity-Quality" possibility frontier of the whole economy.
The thick line is an individual's budget "line". It represents equation (20).
Figure 3:

[1] $f = 1$

[2] $0 < f < 1$

[3] $f = 0$
Figure 4

(1): Equation [20] in the text (The budget "line")

(2): Equation [21] in the text (The indifference curve)
Figure 5

(1): the budget "line" representing equation [20]

(2): the budget "line" representing equation [26]
The thick line, which represents (34), is downward sloping.