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TRADE IN KNOWLEDGE-BASED SERVICES: FACTOR MARKET IMPLICATIONS

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Using a model of 'trade in knowledge-based services' (e-Trade), the paper presents that recently increased wage inequality in advanced economies primarily reflects intra-industry trade in knowledge-based services with other advanced economies. In order to highlight the effects of trade in knowledge-based services on the factor markets in the presence of digital marketplaces, the paper employs the Chamberlinian monopolistic competition theory of intra-industry trade in intermediate inputs. In this model, there will be welfare gains from intra-industry trades in knowledge-based services. However, e-Trade results in increased wage inequality between the skilled and unskilled labors in the presence of sector-specific productivity growth. As a result, it increases the skilled labors devoted to the service sector, and expands the size of the service/technology sector.

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I. INTRODUCTION

There is a noted tendency for all advanced economies to simultaneously increase production and eventually their trades in most categories of services. In particular, knowledge-based services are both differentiated and knowledge intensive. As in Markusen (1989), knowledge intensity suggests the existence of strong scale economies since knowledge must be acquired with relating high

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initial learning costs, after which the knowledge-based services can be provided at a low marginal cost (as in an engineering consultant selling the same blueprints to different firms).

Historically, international trade flows have consisted mainly of goods. Whether it was spices or automobiles, it was far easier to ship goods overseas than services. Commodity trade occurs via the transport of goods from the location of production to the location of consumption. Service transactions are often characterized by the requirement that there be a double coincidence in both time and space of the proximity of the buyer and seller. For this reason the transportability and hence tradability of many services is limited. However, this situation is changing fundamentally with technological progress of information technology. New digital marketplaces such as Internet enable all types of knowledge-based services to trade at very low costs. Thus the incentives for specialization and outsourcing of knowledge-based services are increasingly expanding.

With the advent of the Internet, it becomes much easier to provide services of all types—banking, insurance, accounting, legal services, administrating, consulting, R&D, designs, data processing, advertising, retailing, auctions, publishing, gambling, etc.—through a Web site that is globally accessible. For instance, now plant managers control distant foreign production lines, financial advisors monitor the performance of worldwide investment opportunities by the minute, and scientists around the world team up on complex simulations of hurricanes or black holes via the Internet. Indeed, today we are in the midst of the "Third Industrial Revolution", fueled by advances in information technology. This revolution favors more skilled workers, replaces tasks previously performed by the unskilled, and exacerbates inequality (Camellia, 1999; Acemoglu, 2000). With skill-biased technological change, rising demand for skilled workers who effectively harness new information technologies has been outspacing supply. As a result, the skilled workers' wage has been increasing more rapidly than that of the unskilled workers. This supply-demand gap has been an important source of widening earnings inequality.

However, we may need to look deeper than skill-biased technological change if we are to fully understand widening wage dispersion. Rapidly expanding "trades in knowledge-based services via the digital marketplaces" (e-Trade) are the driving force behind increasing income inequality. Admittedly, most trades in knowledge-based services are of the intra-industry type among the developed economies. That is, increased trade in knowledge-based services with other developed economies rather than increased goods trade with developing countries is commonly viewed as the driving force behind the recently increased wage inequality between the skilled and unskilled workers in advanced economies.

In the theory of international trade, a number of papers have incorporated services in trade modeling. In the context of services as intermediate inputs produced with constant returns to scale, the Ricardo-Viner type of model (Jones and Ruane, 1990) and the Heckscher-Ohlin type of model (Melvin, 1989; Burgess, 1990) have been developed. In the context of producer services with increasing returns to scale, the contributions of Markusen (1989), Francois (1990), Ishikawa (1992), and Marrewijk, Stibora, Vaal and Viaene (1997) are of particular importance.

The relationship between inter-industry trade and inequality has been the subject of intensive research and debate in the last decades. Wood (1995), Freeman (1995), and Leamer (2000) argue that the increase in the wage inequality between skilled and unskilled labor reflects the positive effect of increased trade with developing countries. Their argument implies that North-South trade could result in major job losses for unskilled workers in the advanced economies even when the import penetration ratio is low, and trade between the two groups is balanced. However, Lawrence and Slaughter (1993), Bhagwati (1995), and Krugman (2000) argue that the decline in unskilled wages, and the growing inequality of earnings between skilled and unskilled labor has very little to do with the growing trade links with the developing countries. Their arguments are 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.[1]

This paper develops a model of intra-industry trade in knowledge-based services in the presence of digital marketplaces. The model is used to confirm and illustrate that recent changes in the distribution of income in advanced economies primarily reflect intra-industry trade with advanced countries rather than inter-industry trade with developing countries. The world economy consists of two identical developed countries. The model consists of two competitive sectors, one producing a manufacturing good with skilled and unskilled labor under constant returns to scale and the other a technology good generated by costlessly assembled differentiated knowledge-based services. These knowledge-based services are produced in the presence of increasing returns and monopolistic competition. In order to highlight effects of trade in knowledge-based services on the factor markets, we employ the Chamberlinian monopolistic competition theory of intra-industry trade in intermediate inputs along the line by Krugman (1979) and Helpman (1981). As in Ethier (1982) and Markusen (1989), the analysis have emphasized more on two-way trades in intermediate inputs than on final products trade. The welfare implications of two-way trade thus relate not only to consumer demand for final products, but also to the benefits of an increased division of labor and related productivity gains. The way in which we incorporate services into the monopolistic competition model is analytically similar to Markusen (1989) and Harris (1998). However, Markusen (1989) focused only on the welfare effect of trade in specialized intermediate inputs. In this model, we

[1] In the U.S. and U.K., the weekly earnings of the 90^{th} percentile worker relative to the 10^{th} percentile worker increased by over 23% for male from 1981 to 1995 (Acemoglu, 2002).

focus on the factor market implications of trade in knowledge-based services as intermediate inputs. Harris (1998) developed a general purpose technology model of interregional trade with interregional factor mobility in skilled labor affected by the advent of Internet. In this paper, we examine a model of intra-industry trade in knowledge-based services without international factor mobility in skille labor.

This paper is organized as follows. Section 2 develops the basic model and specifies the underlying assumptions. Section 3 discusses equilibrium in a closed economy. Section 4 examines the effects of opening trade in services in the presence of digital markets. Section 5 investigates its factor market implications. Section 6 provides some concluding remarks.

II. THE BASIC MODEL

In this section we consider an economy producing two final goods, X (the technology good) and Y (the manufacturing good), and n differentiated intermediate inputs or services, Z_i, $i=1, ..., n$. There are two factors of production, skilled and unskilled labor, denoted by S and L. Both are assumed to be physically immobile internationally.

The manufacturing sector uses unskilled and skilled labor with a constant-return-to-scale production function

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

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

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

$$X = \left(\sum_{i=1}^{n} Z_1^{\rho}\right)^{1/\rho}, \ 0 < \rho < 1 \tag{2}$$

where ρ is a positive monotone transformation of the elasticity of factor substitution.[2]

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

The intermediate input (service), Z_i is produced only by the skilled labor.[3] The total skilled labor (S_i) used in producing Z_i consists of a fixed input, F, and a variable input directly proportional to output Z_i:

$$S_i = F + Z_i \tag{3}$$

Note that skilled labor is used directly in the manufacturing sector but only indirectly in the technology sector as it is used to produce the intermediate inputs or services which are the sole inputs to the technology sector.

Within an economy, skilled labor is mobile between the manufacturing sector and services (intermediate inputs) sector. The existence of scale economies in the services sector limits the production of each intermediate input to at most one firm, since it is more profitable to produce a different variety than to share a market with another firm. Let S and L be the constant endowments of skilled and unskilled labor. Full employment of these factors requires:

$$S_y + \sum_{i=1}^{n} S_i = S \tag{4}$$

$$L_y = L \tag{5}$$

With identical technologies among all services suppliers, facing the same skilled wage rate, ν, the optimal output produced by the services suppliers are all equal: $Z_i = Z$ for all $i = 1, \dots, n$. Moreover, profit maximization requires that the marginal revenue equal the marginal cost which is the skilled wage rate:

$$q\left(1 - \frac{1}{\varepsilon}\right) = \nu, \quad i = 1, \dots, n \tag{6}$$

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

We take good Y as the numeraire, $p_y = 1$, and denote the relative price of X, p_x / p_y, by p. Producers of technology sector maximize profits by choosing the optimal inputs of services, taking the number of services firms (n), the relative price of good X (p), and the price of the services (q) as given, subject to production function (2). The first-order condition is given by

[3] In this paper, 'services' refer in most contexts to the knowledge-based services as intermediate inputs. 'Knowledge-based services' are mainly intermediate inputs in the production of technology goods. These do not include all services. However, this type of services is an important subject in current policy issues on trade in services.

$$p = qn^{-\sigma} \tag{7}$$

where $\sigma = (1-\rho)/\rho$. Using equation (6), the above first-order condition can be expressed as

$$n = (\nu/\rho p)^{\frac{1}{\sigma}} \tag{8}$$

At a constant p, an increase in the number of services reduces the cost of good X and therefore raises the skilled wage rate. This relation is depicted in Figure 1 as the OR curve.

Producers of manufactures 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

$$\frac{L}{S_y} = \frac{(1-\alpha)}{\alpha}\frac{\nu}{w} \tag{9}$$

where w is the unskilled wage rate. In the long run, new service firms enter the service markets until all firms break even. For $i = 1, \ldots, n$, we thus obtain

$$qZ_i = \nu S_i = \nu(F + Z_i) \tag{10}$$

Using equations (6) and (10), the output of a single service firm is constant and equals

$$Z_i = (\varepsilon - 1)F \tag{11}$$

Substituting equation (11) into (10), we get the amount of skilled labor employed in service sector i:

$$S_i = \varepsilon F \tag{12}$$

Combining this expression with the full employment condition (4) yields the so-called no-entry equation (E), which determines the number of services firms in the economy:[4]

[4] In general, from the first-order condition of profit maximization for a producer of good Y, we have

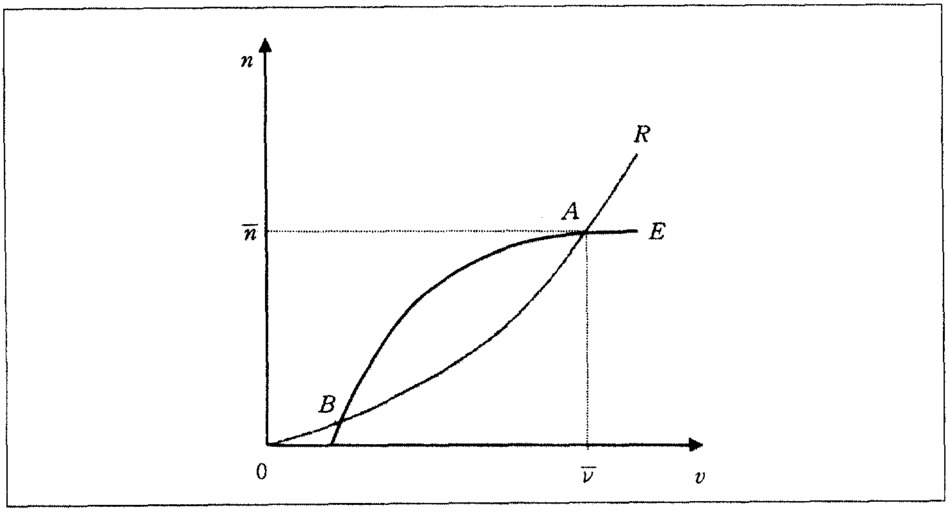
$$\nu = p_y\, G_{S_y}(L_y,\ S_y)$$

Hence, using $L_y = \overline{L}$ and $p_y = 1$, we have $S_y = S_y(\nu)$.

$$n = \frac{1}{\varepsilon F}[S - S_y(\nu)] \tag{13}$$

This is the second relation between the number of service varieties and the skilled wage rate, given the relative price p. When taken together, the relative cost equation and the no-entry equation determine the equilibrium number of service varieties and the equilibrium skilled wage rate, for given p and S. This situation is represented in Figure 1, which depicts the no-entry equation E and the relative cost equation R in the (ν, n) space.

[Figure 1] Production equilibrium $(\sigma < 1)$



The no-entry equation is always concave, while the relative cost equation is convex if and only if $\sigma < 1$.[5] The slope of the no-entry equation can be explained as follows: an increase in n requires additional skilled labor for the

[5] The no-entry equation (13) is always concave because

$$\frac{\partial n}{\partial \nu} = -\frac{1}{\varepsilon F} S_y'(\nu) > 0$$

and

$$\frac{\partial^2 n}{\partial \nu^2} = -\frac{1}{\varepsilon F} S_y''(\nu) < 0$$

where $S_y(\nu) = \alpha^{\frac{1}{1-\alpha}} \nu^{\frac{1}{\alpha-1}} L$ with $0 < \alpha < 1$, then $S_y'(\nu) < 0$, $S_y''(\nu) > 0$. The relative cost equation (8) is convex if $\sigma < 1$:

$$\frac{\partial n}{\partial \nu} = \frac{1}{\sigma} \beta^{-\frac{1}{\sigma}} p^{-\frac{1}{\sigma}} \nu^{\frac{1-\sigma}{\sigma}} > 0$$

and

$$\frac{\partial^2 n}{\partial \nu^2} = \frac{1}{\sigma}\left(\frac{1}{\sigma} - 1\right) \beta^{-\frac{1}{\sigma}} p^{-\frac{1}{\sigma}} \nu^{\frac{1-2\sigma}{\sigma}} > 0.$$

service/technology sector, which must be attracted from the manufacturing sector. Consequently, the marginal productivity of skilled labor in the manufacturing sector increases and the skilled wage rate goes up.

With respect to the relative cost which is in line with the upward sloping R -curve equation, an increase in the skilled wage rate increases the cost of producing X for given n and p. The only way to reduce costs and facilitate production of X is to increase the number of service varieties used.

As shown in Figure 1, there are generally two points of intersection of the R and E curves, illustrated here by A and B. The stable equilibrium is the point at which the slope of the relative cost equation exceeds that of the no-entry equation, which is point A.[6]

III. EQUILIBRIUM IN A CLOSED ECONOMY

In order to determine the autarkic equilibrium, we assume Cobb-Douglas preferences. Hence, a fixed share of income, μ, is spent on the technology good, while the remainder, $1-\mu$, is spent on the manufacturing good. National income consists of the skilled labor income and the unskilled labor income:

$$I(w, \nu) = wL + \nu S \tag{14}$$

The demand for the technology good X^d is a function of w, v and p:

$$X^d(w, \nu, p) = \mu(wL + \nu S)/p \tag{15}$$

The supply of good X^s can be written as a function of ν and p by using the production function (2), the first-order conditions for profit maximization (8), and the no-entry equation (13):

$$X^s(\nu, p) = \frac{\nu}{p}[S - S_y(\nu)] \tag{16}$$

Similarly, the demand and supply functions for good Y are, respectively,

[6] This can be checked by looking at what happens if the relative price of technology good rises. If the economy is on the concave part of its PPF, a rise in p leads to the required normal reaction in the sense that the production of technology good increases. This can only be the case if skilled labor employment in the service/technology sector, and thus the variety of services, rises. The skilled wage rate must therefore also rise in order to force manufacturing good producers to dismiss skilled labor. As in Figure 1, a rise in p takes the form of a shift of the R-curve to the right, equilibrium point A (not B) gives the required changes in n and ν.

$$Y^d(w, \ \nu) = (1-\mu)(wL + \nu S) \tag{17}$$

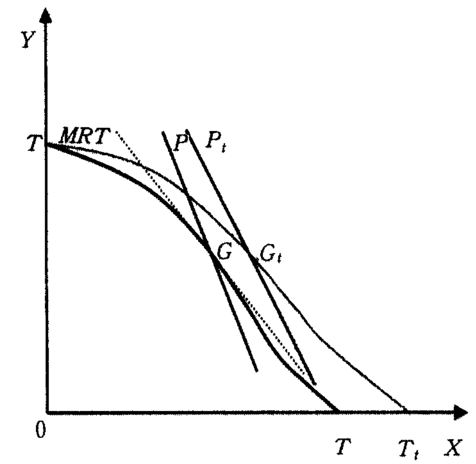
$$Y^s(\nu) = \alpha^{\frac{\alpha}{1-\alpha}} \nu^{\frac{\alpha}{\alpha-1}} L \tag{18}$$

The autarkic equilibrium for X good can be obtained by equating supply and demand, i.e., $X^s(\nu, p) = X^d(w, \nu, p)$. These results enable us to derive the PPF, yielding all production combinations of technology goods and manufacturing goods for which the factor market is cleared,

$$Y = L^{1-\alpha}\left[S - \left(\frac{1}{\rho}(\varepsilon F)^{\sigma} X\right)^{1/(\sigma+1)}\right]^{\alpha} \equiv f(X) \tag{19}$$

with $f'(X) < 0$.[7] 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 services varieties in the production of technology goods. That is, we assume that equilibrium occurs on the concave portion of the PPF in Figure 2.

[Figure 2] The production possibility frontier



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 equations (8), (9) and (19), the ratio of both at the autarky equilibrium equals

[7] With $f''(X)\left\{\begin{matrix} > \\ < \end{matrix}\right\}0$, the PPF is concave up to the unique inflexion point, $\hat{X} = \beta(\varepsilon F)^{-\sigma}\left[\frac{\sigma S}{\sigma+1-\alpha}\right]^{\sigma+1}$, and is convex thereafter.

$$\frac{MRT}{MRS} = \sigma + 1 \rangle\ 1 \Leftrightarrow MRT \langle\ p$$

As a result, in autarky the economy will produce and consume too much manufacturing good and not enough technology good. In Figure 2, TT is the PPF of the autarky. The autarkic equilibrium skilled wage, v, the autarkic number of firms, n (from equation (13)), and the autarkic price, p (from equation (8)) are as follows:

$$\nu = \alpha^{\alpha}(1-\mu)^{\alpha-1}(\alpha+\mu-\alpha\mu)^{1-\alpha}L^{1-\alpha}S^{\alpha-1} \tag{20}$$

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

$$p = \theta L^{1-\alpha}F^{\sigma}S^{\alpha-(1+\sigma)} \tag{22}$$

where $\theta = \mu^{1+\sigma}(1-\mu)^{\alpha-1}\rho\varepsilon^{-\sigma}\alpha^{\alpha}(\alpha+\mu-\alpha\mu)^{1+\sigma-\alpha}$. By using equations (16) and (17), the equilibrium production levels of good X and Y are:

$$X = \mu^{1+\sigma}\rho\varepsilon^{-\sigma}(\alpha+\mu-\alpha\mu)^{-(1+\sigma)}F^{-\sigma}S^{1+\sigma} \tag{23}$$

$$Y = (1-\mu)^{\alpha}\alpha^{\alpha}(\alpha+\mu-\alpha\mu)^{-\alpha}L^{1-\alpha}S^{\alpha}. \tag{24}$$

This equilibrium production point is shown by G in Figure 2.

Ⅳ. TRADE IN KNOWLEDGE-BASED SERVICES IN THE PRESENSE OF DIGITAL MARKETS

In this section we start with two structurally identical economies of the kind specified above, and that they have no trade initially. To make the point most strongly, assume that the economies have identical tastes, technologies and factor endowments. In a model of comparative advantage trade, there would be no reason for trade to occur between these economies, and no potential gains from trade. In this model of noncomparative advantage trade, however, there will be both trade and gains from trade which is all intra-industry trade in knowledge-based services. To see this, suppose that trade is opened between these two economies at zero transportation cost.

Consider a situation in which there is free trade in goods and services versus autarky, assuming trades in Y, X and Z. Symmetry ensures that skilled and unskilled wage rates in the two economies will be equal, and that the prices of the three goods produced in either economy will be respectively the same. Moreover, since-both economies have the same skilled-unskilled labor ratio, they produce the same quantity of manufacturing good per capita and the same number of services per capita. In this model, all trades are intra-industry type and there is no intersectoral trade: that is, no manufacturing good is exported or imported and net exports (imports) of services are zero in every economy.

The direction of intra-industry trade — which economy exports which services — is indeterminate; all we can say is that each knowledge-based service will be produced only in one economy, because there is no reason for firms to compete for markets in this model. However, the volume of intra-industry trade is determinate. Since all services will have the same price, expenditures on each economy's services will be proportional to the economy's factor endowments. The value of imports for services in home economy's expenditure, for instance, will be

$$M=\frac{\mu(wL+\nu S)n^*}{p(n+n^*)}=\frac{\mu^*(w^*L^*+\nu^*S^*)n}{p^*(n+n^*)}=M^* \tag{25}$$

as the same value of imports for the services in foreign economy's expenditure. Trade is balanced, as it must be, since each individual agents budget constraint is satisfied. The volume of trade as a fraction of world income is maximized when the economies are of equal size.

The key point to be gained from this analysis is that economies of scale in the Z sector can be shown to give rise to intra-industry trade and gains from intra-industry trade even when there are no international differences in tastes, technology, or factor endowments. Hence the production levels of technology good in both economies increase as a result of the positive externality associated with an increase in the number of varieties. That is, given the symmetric CES input structure, sector X purchases services from all worldwide service firms. Each economy demands twice the autarkic number of service varieties for its production of X goods but only accounts for half the world service production. Thus, in aggregate, the number of differentiated service inputs rises from n to $2n$.

This result enables us to derive the new PPF of trade in services, yielding all production combinations of technology goods and manufacturing goods for which trade in knowledge-based services results in increased productivity.

$$Y_t=L^{1-\alpha}\left[S-\left(\frac{1}{\rho}\left(\frac{\varepsilon F}{2}\right)^{\sigma}X_t\right)^{1/(\sigma+1)}\right]^{\alpha}\equiv f(X_t) \tag{26}$$

Indeed, as in equation (26), TT_t in Figure 2 is the new Pareto-optimum frontier which results from trade in knowledge-based services TT_t lies everywhere outside of TT locus except T. By using equations (22), (23), and (24), the equilibrium with trade in services is given in the following equations:

$$X_t = 2^{\sigma}\mu^{1+\sigma}\rho\varepsilon^{-\sigma}(\alpha+\mu-\alpha\mu)^{-(1+\sigma)}F^{-\sigma}S^{1+\sigma} \tag{27}$$

$$Y_t = (1-\mu)^{\alpha}\alpha^{\alpha}(\alpha+\mu-\alpha\mu)^{-\alpha}L^{1-\alpha}S^{\alpha} \tag{28}$$

$$p_t = 2^{-\sigma}\theta L^{1-\alpha}F^{\sigma}S^{\alpha-(1+\sigma)} \tag{29}$$

The output of X in each economy increases with trade in knowledge-based services as in equation (27). The new equilibrium production point with trade in knowledge-based services is illustrated by G_t in Figure 2. Each economy's income increases with trade in knowledge-based services due to commodity and factor price equalization and increasing returns to n. Hence this analysis provides that free trade in knowledge-based services is Pareto-superior to autarky.

V. FACTOR MARKET IMPLICATIONS

In this section we focus on the factor market implications of trade in knowledge-based services. Consider first an economy with an endowment of skilled labor S and unskilled labor L. Both X and Y goods are sold at world prices p and the numernaire. The price of service input i is q_i. The symmetric marginal cost equilibrium has n services produced in quantities $Z_i = Z$ with prices $q_i = q$. Within an economy, skilled labor is mobile between sectors Y and Z.

Using equation (8), we can solve for the skilled wage rate in the service/technology sector as a function of the relative price of X and the degree of input differentiation as follow:

$$\nu_x = \rho p n^{\sigma} \tag{30}$$

Equation (30) gives the value of the average product of skilled labor in the service/technology sector, and this is increasing in the level of input differentiation. In zero-profit monopolistically competitive equilibrium, the number of service varieties, n, adjusts such that price equals average cost on each variety. We therefore have from equation (10):

$$q = \nu + \frac{\nu F}{Z_i} \tag{31}$$

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

$$Z = F\left(\frac{\rho}{1-\rho}\right) \tag{32}$$

Total skilled labor use in sector X is given by

$$S_x = n(F + Z_i) \tag{33}$$

Solving the number of service varieties as a function of S_x gives

$$n = \frac{S_x}{F + Z_i} = \frac{S_x}{F}(1-\rho) \tag{34}$$

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

$$\nu_x = \rho p(1-\rho)^{\sigma} F^{-\sigma} S_x^{\sigma} \tag{35}$$

Equation (35) provides the value of the average product of skilled labor in the service/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

$$\nu_y = G_{S_y}(L_y,\ S_y) \tag{36}$$

Equation (36) gives the value of marginal product of skilled labor in the manufacturing sector and it is decreasing in the level of skilled labor input. The unskilled labor (L) is a specific factor in the manufacturing sector. So we also have the unskilled wage equals marginal products condition (or price equals unit cost) in that sector:

$$w = G_L(L, S_y) \tag{37}$$

Factor market clearing in a single market is depicted in Figure 3 (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 marginal product of skilled labor schedule in the manufacturing sector (VMP_{S_y}) is drawn, and on the right a rising value of the average product schedule for skilled labor in the technology sector (VAP_{S_x}). [8]

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[8] The VMP_{S_y} equation (37) is always convex, because

$$\frac{dVMP_{S_y}}{dS_y} = \alpha(\alpha-1)L_y^{1-\alpha}S_y^{\alpha-2} < 0$$

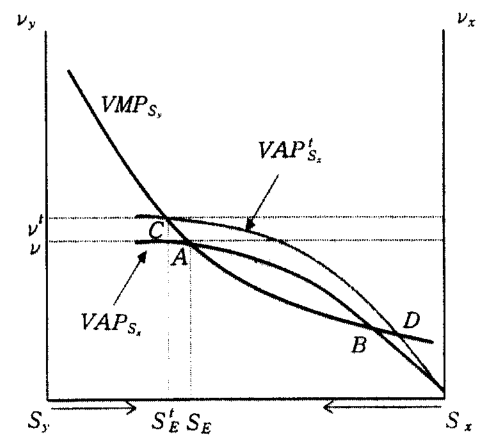
and

$$\frac{d^2\, VMP_{S_y}}{dS_y^{\ 2}} = \alpha(\alpha-1)(\alpha-2)L_y^{1-\alpha}S_y^{\alpha-3} > 0$$

with $0 < \alpha < 1$, while the VAP_{S_x} equation (36) is concave because

As in Figure 3, there are generally two points of intersection of the VMP_{S_y} and VAP_{S_x} curves, illustrated here by A and B. The stable equilibrium is the point at which the slope of the VMP_{S_y} is steeper than the slope of the VAP_{S_x}, which is the case at point A.[9]

[Figure 3] Skilled wages and trade in knowledge-based services



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

$$\nu = \nu_x = \nu_y \tag{38}$$

Now consider trade in knowledge-based services between two economies. The

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$$\frac{dVAP_{S_x}}{dS_x} = \sigma\rho(1-\rho)^{\sigma} pF^{-\sigma}S_x^{\sigma-1} > 0$$

and

$$\frac{d^2 VAP_{S_x}}{dS_x{}^2} = \sigma(\sigma-1)\rho(1-\rho)^{\sigma} pF^{-\sigma}S_x^{\sigma-2} < 0$$

if and only if $\sigma < 1$.

[9] We can check this by looking at what happens if the relative price of technology good rises. If the economy is on the concave part of its PPF, a rise in p leads to the required normal reaction in the sense that the production of technology good increases. This can only be the case if skilled labor employment in the service/technology sector, and thus the variety of services, rises. Therefore the skilled wage rate must rise in order to force manufacturing good producers to dismiss skilled labor. Hence, a rise in p takes the form of a shift of the VAP_{S_x} curve to the upwards, equilibrium point A gives the required changes in S_E and ν.

impact of trade in knowledge-based services is to allow service firms to sell their services to any X sector firm, no matter where it is located. This effectively integrates economically the X and Z sectors in the world markets. Since both are direct and indirect users of only skilled labor, the actual location of X sector output across economies is indeterminate. Given the symmetric CES input structure, sector X purchases services from all economies service firms. Thus, in aggregate, the number of differentiated service inputs rises from n to $2n$. In this model the productivity gains of trade in knowledge-based services will raise skilled wages and reduce unskilled wages. The increase in wage inequality is thus correlated with an increase in trade in knowledge-based services.

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

$$\nu_x^t = 2^{\sigma}\ \rho p(1-\rho)^{\sigma}\ F^{-\sigma} S_x^{\sigma} > \nu_x \tag{39}$$

$$\nu_y = G_{S_y}(L,\ S_y) \tag{40}$$

$$S_y^t + S_x^t = S \text{ and } \nu^t = \nu_x^t = \nu_y^t \tag{41}$$

The value of the average product curve is shifted upwards from VAP_{S_x} to $VAP_{S_x}^t$. Then the effect is represented in Figure 3, which compares the autarky equilibrium, point A, and post trade in knowledge-based services equilibrium, point C. Put differently, the skilled labor devoted to the service/technology sector is increased by $S_E S_E^t$ and the skilled wage is raised from ν to ν^t. The wage of unskilled labor is reduced as skilled labor shifts from the manufacturing sector to the service/technology sector.

Ⅵ. CONCLUDING REMARKS

The paper examines a model of "intra-industry trade in knowledge-based services in the presence of digital marketplaces" (e-Trade). The model is used to confirm and illustrate that recently increased wage inequality in advanced economies primarily reflect intra-industry trade with other advanced economies rather than inter-industry trade with developing economies. In order to focus on the effects of trade in knowledge-based services on the factor markets, the model adapts the Dixit-Stiglitz (1977) representation of differentiated goods to differentiated intermediate inputs. Knowledge-based services as 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 services.

In this model, there will be welfare gains from intra-industry trade in knowledge-based services but no intersectoral trade. As a result the wage premium to skilled labor increases and so does the real wage of skilled labor. It increases resources devoted to the service sector, and thus the size of the service/technology sector. At the same time the unskilled wage is lowered as skilled labor shifts from the manufacturing sector to the service/technology sector. Thus intra-industry trade in knowledge-based services (e-Trade) results in increased income inequality between skills in the presence of increased sector-specific productivity growth.

These results are particularly relevant to the current issues about liberalization of trade in knowledge-based services. The welfare results of this model suggest the possibility of significant gains from liberalized trade in knowledge-based services, especially via the Internet as a digital marketplace. In particular, the wage inequality results of this analysis show that the recent increase in inequality can be further explained by the increased trade in knowledge-based services through the newly emerging digital markets.

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