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Trade and Inequality in the Digital Economy*

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This paper presents a simple two-sector general equilibrium model of noncomparative advantage trade between structurally identical advanced economies. Attention has focused on the effects of trade in information technology (IT) goods and services on the wage inequality in the digital economy. The model confirms and illustrates that wage inequality in the digital economy reflect trade in IT goods and services between advanced economies. In particular, this paper shows that even though the relative price of skilled labor-intensive technology good is declined with trade in IT goods and services, the wage of skilled labor increases. The reason is that as Jorgenson (2001) has empirically found, the price elasticity of demand for the technology goods is elastic.

Key Words : Trade in IT Goods and Services, Wage Inequality, Price Elasticity, Digital Economy

Ⅰ. Introduction

In the digital economy, information technology (IT) goods and services is a major

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driver of economic change, restructuring businesses, affecting skills and employment, and contributing to growth (OECD, 2004).[1] The vitality of the digital economy is based on IT goods and services that support IT-enabled business process, Internet and e-commerce. In fact, IT goods and services provide vital input of the production of other goods and services. The use of IT as intermediate inputs can play in creating new economic efficiency.[2] Thus the incentives for specialization and outsourcing of IT goods and services are increasingly expanded. As a result, the IT sector is highly and increasingly globalized in the digital economy.

With skill-biased technological change, in particular, the wage of skilled workers has been increasing more rapidly than that of the unskilled workers. However, we may need to look deeper than skill-biased technological change if we are to fully understand widening wage dispersion. Recently international trade in IT goods and services through the newly emerging digital economy can further explain the wage inequality. Rapidly expanding trade in IT goods and services in the digital economy are the main sources behind increasing income inequality. Admittedly, most trades in IT goods and services are of the intra-industry type among the developed economies. That is, increased intra-industry trade among the developed economies rather than increased inter-industry trade between the developed and developing countries are commonly viewed as the forces behind the increased wage inequality between skills in advanced economies.[3]

The purpose of this paper is to focus on the effects of trade in IT goods and services on wage inequality. Unlike most the supply-side analyses, we put forth an argument that trade in IT goods and services is a main source of recent wage inequality. In support of this claim, we demonstrate that in addition to the standard theory of gains from trade in

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1) As in Brynjolfsson and Kahin (2000), the term "digital economy" refers specifically to the recent and still largely unrealized transformation of all sectors of the economy by the computer- enabled digitization of information, and the digital economy includes goods or services whose development, production, sale, or provision is critically dependent upon digital technologies.

2) For example, average growth for IT-intensive industries in the U.S. economy between 1989 and 2001 was over 3 percent, far exceeding growth in the less IT-intensive industries which averaged 0.42 percent (U.S. Department of Commerce, 2003).

3) International outsourcing of IT and IT-enabled business services has grown rapidly. Over three-quarters of exports are from OECD countries (OECD, 2004).

IT goods and services, both economies will experience further gains from factor mobility due to trade in IT goods and services. This paper specifically develops a simple two-sector general equilibrium model of noncomparative advantage trade between structurally identical developed countries. The model consists of two competitive sectors, one producing a regular good with skilled and unskilled labor under constant returns to scale and the other a technology good produced by costlessly assembling IT goods and services as intermediate inputs. The IT goods and services or intermediate good is produced under increasing returns and monopolistic competition.

The argument presented in this paper is based particularly on the following three assumptions. The first is that trade in IT goods and services is driven by a North-North trade between structurally identical economies. Because IT goods and services as intermediate inputs are invented through costly R&D investment, imported IT intermediate inputs imply an implicit sharing of the technology that was created in other economies. This kind of trade in middle products provides a positive link between the number of variety of specialized inputs and productivity of technology sector. The second assumption is that the price elasticity of demand for technology goods is elastic. Some evidence found in Jorgenson (2001) supports our assumption that the technology sector share of total expenditure is increasing with the relative price decline in technology goods because of the elastic (high) price elasticity of demand.[4] The third and most fundamental assumption is that our utility function takes a simple modified Cobb-Douglas form of changing demand shares. We assume that the technology sector share of total expenditure depends on the relative price of technology goods. Theoretically, when the relative price of technology goods decreases, a substitution effect shifts demand from the regular goods to the technology goods. But this effect is exactly off-set by an income effect in the standard Cobb-Douglas preferences. In our modified framework, by contrast, the substitution effect outweighs the income effect if and only if

4) We can calculate the absolute value of the price elasticity of demand for the technology good such as computers, software, communications equipment, and information technology services from Jorgenson (2001) as follows: ε_p=2.75 per year from 1990 to 1995, and ε_p=2.03 per year from 1995 to 1999.

the technology good has elastic price elasticity of demand.

A main insight of this paper is that trade in IT goods and services can affect the wage inequality dependently of changes in demands. Trade in IT goods and services can explain the falling relative prices of technology goods, the increased technology sector share of total expenditure, and the wage premium of skilled labor. In the model of this paper, we establish that a specific channel exists through which trade in IT goods and services can influence relative wages. The key mechanism of this channel is the fact that the price elasticity of demand for IT-intensive technology goods is elastic. Because of this characteristic, the falling relative price of technology good due to trade in IT goods and services appears to bring forth the increased technology sector share of total expenditure in the economy. As a consequence, the wage of skilled labor is increased in spite of the acceleration in the rate of price decline in technology good that is skilled labor intensive.

The relationship between inter-industry trade and wage inequality has been the subject of intensive research and debate in the last decade. Wood (1995) and Leamer (2000) argue that North-South trade could reduce the relative wage of unskilled workers in the advanced economies even if the import penetration ratio is low and trade between the two groups is balanced. However, Lawrence and Slaughter (1993) and Krugman (2000) argue that imports of manufactured goods from developing countries are still only about two percent of the combined GDP of OECD, and that there is very little evidence of the Stolper-Samuelson effects. Particularly, Feenstra and Hanson (2001) confirm by three empirical methods that trade in intermediate inputs is an important explanation for the increase in the wage inequality in the U.S. and elsewhere.

A simplified one-sector model in which all trades are of the intra-industry type is initially modeled by Krugman (1979). In his model, intra-industry trade has no effect on income distribution, and is likely to lead to higher welfare for all agents. Intra-industry trade has then been incorporated into multisector model by Helpman (1981), Ethier (1982), Markusen (1989), and others. However, the factor market implications of intra-industry trade are ignored in these studies. The model of this paper is used to confirm and illustrate that recent changes in the distribution of income in advanced economies primarily reflect intra-industry trades in IT goods and services among advanced countries rather than trades with developing countries. Furthermore, as Jorgenson (2001) empirically found, the analysis shows that despite the decline in the relative price of technology good which is skilled labor intensive, the wage of skilled labor increases since the price elasticity of demand in the technology goods is elastic. The way in which we incorporate IT goods and services into the monopolistic competition model is analytically similar to Markusen (1989) and Harris (1998). Markusen (1989) focused only on the welfare effect of trade in specialized intermediate inputs. However, this paper focuses on the wage inequality effects of trade in IT goods and services as intermediate input. Harris (1998) developed a general purpose technology model of interregional trade affected by the advent of Internet. He analyzed a small open economy model of interregional factor mobility in skilled labor. However, the model developed in this paper examines a two-country model of intra-industry trade in IT goods and services without international factor mobility in skilled labor. In particular, this paper adds a major contribution to existing theoretical literature on the relationship between intra-industry trade and wage inequality. The first is that this paper explicitly takes a modified Cobb-Douglas utility function of changing demand shares. The second is that the paper shows that there exists a skill-premium in spite of the relative price decline of a skill-intensive technology good.

The paper proceeds as follows. Section 2 introduces a modified Cobb-Douglas utility function, and analyzes a simple two-sector general equilibrium of the demand-side model. Section 3 shows the effects of trade in IT goods and services on wage inequality as well as welfare gains. Section 4 focuses on the implications for factor market. Section 5 provides some concluding remarks.

Ⅱ. The Basic Model

We consider an economy producing two final goods, X (the technology good) and Y

(the regular good), and n IT goods and services as intermediate inputs, Z_i, $i = 1,...,n$. We take good Y as the numeraire, $p_y = 1$, and denote the relative price of X, p_x/p_y, by p. There are two factors of production, skilled (or human capital) and unskilled labor, denoted by H and L. Both are assumed to be physically immobile internationally.

1. Demand

Consumers worldwide share identical, homothetic preferences. The representative consumer has a sort of modified Cobb-Douglas utility function which is parameterized as

$$U(C_x, C_y) = C_x^{\varphi} C_y^{1-\varphi} \tag{1}$$

where C_x denotes consumption of technology goods, C_y consumption of regular goods, and $\varphi \in (0,1)$. In contrast to the standard Cobb-Douglas preferences, we assume that the technology sector share of total expenditure depends on the relative price of technology goods.[5] This means that the changing relative price of X will affect the X sector share of total expenditure (or demand). This model is an attempt to understand the implications of changing relative prices of technology goods on the varying technology sector share of total expenditure (or demand). The effects of a fall in relative price of technology goods on varying expenditure shares depends basically on the price elasticity of demand for the technology goods.[6] If the goods produced by the technology sector have a high (or low) price elasticity of demand, the falls over time in their relative prices will boost (or reduce) the share of total expenditure. The falls in the relative prices of technology good will leave the technology sector share of total expenditure

5) As in Mitra and Trindade (2003), we introduce a modified Cobb-Douglas utility function of changing demand shares. In contrast to an indirect utility type model of Mitra and Trindade (2003), the model developed in this paper examines a direct utility type.

6) As in Mitra and Trindade (2003), the demand share will also depend on the income elasticity of demand. If the good produced by the technology sectors are superior goods, the share, φ, will rise as economic growth continues. However, this effect will not be modeled here.

unchanged only if a unitary price elasticity of demand, i.e., $\varepsilon_p=1$ (the standard Cobb-Douglas case) (DeLong, 2002).7) Our assumption means that a change in relative price can affect a change in preferences between two final goods. The direction of bias will depend on the direction of the shift in preferences. The shift in preferences leads to a change in consumption ratios at the new relative price.

Now we assume that national income consists of the skilled labor income and the unskilled labor income as follows:

$$pX + Y = I(w^L, w^H) = w^L L + w^H H \tag{2}$$

where w^L is the reward to unskilled labor and w^H the reward to skilled labor. Then the demand for the technology good X^d is a function of w^L, w^H and p as follows:

$$X^d(w^L, w^H, p) = \varphi(w^L L + w^H H)/p \tag{3}$$

Similarly, the demand function for good Y is,

$$Y^d(w^L, w^H) = (1-\varphi)(w^L L + w^H H) \tag{4}$$

This form implies constant expenditure shares given the relative prices, p. Hence, a fixed share of income, φ, is spent on the technology goods, while the remainder, $1-\varphi$, is spent on the regular goods.

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7) In equilibrium, the expenditure on the technology good equals the revenue of the technology sector, pX. Then we have

$$\left[\frac{d\left(\frac{pX}{pX+Y}\right)}{\left(\frac{pX}{pX+Y}\right)} / \frac{dp}{p}\right]\begin{Bmatrix}<\\=\\>\end{Bmatrix}0 \Leftrightarrow \frac{d[pX(p)]}{dp} = X\left(1+\frac{dX/X}{dp/p}\right) = X(1-\varepsilon_p)\begin{Bmatrix}<\\=\\>\end{Bmatrix}0 \Leftrightarrow \varepsilon_p\begin{Bmatrix}>\\=\\<\end{Bmatrix}1.$$

2. Supply

The production function in the regular sector is specifically given by

$$Y = G(L_y, H_y) = L_y^{1-\alpha} H_y^{\alpha} \tag{5}$$

$G(\cdot)$ is twice differentiable, increasing, and strictly quasi-concave.

The technology sector uses the n differentiated intermediate inputs, $Z_i(i = 1,\dots,n)$, to produce the final good X. Given an n vector Z of specialized inputs, the production function is

$$X = \left(\sum_{i=1}^{n} Z_i^{\beta}\right)^{1/\beta}, \quad 0 < \beta < 1 \tag{6}$$

where β is a positive monotone transformation of the elasticity of factor substitution.[8] In this functional form of the Dixit and Stiglitz (1977) representation, the output of technology good is an increasing function of the total number of specialized intermediate inputs used by producer.

The IT goods and services as intermediate inputs, Z_i, is produced only by the skilled labor.[9] The total skilled labor (H_i) used in producing Z_i consists of a fixed input, F,

8) As in Ethier (1982), the technology goods are costlessly assembled from IT inputs. With this CES form, different value of the parameter, β, can be used to represent technologies with vastly different substitutability between inputs. A higher value of β indicates that intermediate inputs can be more easily substituted for each other in the assembly of finished technology goods. Thus lower values of β correspond to greater "production differentiation" within the technology sector.

9) In this analysis, 'inputs' refer in most contexts to the 'IT inputs' as intermediatesand thus IT inputs and intermediate inputs will be used interchangeably. IT inputs are mainly intermediate inputs in the production of technology goods. These do not include all inputs. However, this type of inputs is an important subject in current policy issues on trade in IT inputs.

and a variable input directly proportional to output Z_i:

$$H_i = F + Z_i \tag{7}$$

Note that skilled labor is used directly in the regular sector but only indirectly in the technology sector as it is used to produce the IT inputs as intermediates that are the sole inputs in the production of technology goods.

Within an economy, skilled labor is mobile between the regular sector and IT input/technology sector. The existence of scale economies in the IT input sector limits the production of each IT input to at most one firm, since it is more profitable to produce a different variety than to share a market with another firm. Full employment of these factors requires:

$$H_y + \sum_{i=1}^{n} H_i = H \tag{8}$$

$$L_y = L \tag{9}$$

With identical technologies among all firms in the IT inputs industry, facing the same skilled wage rate, w^H, the optimal output produced by the IT inputs producers are all equal: $Z_i = Z$ for all $i = 1,...,n$. Moreover, profit maximization requires that the marginal revenue equal the marginal cost which is the skilled wage rate:

$$q\left(1 - \frac{1}{\varepsilon}\right) = w^H, \quad i = 1,...,n \tag{10}$$

where q is the price of a differentiated IT input and ε the elasticity of demand for a differentiated input, which can be approximated by $1/(1-\beta) > 1$ since the number of varieties are assumed to be large.

Producers of technology sector maximize profits by choosing the optimal IT inputs, taking the number of intermediate input firms (n), the relative price of good X (p), and the price of the IT input (q) as given, subject to production function (6). The first-order condition is given by

$$p = qn^{-\sigma} \tag{11}$$

where $\sigma = (1-\beta)/\beta$. Producers of regular sector maximize profits by choosing the optimal input mix of skilled and unskilled labor. The first-order condition of profit maximization for a producer of good Y is given by

$$\frac{L}{H_y} = \frac{(1-\alpha)}{\alpha}\frac{w^H}{w^L} \tag{12}$$

In the long run, IT input firms enter the intermediate good markets until all firms break even. For i=1,...,n, we thus obtain

$$qZ_i = w^H H_i = w^H (F + Z_i) \tag{13}$$

Using eqs. (10) and (13), the output of a single IT input firm is constant and equals

$$Z_i = (\varepsilon - 1)F \tag{14}$$

Substituting (14) into (13), we get the amount of skilled labor employed in IT inputs sector i:

$$H_i = \varepsilon F \tag{15}$$

Combining this expression with the full employment condition (8), the number of IT input firms in the economy is determined as follows:[10)]

$$n = \frac{1}{\varepsilon F}\left[H - H_y\left(w^H\right)\right] \tag{16}$$

Then we can get the supply of good X^s as a function of w^H and p by using eqs. (6), (11) and (16):

$$X^s\left(w^H, p\right) = \frac{w^H}{p}\left[H - H_y\left(w^H\right)\right] \tag{17}$$

3. Equilibrium

Now we can derive the Production Possibility Frontier (PPF), yielding all production combinations of technology goods and regular goods for which the factor market is cleared, by using eqs. (5), (16), and (17),

$$Y = L^{1-\alpha}\left[H - \left(\frac{1}{\beta}(\varepsilon F)^{\sigma} X\right)^{1/(\sigma+1)}\right]^{\alpha} \equiv f(X) \tag{18}$$

with $f'(X) < 0$.[11)] In Fig. 1, *TT* is the PPF of the autarky. Note that we are dealing with a second-best PPF, as producers of *X* do not take into account the positive externality associated with the number of IT input varieties in the production of technology goods. That is, we assume that equilibrium occurs on the concave portion of the PPF in Fig. 1.

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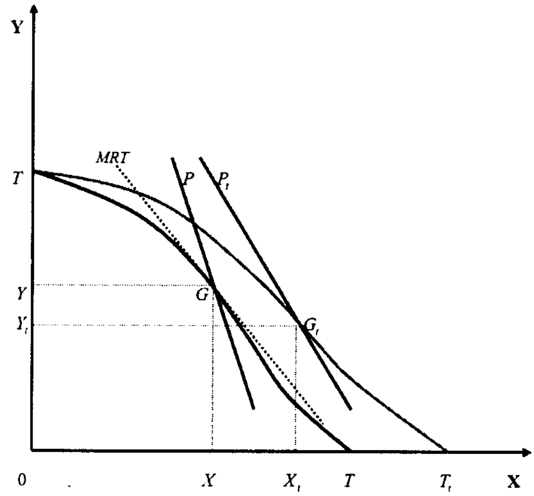
10) In general, from the first-order condition of profit maximization for a producer of good *Y*, we have $w^H = p_y G_{S_y}(L_y, H_y)$. Hence, using $L_y = \bar{L}$ and $p_y = 1$, we have $H_y = H_y\left(w^H\right)$.

11) With, $f''(x) \begin{Bmatrix} > \\ = \\ < \end{Bmatrix} 0$ the PPF is concave up to the unique inflexion point, $\tilde{X} = \beta(\varepsilon F)^{-\sigma}\left(\frac{\sigma H}{\sigma + 1 - \alpha}\right)^{\sigma+1}$, and is convex thereafter.

Fig. 1. The effects of trade in IT goods and service



The marginal rate of transformation (MRT) is given by $-f'(X)$ while the marginal rate of substitution (MRS) is given by p as there is no consumption externality. By using eqs. (11), (12) and (18), the ratio of both at the autarky equilibrium equals

$$\frac{MRT}{MRS} = \sigma + 1 > 1 \Leftrightarrow MRT < p \tag{19}$$

As a result, in autarky the economy will produce and consume too much regular goods and not enough technology goods.

Mathematically, the autarkic equilibrium can be obtained by equating supply and demand of X good, i.e., $X^s(w^H, p) = X^d(w^L, w^H, p)$. The autarkic price, p (from eq. (11)), the autarkic number of firms, n (from eq. (16)), and the autarkic equilibrium skilled wage, w^H, and unskilled wage, w^L, are as follows:

$$p = \theta L^{1-\alpha} F^{\sigma} H^{\alpha-(1+\sigma)} \tag{20}$$

where $\theta = \beta^{-1}\alpha^{\alpha}\varepsilon^{\sigma}\varphi^{-\sigma}(1-\varphi)^{\alpha-1}(\alpha+\varphi-\alpha\varphi)^{1+\sigma-\alpha}$.

$$n = \left(\frac{\varphi}{\alpha + \varphi - \alpha\varphi} \right) \left(\frac{H}{\varepsilon F} \right) \tag{21}$$

$$w^H = \alpha^\alpha (1-\varphi)^{\alpha-1} (\alpha + \varphi - \alpha\varphi)^{1-\alpha} L^{1-\alpha} H^{\alpha-1} \tag{22}$$

$$w^L = (1-\alpha)\alpha^\alpha (1-\varphi)^\alpha (\alpha + \varphi - \alpha\varphi)^{-\alpha} L^{-\alpha} H^\alpha \tag{23}$$

By using eqs. (4) and (17), the equilibrium production levels of good X and Y are:

$$X = \varphi^{1+\sigma} \beta \varepsilon^{-\sigma} (\alpha + \varphi - \alpha\varphi)^{-(1+\sigma)} F^{-\sigma} H^{1+\sigma} \tag{24}$$

$$Y = (1-\varphi)^\alpha \alpha^\alpha (\alpha + \varphi - \alpha\varphi)^{-\alpha} L^{1-\alpha} H^\alpha \tag{25}$$

This equilibrium production point is shown by G in Fig. 1.

Ⅲ. Trade in the Digital Economy

In this section we consider a new trade model of intra-industry type in which each advanced economy introduces new IT goods and services as intermediate inputs, which are imported by the other advanced economy. The model also incorporates the notion that the price elasticity of demand for skill-intensive technology goods is elastic. To make the point most strongly, we consider the two identical, completely isolated economies of the kind specified above, and suppose that trade in IT goods and services occurs between these structurally identical two economies at zero transportation cost.

Given this setup, we examine the effects of trade in IT goods and services in the digital economy. First, trade in IT goods and services as specialized inputs increases the number of input varieties in the X sector, which enhances the competitiveness of this sector. That is, trade in IT goods and services effectively integrates economically the Z and X sectors in the world markets. Given the symmetric CES input structure, each economy will immediately exchange half of its IT input stock for half of the IT input stock of the other economy when IT inputs trade is allowed. Therefore, in aggregate, the number of differentiated inputs rises from n to $2n$ initially. Then productivity of X sector in both economies grows via increases in n. Next, the higher productivity of good X leads to the lower average cost for good X. This lower average cost of good X leads subsequently to the lower relative price for good X. Hence, if the productivity of technology good is increased, the relative price for technology good will be lowered after IT inputs trade. Based on the high price elasticity of demand for the technology good, this lower relative price for technology good leads ultimately to greater demand and thus greater expenditure share for technology sector throughout the economy. This means that the expenditure share on the technology sector goes up with trade in IT inputs. As a result, the wage premium to skilled labor in the IT input/technology sector increases and so does the real wage of skilled labor.

However, this is not the end of the story. Besides these gains, each economy will experience further gains from factor mobility due to trade in IT goods and services. Given the specification of our model, this skilled wage premium in the sector X/Z accelerates skilled labor to shift from regular sector to the IT input/technology sector. It increases resources devoted to the intermediate input sector and the size of the IT input/technology sector. Since Z is unchanged in the post-trade equilibrium due to (14), the post-trade number of varieties in each economy will be further increased from n to $n_t(>n)$ as the skilled labor devoted to the IT input/technology sector increases. This means that if and only if the price elasticity of demand for the technology good is elastic, the number of varieties in each economy is further increased from n to $n_t(>n)$ as skilled labor allocated to X/Z sector increases. In other words, the higher is the price elasticity of demand for technology goods after trade in IT inputs, the greater will be the number of varieties developed for the technology sector, and thus the stronger will be the forces pushing the expenditure share up as their price declines.[12] If the expenditure share on the technology sector is further increased, the real wage of skilled labor in the post-trade equilibrium will be increased.

This can also be seen mathematically. In the new equilibrium due to trade in IT inputs, the technology sector uses twice the post-trade number of varieties ($2n_t$), but half of its IT inputs ($Z_i/2$) to produce the final good X_t. More specifically, we have the post-trade production function of X_t as

$$X_t = \left(\sum_{i=1}^{2n_t} \left(\frac{Z_i}{2} \right)^{\beta} \right)^{1/\beta}, \ 0 < \beta < 1 \tag{26}$$

With identical technologies among the supplier of intermediates, who all face the same post-trade skilled wage rate, w_t^H, the optimal outputs produced by the supplier of IT inputs as intermediates are all equal: $Z_i = Z$ for all $i = 1, \ldots, n_t$. The optimality condition for this problem is straightforward: at the optimal choice of output we must have marginal revenue equal to marginal cost. In terms of algebra, we can write the optimization condition as

$$q_t \left(1 - \frac{1}{\varepsilon} \right) = w_t^H, \ i = 1, \ldots, n_t \tag{27}$$

where q_t is the post-trade price of IT inputs. Producers of technology sector maximize profits by choosing the optimal IT inputs, taking the post-trade number of varieties ($2n_t$), the post-trade relative price of technology good (p_t), and the post-trade price of IT inputs (q_t) as given, subject to (26). Then the first-order condition is given by

$$p_t = q_t (2n_t)^{-\sigma} \tag{28}$$

12) If the price elasticity of demand is unitary as the adoption of new technology continues with free input trade, the expenditure share will be the same as their price declines, and thus the number of varieties developed for the technology sector will not be changed. If the price elasticity of demand is smaller than 1 as new technology adoption continues with free input trade, the stronger will be the forces pushing the expenditure share down as their price declines, and thus the lesser will be the number of varieties developed for the technology sector.

From (16), we have the number of IT input firms in the post-trade equilibrium:

$$n_t = \frac{1}{\varepsilon F}\left[H - H_y\left(w_t^H\right)\right] \tag{29}$$

In the post-trade equilibrium, as a consequence, we have a lower relative price, $p > p_t > 2^{-\sigma} p$.13) In our model, then, the lower relative price for technology good leads eventually to greater the technology sector share of total expenditure (or demand).

In the demand side, the post-trade utility function for the representative consumer is specifically given by

$$U_t = C_x^{\varphi_t} C_y^{1-\varphi_t} \tag{30}$$

where $\varphi_t > \varphi$.14) National income consists of the post-trade skilled labor income and the post-trade unskilled labor income as

$$p_t X_t + Y_t = I_t = w_t^L L + w_t^H H \tag{31}$$

where w_t^L is the post-trade reward to unskilled labor. Then the post-trade demand for technology goods is a function of w_t^L, w_t^H and p_t as

$$X_t^d\left(w_t^L, v_t, p_t\right) = \varphi_t\left(w_t^L L + w_t^H H\right) / p_t \tag{32}$$

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13) In the post-trade equilibrium, p_t does not decrease until $2^{-\sigma} p$ since φ increases as p decreases, i.e., $d\varphi / dp < 0$. Meanwhile p_t should be less than p since $\infty > \varepsilon_t > 1$.

14) Because the technology goods have an elastic price elasticity of demand, the relative price decline of technology goods due to trade in IT goods and services increases the share of total expenditure. In this case, the substitution effect in response to the falling of relative price of technology goods outweighs the income effect. The analysis will be qualitative because the direction of change is the only matter considered.

The post-trade supply of technology goods can be written as a function of w_t^H and p_t by using eqs. (26), (27), (28) and (29):

$$X_t^s(w_t^H, p_t) = \frac{w_t^H}{p_t}\left[H - H_y(w_t^H)\right] \tag{33}$$

Similarly, the post-trade demand and supply functions for regular goods are respectively,

$$Y_t^d(w_t^L, w_t^H) = (1-\varphi_t)(w_t^L L + w_t^H H) \tag{34}$$

$$Y_t^s(w_t^H) = L^\alpha H_y(w_t^H)^{1-\alpha} \tag{35}$$

Now, using (29), (33), and (35) we can derive the post-trade PPF as follows:

$$Y_t = L^{1-\alpha}\left[H - \left(\frac{1}{\beta}\left(\frac{\varepsilon F}{2}\right)^\sigma X_t\right)^{1/(\sigma+1)}\right]^\alpha \equiv f(X_t) \tag{36}$$

with $f'(X_t) < 0$.[15] In Fig. 1, TT_t where lies everywhere outside of TT locus except T is the PPF of the new frontier which results from trade in IT goods and services. In the post-trade situation, the new equilibrium is illustrated by G_t in Fig. 1.

The post-trade equilibrium can be calculated by equating supply and demand for X good, i.e., $X_t^s(w_t^H, p_t) = X_t^d(w_t^L, w_t^H, p_t)$. Specifically, the relative price of post-trade equi-librium p_t is given by

$$p > p_t = 2^{-\sigma}\theta_t L^{1-\alpha} F^\sigma H^{\alpha-(1+\sigma)} > 2^{-\sigma} p \tag{37}$$

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15) With $f''(x_t) \begin{Bmatrix} > \\ - \\ < \end{Bmatrix} 0$, the PPF is concave up to the unique inflexion point, $\tilde{X}_t = \beta\left(\frac{\varepsilon F}{2}\right)^{-\sigma}\left(\frac{\sigma H}{\sigma+1-\alpha}\right)^{\sigma+1}$ and is convex thereafter.

where $\theta_t = \beta^{-1}\alpha^{\alpha}\varepsilon^{\sigma}\varphi_t^{-\sigma}(1-\varphi_t)^{\alpha-1}(\alpha+\varphi_t-\alpha\varphi_t)^{1+\sigma-\alpha} > \theta$. The post-trade number of IT input firms is as follows:

$$n_t = \left(\frac{\varphi_t}{\alpha+\varphi_t-\alpha\varphi_t}\right)\left(\frac{H}{\varepsilon F}\right) > n \tag{38}$$

In the post-trade equilibrium, skilled wage w_t^H and unskilled wage w_t^L are given as follows:

$$w_t^H = \alpha^{\alpha}(1-\varphi_t)^{\alpha-1}(\alpha+\varphi_t-\alpha\varphi_t)^{1-\alpha}L^{1-\alpha}H^{\alpha-1} > w^H \tag{39}$$

$$w_t^L = (1-\alpha)\alpha^{\alpha}(1-\varphi_t)^{\alpha}(\alpha+\varphi_t-\alpha\varphi_t)^{-\alpha}L^{-\alpha}H^{\alpha} < w^L \tag{40}$$

By using eqs. (16) and (17), the equilibrium production levels of good X_t and Y_t are given as follows:

$$X_t = 2^{\sigma}\varphi_t^{1+\sigma}\beta\varepsilon^{-\sigma}(\alpha+\varphi_t-\alpha\varphi_t)^{-(1+\sigma)}F^{-\sigma}H^{1+\sigma} > 2^{\sigma}X \tag{41}$$

$$Y_t = (1-\varphi_t)^{\alpha}\alpha^{\alpha}(\alpha+\varphi_t-\alpha\varphi_t)^{-\alpha}L^{1-\alpha}H^{\alpha} < Y \tag{42}$$

In the post-trade equilibrium, therefore, the output of X_t increases and the output of Y_t decreases in each economy. Under the conditions of $(w^L - w_t^L)L < (w_t^H - w^H)H$, each economy's income increases with trade in IT goods and services.16) This result shows that trade in IT inputs is Pareto-superior to autarky. Furthermore, our two-country model illustrates an inverse relationship between productivity and price because of the characteristics of price elasticity of demand for the technology good. That is, the decline

16) In case of $(w^L - w_t^L)L > (w_t^H - w^H)H$, each economy's income decreases with trade in IT goods and services.

in relative price of technology goods results in the increased sectoral demand shares in our modified Cobb-Douglas preferences. Hence this analysis shows that in spite of the decline of relative price for technology good, the post-trade skilled labor wage is increased while the post-trade unskilled wage is lowered.

Ⅳ. The Implications for Factor Market

In this section we can in further detail address the wage inequality effects of trade in IT goods and services in another way. The focus is specified on the implications for factor market as a result of trade in IT goods and services. Consider first an autarky economy of the kind specified basic model.

By using eqs. (10) and (11), we can solve for the skilled wage in the IT inputs/technology sector as a function of the price of X and the degree of input differentiation as follows:

$$w_x^H = \beta p n^{\sigma} \tag{43}$$

Eq. (43) gives the value of the average product of skilled labor in the IT inputs/technology sector, and this is increasing in the level of input differentiation. In zero-profit monopolistically competitive equilibrium, the number of IT varieties, n, adjusts such that price equals average cost on each variety. We therefore have from

$$q = w^H + \frac{w^H F}{Z_i} \tag{44}$$

Using the markup rule and price equals average cost, we solve for equilibrium scale Z in the representative IT sector as

$$Z = F\left(\frac{\beta}{1-\beta}\right) \tag{45}$$

Total skilled labor use in sector X is given by

$$H_x = n(F + Z_i) \tag{46}$$

Solving the number of IT varieties as a function of H_x gives

$$n = \frac{H_x}{F + Z_i} = \frac{(1-\beta)}{F} H_x \tag{47}$$

The number of varieties is linear in the supply of skilled labor to the service sectors. Substituting for n in the IT sector wage equation, we have

$$w_x^H = p\beta(1-\beta)^{\sigma} F^{-\sigma} H_x^{\sigma} \tag{48}$$

Eq. (48) provides the value of the average product for skilled labor in the IT inputs/technology sector and it is increasing in the level of skilled labor input. From the first-order condition of profit maximization for a production of good Y, we also have the skilled wage equal marginal products condition in the Y sector:

$$w_y^H = \partial G(L, H_y) / \partial H_y \tag{49}$$

Eq. (49) gives the value of marginal product for skilled labor in the regular sector and it is decreasing in the level of skilled labor input. The unskilled labor (L) is a specific factor in the regular sector. So we also have the unskilled wage equals marginal products condition (or price equals unit cost) in that sector:

$$w^L = \partial G(L, H_y) / \partial H_y \tag{50}$$

Factor market clearing in a single market is depicted in Fig. 2 (the traditional specific factors diagram) with the horizontal axis representing the total available supply of skilled labor in a single economy. On the left side a downward-sloping value of marginal product for skilled labor schedule in the regular sector (VMP_{H_y}) is drawn, and on the right a rising value of the average product schedule for skilled labor in the technology sector (VAP_{H_x}).[17] As in Fig. 2, there are generally two points of intersection of the VMP_{H_y} and VAP_{H_x} curves, illustrated here by A and B. The stable equilibrium is the point at which the slope of the VMP_{H_y} is steeper than the slope of the VAP_{H_x}, which is the case at point A.[18]

The equilibrium allocation of skilled labor is determined by intersection of the two schedules. Only this allocation of skilled labor equalizes the skilled wage rate between the two sectors, and perfect skilled labor mobility will not allow for any wage differential. Thus, at point A, we have

17) The VMP_{H_y} eq. (49) is always convex, because

$$\frac{\partial VMP_{H_y}}{\partial H_y} = \alpha(\alpha - 1)L_y^{1-\alpha} H_y^{\alpha-2} < 0$$

and

$$\frac{\partial^2 VMP_{H_y}}{\partial H_y^{\ 2}} = \alpha(\alpha - 1)(\alpha - 2)L_y^{1-\alpha} H_y^{\alpha-3} > 0$$

with $0 < \alpha < 1$. The VAP_{H_x} eq. (48) is always concave, since

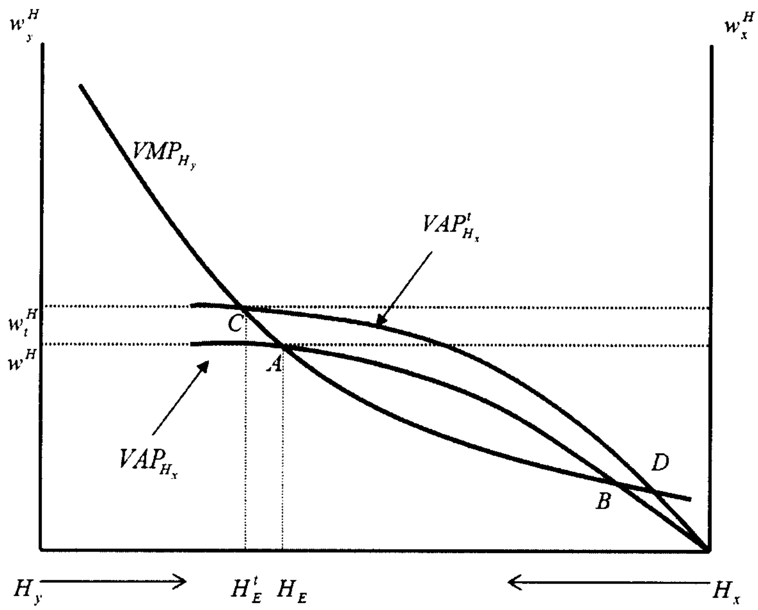
$$\frac{\partial VAP_{H_x}}{\partial H_x} = \sigma\beta(1 - \beta)^{\sigma} pF^{-\sigma} H_x^{\sigma-1} > 0$$

and

$$\frac{\partial^2 VAP_{H_x}}{\partial H_x^{\ 2}} = \sigma(\sigma - 1)\beta(1 - \beta)^{\sigma} pF^{-\sigma} H_x^{\sigma-2} < 0.$$

18) We can check this by a type of Marshallian Stability familiar from thespecific factors model. If skilled labor supplies are fixed in the two sectors at an allocation other than the point A, then skilled wages will differ in the short run between the two sectors. As drawn in Fig. 2, to the right of the point A skilled wages in sector Xwould be above those of sector Y. This would lead to move from sector Y to sector X and for skilled wages to equalize. A similar argument is valid if the short-run allocation is to the left of the point A.

Fig. 2. The factor market implications of trade in IT goods and services



$$w^H = w_x^H = w_y^H$$

Now consider trade in IT goods and services between two economies. The impact of trade in IT goods and services is to allow IT firms to sell their IT inputs to any X sector firm, no matter where it is located. This effectively integrates economically the X and Z sectors in the world markets. The production level of X sector in both economies expands via increases in n. As in the previous sector, in aggregate, the number of differentiated IT inputs rises from n to $2n_t$ eventually. In the post-trade equilibrium the productivity benefits of trade in IT goods and services lead to increase the productivity in technology sector. These productivity gains will raise skilled wages and reduce unskilled wages. The increase in wage inequality is thus correlated with an increase in trade in IT goods and services.

The new equilibrium in a representative economy is characterized by the following equations:

$$\left(w_x^H\right)_t = 2^\sigma p_t \beta (1-\beta)^\sigma F^{-\sigma} \left(H_x^t\right)^\sigma \tag{51}$$

$$\left(w_y^H\right)_t = \partial G\left(L, H_y\right) / \partial H_y \tag{52}$$

$$H_y^t + H_x^t = H \text{ and } w_t^H = \left(w_x^H\right)_t = \left(w_y^H\right)_t \tag{53}$$

The value of the average product curve is shifted upwards from VAP_{H_x} to $VAP_{H_x}^t$. Then the effect is represented in Fig. 2, which compares the autarky equilibrium, point A, and post trade in IT goods and services equilibrium, point C. Put differently, the skilled labor devoted to the IT inputs/technology sector is increased by $H_E H_E^t$ and the skilled wage is raised from w^H to w_t^H. The wage of unskilled labor is reduced as skilled labor shifts from the regular sector to the IT inputs/technology sector.

V. Concluding Remarks

This paper develops a simple two-sector general equilibrium model of noncomparative advantage trade between structurally identical developed countries. In order to highlight effects of trade in IT goods and services on the factor market, we employ the Dixit-Stiglitz (1977) representation of differentiated goods to specialized IT inputs. We suggest that IT goods and services as enabling intermediate inputs are produced with increasing returns and so differentiation is limited by the extent of the market, and increases with international trade in specialized IT goods and services.

This paper shows that IT inputs trade in the digital economy can affect the wage inequality in the advanced economies. A key insight of this paper is that in spite of the relative price decline of skill-intensive technology goods, the wage of skilled labor increases. The reason is that the price elasticity of demand for technology good is elastic. In the digital economy, trade in IT goods and services as intermediate inputs increases operating efficiency, reduces average costs in the technology sector, and eventually induces the relative price decline of technology goods. However, if and only if the technology is elastic, the relative price decline in technology goods results in the increased technology sector share of total expenditure. As a result, the wage premium to skilled labor increases in the IT inputs/technology sector and so does the real wage of skilled labor. These results are quite relevant to the new issues about liberalization of trade in IT goods and services as enabling intermediate inputs. In the digital economy such as the Korean economy as well as the advanced economies, therefore, trade liberalization in IT goods and services can result in not only significant welfare gains but also widening the wage gap between skills.

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논문초록

디지털경제에서의 국제무역과 소득격차

윤 상 철

본 논문은 구조적으로 동일한 선진경제들간의 비경쟁우위 무역에 관한 단순 2부문 일반균형모형을 제시한다. 주된 관심은 IT (정보기술) 재화 및 서비스무역이 임금격차에 미치는 영향에 집중되어 있다. 이 모형은 디지털경제에서의 임금격차가 주로 선진경제들간의 IT 재화 및 서비스무역에 기인되고 있음을 설명하고 확인한다. 특히, 이 논문은 IT 재화 및 서비스무역에 의해 숙련노동집약적인 기술재의 상대가격이 하락함에도 불구하고, 숙련노동에 대한 보수는 오히려 증가하고 있음을 보여 준다. 그 이유는 Jorgenson(2001) 교수가 경험적으로 뒷받침하고 있는 바와 같이 기술재에 대한 수요의 가격탄력성이 탄력적이기 때문이다.

주제어: IT 재화 및 서비스무역, 임금격차, 수요의 가격탄력성, 디지털경제