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**Information technology, richness of services and  
income distribution: is ICT after all the great equalizer?**

by

**Hildegunn Kyvik Nordås**

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# Information technology, richness of services and income distribution: is ICT after all the great equalizer?

Hildegunn Kyvik Nordås, SNF\*

## Abstract

*This paper discusses how information and communication technology (ICT) affects the richness and reach of services such as education, health and entertainment. These services consist of several components, some of which can be digitized and transmitted over geographical distances. Digitization and transmission require an investment in ICT. A general equilibrium model is developed and numerical simulations in a stylized two-factor, two-region, center-periphery setting are presented. Diffusion of information technology, modeled as a reduction in the cost of digitizing and transmitting information over geographical distances, has a dramatic impact on skilled workers' wages in the periphery, both relative to unskilled workers in their own region and relative to skilled workers at the center. Trade in intermediate services improves the welfare of low-income groups in the periphery and leads to a more equal distribution of income both between the center and the periphery and within the periphery.*

JEL codes: D23, F12, F13, R12, R13.

Keywords: Trade in services, transaction costs, income distribution, ICT

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\* E-mail: [Hildegunn.Nordas@snf.no](mailto:Hildegunn.Nordas@snf.no), Postal address Department of Economics, NHH, Helleveien 30, 5045 Bergen, Norway.

# 1 Introduction

Does the diffusion of information and communication technology (ICT) eliminate the relevance of distance? Or does the communication revolution lead to increased centralization? And are we witnessing a growing digital gap that leads to increased income disparities both within and across countries? These questions have given rise to a lively debate among scholars as well as policy makers and the general public. The low cost of storing and transmitting huge amounts of information allows people to access information, search for suppliers/customers, enter into contracts and exchange services without much regard for distance, goes the argument. However, the information economy is also characterized by rapid technological change, a high rate of innovation, customized products and short product cycles. In this environment of complexity, some essential information cannot be digitized but is entrenched in relationships and communicated through direct interaction. Leamer and Storper (2001) argue that coordination of economic activity across space is determined by two opposite forces. The transformation of complex tasks into routine activities that can be accomplished wherever the costs are lowest contributes to decentralization or de-agglomeration. On the other hand, frequent innovations that require complex coordination contribute to centralization or agglomeration.

There are several channels through which ICT may cause increasing income disparities. First, network externalities imply that the growth effect of ICT investments is higher after a critical mass has been reached. Röller and Waverman (2001) have estimated the critical mass to be close to universal access to telecommunications. The network effect will contribute to a widening income gap between those countries that have universal access to telecommunications and those countries where connectivity is still below that level. Second, ICT appears to be complementary to skilled labor. A growing share of ICT in total investment may therefore increase demand for skilled labor and at least temporarily bid up the wage rate of skilled labor. On the other hand, ICT makes the knowledge and information embodied in skills more easily accessible, and may therefore alleviate skills scarcity.

This paper explores the impact of ICT on key information-intensive services sectors such as health, education and entertainment. These sectors are important for social and economic development, they account for a relatively large share of national expenditure in most countries, they are skills-intensive and they employ a relatively large share of the total skilled labor force in most countries. Although these key consumer services are still largely seen as non-traded sectors, thanks to ICT they increasingly source inputs from far afield. In

the education sector interactive learning programs are used alongside traditional lectures, while students are encouraged to go to the Internet for information. In addition, ICT has provided teachers, lecturers and students alike with easy access to R&D conducted anywhere in the world. Finally, ICT has introduced the possibility of low-cost access to media and two-way communication with peers in other regions. In the health sector, local doctors and nurses have the opportunity to complement their skills and services with telemedicine, make use of distant laboratories for analyzing tests, and to outsource routine tasks such as the typing of patient journals to lower-cost regions or countries. In the entertainment sector, local companies assemble services such as cooking, serving food and drink, wide-screen direct broadcasting of football-matches or concerts taking place far afield, on-line gambling, and so on. Thus, although the final consumer services are still mainly provided by local suppliers, trade in intermediate services makes the final consumer services richer.

A formal model that captures these features of the services sectors is developed in the paper. Services are modeled as a composite of components or attributes that can be separated and provided from a distance when digitized. During digitization, some information may be lost such that information communicated directly face-to-face is richer than digitized information communicated over electronic networks. The loss of information is modeled as an iceberg transformation cost. In addition firms incur a fixed costs when entering the other region. The cost covers investment in ICT equipment, skills upgrading and the organizational restructuring necessary to connect to a network that transforms the service and transmits it to the other region. The model is developed for two regions that differ both in market size and relative factor endowments. The two regions can be interpreted in several ways, e.g., a rural and an urban region within a country, a small and a large country, or a rich and a poor country.

The paper studies how changes in the transformation cost affect trade and relative factor prices within and between regions for different levels of the fixed cost. I find that the impact is most dramatic for skilled workers in the Small region. The skills that yielded them a handsome premium in the local market in autarky become less valuable when faced with competition from imported skills-intensive services. The rest of the paper is organized as follows: Section two briefly reviews relevant literature on the interrelationship between location, income distribution and information technology. Section 3 develops the model in a closed economy and discusses its properties. The model is extended to a two-region setting with exogenously declining (iceberg) transformation costs in section 4, where I also present numerical simulations. Section 5 summarizes and concludes.

## 2 Relations to previous research

Harris (1998) developed a model of international trade in business services over the Internet. He applied a small open economy setting where prices are exogenously given in the world market, and digitized information is a perfect substitute to face-to-face communicated information. He found that the skills premium increases with skilled labor supply but that the location of business services firms is indeterminate. The model developed here, in contrast, applies a two-region general equilibrium framework in which prices are determined endogenously. This difference in approach turns out to yield opposite results regarding the relation between the supply of skilled workers and the skills premium. In my model the skills premium declines with skilled labor supply since output prices adjust to changes in cost. Furthermore, the transformation cost of traded services makes digitized and face-to-face communicated information less than perfect substitutes. With this feature the industrial structure in each region is determined in my model.

Venables (1994) introduced fixed costs of entering a foreign market in a Dixit-Stiglitz type model with symmetric countries and one production factor. Consumers follow a three-stage procedure of allocating expenditure. First they decide on the expenditure share of the industry in question. Next, expenditure on the industry is distributed on the varieties produced by each country according to the Armington assumption. Finally, expenditure on each variety is determined. This procedure is necessary in order to obtain a solution where both exporting and non-exporting firms can coexist in equilibrium. Venables shows that trade liberalization, modeled as a decline in variable iceberg trade costs, increases the proportion of trading firms and reduce the total population of active firms. The latter effect is due to the fixed cost of exporting, which implies that trading firms have to be larger than non-trading firms in order to recover the additional fixed cost. The model developed here also allows for the coexistence of exporting and non-exporting firms, but without the complex demand structure applied by Venables. Instead a sector-specific factor in the “traditional” sector and asymmetric regions sustain both types of firms in my model. I replicate Venables’ results that a reduction in variable trade costs, interpreted as a reduction in the cost of digitizing and transmitting information, will lead to an increase in the proportion of firms that engage in export activities, and that the number of varieties in the world economy will suffer. In addition, I analyze the consequences for income distribution within and between regions.

### 3 The model - autarky

The economy has three sectors, labeled X, Y and Z. The X-sector produces complex services such as education, health and entertainment. Its technology is assemblage of intermediate service inputs such as interactive training courses, lectures, broadcasted concerts, counseling etc. These intermediate service inputs are produced by the Z-sector, which consists of  $n$  firms producing differentiated services using skilled labor only. Their production technology exhibits increasing returns to scale. The Y-sector represents an aggregation of “traditional” industries producing goods and services employing unskilled and skilled workers. The number of unskilled and skilled workers in the economy is given exogenously. Products from the Y-sector are costlessly traded over geographical distances, while X-sector services are non-tradable. The number of firms in the Z-sector is determined endogenously in the model by the size of the X-sector. Skilled workers are fully mobile between sectors and firms. The production function of the Y-sector is a standard Cobb-Douglas constant returns to scale production function:

$$Y = L^\alpha S_y^{1-\alpha} \quad (1)$$

The symbol L represents unskilled labor, while S represents skilled labor. The assembly industry's production function is given by:

$$X = \left[ \sum_{i=1}^n z_i^\rho \right]^{1/\rho} \quad (2)$$

This is the familiar Dixit-Stiglitz framework where production increases both with the quantity of each input,  $z$ , and the number of inputs,  $n$ . The elasticity of substitution between any pair of intermediate services is given by  $\varepsilon \equiv 1/(1-\rho)$  and is assumed to be larger than unity. Each firm in turn produces its service subject to an increasing returns technology:

$$z_i = f + \frac{1}{b} s_i \quad (3)$$

where  $f$  is a fixed cost in terms of skilled labor. As usual in Dixit-Stiglitz type models, only one firm produces each input and each firm produces only one product. The number  $n$  thus

represents both the number of firms in the Z-sector and the number of differentiated services being supplied to the X-sector. Consumers have identical preferences described by the utility function:

$$U = AY^\sigma X^{(1-\sigma)} \quad (4)$$

The Cobb-Douglas form of the utility function implies that consumers spend a fixed share of their income on each good. The constant A is an exogenous parameter representing the non-market value that the consumer assigns to living in the region, which could be un-spoilt land areas and other non-commercial benefits from rural lifestyle in the periphery or urban lifestyle at the center.

I start by determining the autarky equilibrium of this economy, when endowments of skilled and unskilled labor are given outside the model. I follow Harris (1998) in assuming that producers of differentiated intermediate services operate in a market characterized by monopolistic competition and thus set the price of the service according to the mark-up price rule:

$$q = \frac{bv}{\rho} \quad (5)$$

where  $v$  is the unit cost of skilled labor. I further assume that there is free entry of firms into the Z-sector. Firms will in that case enter until the profit of the last firm entering is zero. The non-zero profit condition in the service sector is the same for all firms due to symmetry and reads:

$$q = \frac{fv}{z} + bv \quad (6)$$

Combining (5) and (6) yields the unique size of the service producing firm:

$$z = \frac{f}{b} \frac{\rho}{(1-\rho)} \quad (7)$$

The number of firms is determined by the extent of the market and the endowment of skilled labor. The assembly sector is competitive, implying marginal cost pricing:

$$p_x = qn^{(\rho-1)/\rho} = \frac{bv}{\rho} n^{(\rho-1)/\rho} \quad (8)$$

Market equilibrium in the X-sector can now be determined by the following demand and supply conditions:

$$p_x X = (1-\sigma)(wL + vS) \quad \text{and} \quad X = n^{1/\rho} \frac{f\rho}{b(1-\rho)} \quad (9)$$

We now turn to the labor market in order to close the model. Employment of skilled labor in the Z- and Y-sectors, and the skilled labor market equilibrium are given by:

$$S_z = n(f + bz) = \frac{nf}{1-\rho} \quad (10)$$

$$S_y = \frac{(1-\alpha)p_y Y}{v} = \frac{(1-\alpha)\sigma(wL + vS)}{v} \quad (11)$$

$$S_y + S_z = S \quad (12)$$

Inserting (10) and (11) in (12), using (9) yields the allocation of skilled workers between sectors Y and Z:

$$S_y = \frac{(1-\alpha)\sigma}{1-\alpha\sigma} S; \quad S_z = \frac{(1-\sigma)}{1-\alpha\sigma} S \quad (13)$$

Allocation of skilled labor in other words depends on the technology in the Y-sector, i.e., its skills intensity, and consumer preferences. The more skills intensive the traditional sector and the higher the share of their income consumers spend on traditional goods and services, the less skilled workers are employed in the Z-sector. The number of services produced in the economy is determined by (10) and (13):



$$n = \frac{(1-\rho)(1-\sigma)}{f(1-\alpha\sigma)} S \quad (14)$$

Evidently the number of services being produced in the economy and employment in the Z-sector are determined by the same factors since the only input in the Z-sector is skilled labor. In addition  $n$  is determined by the fixed cost of producing services,  $f$ , and the elasticity of substitution between producer services in the assembly industry. The higher the elasticity of substitution and the higher the fixed costs, the lower the number of service firms. The intuition behind this is that when producer services can be easily substituted, there is little to gain from having additional varieties. The linkage between the elasticity of substitution in the X-sector and the number of firms in the Z-sector is an externality between the two sectors. However, since  $\rho$  also appears in the mark-up rate on the price of  $z$  given in equation (5), the externality is internalized by the market and it is therefore termed a pecuniary externality.

The skill premium, defined as the income earned by skilled workers over and above that of unskilled workers, can be found by using (11) and (13).

$$\frac{v}{w} = \frac{(1-\alpha\sigma)}{\alpha\sigma} \frac{L}{S} \quad (15)$$

We see that the skill premium depends on the relative endowments of skilled and unskilled labor, the skill intensity of the manufacturing sector and consumer preferences. As opposed to the Harris (1998) model of a small open economy, the skill premium declines with the endowment of skilled labor, due to general equilibrium effects on relative prices. One of the main findings in the Harris model, namely that an increase in the total supply of skilled labor leads to an increase in the skill premium, does not hold in a general equilibrium framework where output prices are allowed to adjust to changes in costs.

## 4 The two-region case

In this section a second region is introduced. The two regions are distinct in the sense that each region constitutes a closed labor market and a closed market for the X-sector. Skilled workers can move between sectors within the region but not across regions, and unskilled workers cannot move across regions. Finally, Z-sector services can be traded at no cost within each region, but costs are incurred in order to enter the other region and transmit the service

across regions. The two regions have the same production technology described by equations (1) and (3), while the X-sector now gets access to services from the other region and thus assembles both local and imported services. Z-sector services are digitized and transmitted between the two regions subject to an iceberg transformation cost,  $t > 1$ , reflecting the loss of information of electronic communication relative to direct communication. In order to digitize information, the Z-sector service firm also needs to invest in ICT equipment, skills upgrading, organizational restructuring, marketing and possibly also translate the embodied information to another language or another cultural context. We represent this investment by a fixed cost denominated  $g$  that comes on top of the fixed costs  $f$  of setting up a firm. The fixed cost is assumed to be in terms of skilled labor. Given the declining costs of ICT equipment (Jorgenson, 2001) and the relatively high cost of *adopting* ICT (Bresnahan et. al., 2002), this may not be a too unrealistic simplifying assumption. Furthermore, several studies have found that sunk costs of entering export markets are significant in manufacturing industries (Roberts and Tybout, 1997; Bernard and Bradford Jensen, 2001). It is thus not unlikely that similar and significant entry costs are present also for prospective exporters in services industries. In our setting some service providers may choose to export, while others may choose to service the local market only. We denote the share of Z-sector firms that makes the investment  $g$  and exports,  $\theta$ , where  $0 \leq \theta \leq 1$ .<sup>1</sup> The share is endogenously determined in the model. All variables related to Small are denoted with an asterisk.

Equation (3) applies to the service providers that service the local market only, while the service exporters' production function reads:

$$z_i = f + g + \frac{1}{b} s_i \quad (16)$$

We maintain our assumption of free entry in the export market as well as the local market such that the non-profit condition for the exporting firm reads:

$$q = \frac{(f + g)v}{z} + bv \quad (17)$$

and the unique size of the exporting service firm:

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<sup>1</sup> See Venables (1994) for a discussion.

$$z = \frac{(f + g)}{b} \frac{\rho}{(1 - \rho)} \quad (18)$$

Obviously, the exporting firm is larger than the firm producing for the local market only. There are now two possible types of producer service firms in each market; small firms servicing the home market only, and exporting firms servicing both regions. The market clearing condition for each type of firm, given free entry both in the home and export markets reads:

$$\frac{q^{-\varepsilon}}{P_x^{1-\varepsilon}} E = \frac{f\rho}{b(1-\rho)} \quad (19a)$$

$$\frac{q^{-\varepsilon}}{P_x^{1-\varepsilon}} E + \frac{q^{-\varepsilon}\tau}{P_x^{*(1-\varepsilon)}} E^* = \frac{(f+g)\rho}{b(1-\rho)} \quad (19b)$$

$$\frac{q^{*-\varepsilon}}{P_x^{*1-\varepsilon}} E^* = \frac{f\rho}{b(1-\rho)} \quad (19c)$$

$$\frac{q^{*-\varepsilon}}{P_x^{*1-\varepsilon}} E^* + \frac{q^{*-\varepsilon}\tau}{P_x^{(1-\varepsilon)}} E = \frac{(f+g)\rho}{b(1-\rho)} \quad (19d)$$

where  $E$  represents expenditure on the X-sector and  $P_x$  the cost index of the X-sector. We define  $\tau = t^{1-\varepsilon}$ ;  $0 < \tau < 1$ . This definition makes it more convenient to make graphical presentations of changes in the endogenous variables as a consequence of changes in transformation costs for the full range of transformation costs from unity to infinity. Note that there are no transformation costs and all relevant information is maintained during transformation when  $\tau = 1$ , while there are infinite transaction costs and no relevant information is maintained during transformation when  $\tau = 0$ . The price of services sold to the other region is multiplied by  $\tau$ , the iceberg transaction costs parameter, in order to account for losses during digitization and transmission. Inspection of the four market clearing conditions reveals that all of them are satisfied simultaneously only when wages are the same in both regions and  $\tau = g/f$ . This is a case that could only occur by coincidence when all three parameters are exogenous and independent of each other.<sup>2</sup> We therefore disregard the

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<sup>2</sup> There is, however, a possibility that  $\tau = \tau(g)$ , a possibility I leave for future research.

possibility that all four types of firms can coexist in the two regions. We are then left with five possibilities:

1.  $\theta^* = 1$  and  $\theta = 1$ ; all firms in both regions export;
2.  $\theta^* = 1$  and  $0 \leq \theta \leq 1$ ; all firms in Small export while some firms in Big export;
3.  $\theta^* = 0$  and  $0 \leq \theta \leq 1$ ; no firms in Small export while some firms in Big export;
4.  $0 \leq \theta^* \leq 1$  and  $\theta = 1$ ; some firms in Small export while all firms in Big export;
5.  $0 \leq \theta^* \leq 1$  and  $\theta = 0$ ; some firms in Small export while no firm in Big export.

It turns out that in our numerical example with strongly asymmetric factor endowments and market size, and significant fixed costs of entering the export market, case four where all Bigian firms export is only economically feasible for a narrow range of  $\tau$  at low levels of  $g$ . The Smallian market is simply too small for all firms in Big to recover the fixed cost of entering when they compete with local firms that have not incurred this cost. It also turns out that case five where only Smallian firms export is economically infeasible. This time the cost of the Smallian firms is too high for them to be competitive on the Bigian market, due to their higher skills premium. We are then left with three economically feasible solutions; case 1, 2 and 3, which we explore in more detail.

In all cases traditional goods are freely traded between the two regions, and their price must therefore be the same in both regions. This gives us the equilibrium condition:

$$\left(\frac{w}{\alpha}\right)^\alpha \left(\frac{v}{1-\alpha}\right)^{1-\alpha} = \left(\frac{w^*}{\alpha}\right)^\alpha \left(\frac{v^*}{1-\alpha}\right)^{1-\alpha} \quad \text{or} \quad \left(\frac{w}{w^*}\right)^\alpha = \left(\frac{v^*}{v}\right)^{1-\alpha} \quad (20)$$

Employment of skilled labor in the producer service sector in Big reads:

$$S_z = (1-\theta) \frac{nf}{1-\rho} + \theta \frac{n(f+g)}{1-\rho} = \frac{n(f+\theta g)}{1-\rho} \quad (21)$$

and equivalently for Small. The equilibrium condition in the skilled labor market is then found using (21) and the first order conditions for profit maximization in the final goods sector in the two regions, i.e., equation (11) and  $L = \alpha P_y Y / w$ , and similar for Small:

$$\frac{vn}{v^* n^*} = \frac{(\alpha v S - (1-\alpha)wL)}{(\alpha v^* S^* - (1-\alpha)w^* L^*)} \frac{(f + \theta^* g)}{(f + \theta g)} \quad (22)$$

Balance in the market for goods produced by the Y-sector can be expressed as follows:  
 $P_y(Y + Y^*) = \sigma(wL + vS + w^*L^* + v^*S^*)$  which, reorganizing and using the first-order condition mentioned above, can be expressed as:

$$\frac{1 - \alpha\sigma}{\alpha\sigma} = \frac{vS + v^*S^*}{wL + w^*L^*} \quad (23)$$

In order to solve the equation system, we first define relative wages and the relative number of services in the two regions as follows:

$$\frac{n}{n^*} \equiv \tilde{n}; \quad \frac{v}{v^*} \equiv \tilde{v}; \quad \frac{w}{w^*} \equiv \tilde{w} \quad \frac{L}{L^*} \equiv \tilde{L}; \quad \frac{S}{S^*} \equiv \tilde{S}$$

Using these definitions, (20), (22) and (23) can be written as:

$$\tilde{w} = \tilde{v}^{(\alpha-1)/\alpha} \quad (24)$$

$$\tilde{n}\tilde{v} = \frac{(f + \theta^*g) \left[ (1 - \alpha\sigma)(\tilde{w}\tilde{L} + 1)\tilde{v}\tilde{S} - (1 - \alpha)\sigma(\tilde{v}\tilde{S} + 1)\tilde{w}\tilde{L} \right]}{(f + \theta g) \left[ (1 - \alpha\sigma)(\tilde{w}\tilde{L} + 1) - (1 - \alpha)\sigma(\tilde{v}\tilde{S} + 1) \right]} \quad (25)$$

We next consider each of the three feasible cases listed above.

#### 4.1 All firms in both regions export

In the case where all firms in both regions export, there are no firms producing for the local market only. Thus, conditions (19a) and (19c) are irrelevant and (19b) and (19d) yields;

$$\frac{1 - \tilde{v}^{-\varepsilon}\tau}{\tilde{n}\tilde{v}^{1-\varepsilon}\tau + 1} \frac{\tilde{n}\tilde{v}^{1-\varepsilon} + \tau}{\tilde{v}^{-\varepsilon} - \tau} = \frac{\alpha\sigma(\tilde{v}\tilde{S} + 1)\tilde{w}\tilde{L} + (1 - \alpha\sigma)(\tilde{w}\tilde{L} + 1)\tilde{v}\tilde{S}}{\alpha\sigma(\tilde{v}\tilde{S} + 1) + (1 - \alpha\sigma)(\tilde{w}\tilde{L} + 1)} \quad (26)$$

The market equilibrium is given by (24), (25), and (26) setting  $\theta = \theta^* = 1$ , which constitute three equations in three independent variables  $(\tilde{w}, \tilde{v}, \tilde{n})$ . The system is uniquely determined, but it is not possible to find a general analytic expression for each of the three independent

variables. We therefore turn to numerical solutions of the model.<sup>3</sup> In order to capture a realistic center-periphery structure, Big has a much larger population than Small, and the share of the population being skilled is much higher in Big. Table 4.1 presents parameter values and endowments of skilled and unskilled labor in a stylized example of the Bigian and the Smallian economy.

Table 4.1 Endowments and parameters

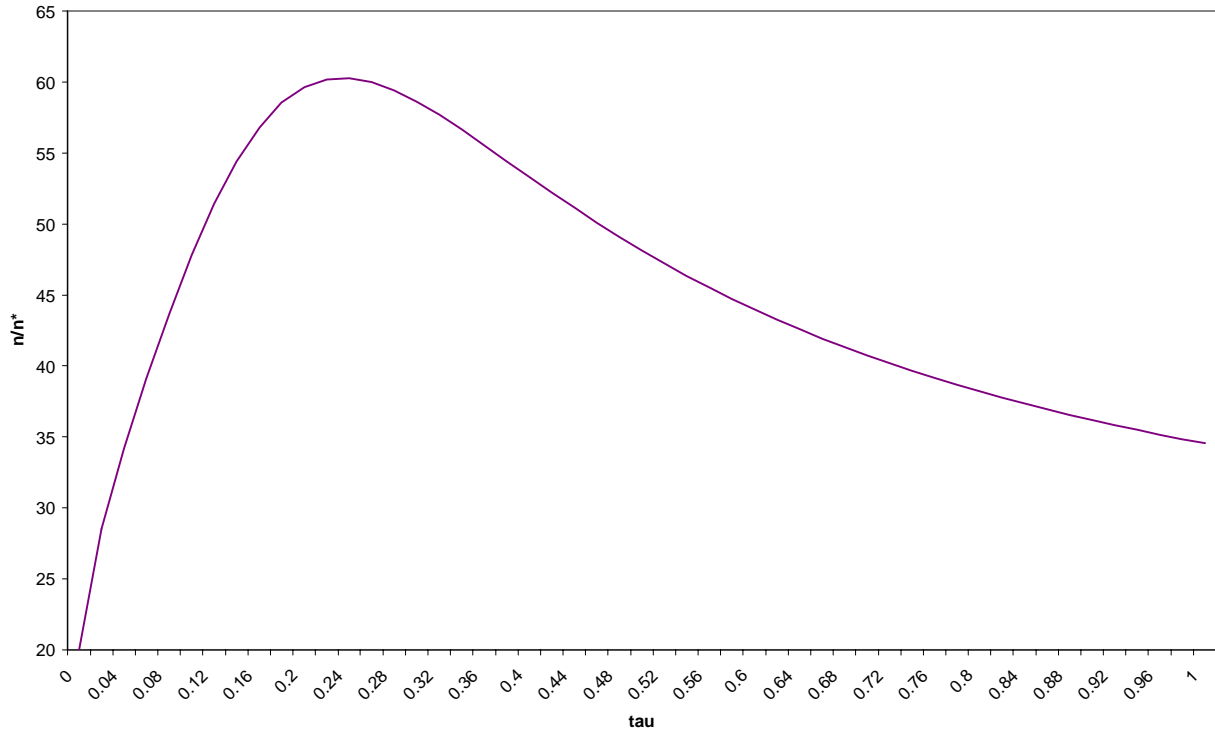
Variable/parameter	Big	Small
Skilled labor	500	25
Unskilled labor	500	50
$\alpha$	0.7	0.7
$\rho$	0.75	0.75
$\sigma$	0.6	0.6

Defining the numeraire  $w = 1$ , it is possible to find the absolute levels of all the endogenous variables in the equation system measured in units of unskilled labor in Big. We ran the model for four alternative levels of the entry cost,  $g$ , (0, 0.4, 1, 1.5). Let us start with analyzing the location of firms in the Z-sector as a function of  $\tau$ . The simulation results are presented in figure 4.1. The transformation costs parameter is given along the horizontal axis, and transformation costs decline as we move from the left to the right.

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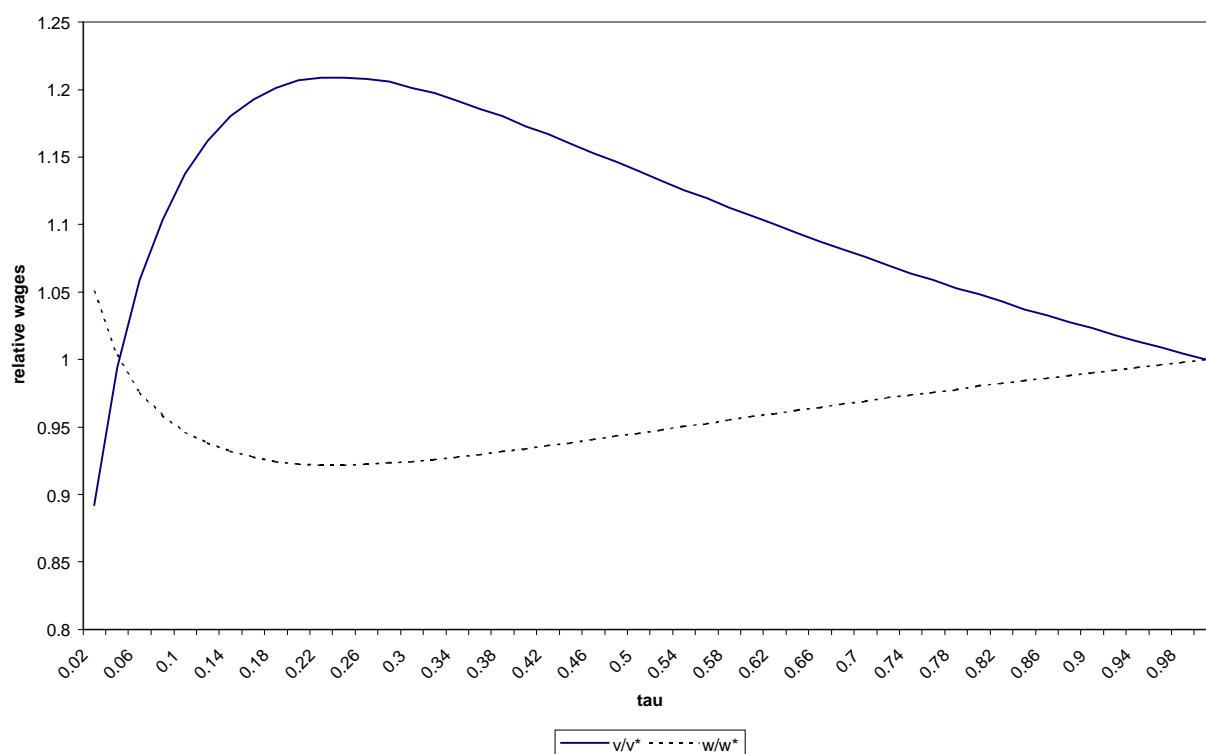
<sup>3</sup> The numerical simulations are run in the GAMS programming software.

Figure 4.1: Relative number of z-sector firms



As can be seen from equations (24) – (26), the relative number of firms is independent of the fixed cost  $g$  as long as it is the same in both regions. The absolute number of firms, in contrast, declines when  $g$  increases. In our numerical example,  $n + n^* \approx 90$  when  $g = 0$  (about the same as in autarky),  $n + n^* \approx 65$  when  $g = 0.4$ ,  $n + n^* \approx 45$  when  $g = 1$  and  $n + n^* \approx 36$  when  $g = 1.5$ . We could find a solution to the model where both regions host Z-sector firms for all  $\tau \in (0,1)$  when  $g = 0$  and  $g = 0.4$ . For relatively high fixed costs ( $g = 1$  and  $g = 1.5$ ), there will be z-sector firms located in Small for very high and very low transformation costs, but not for intermediate values of  $\tau$ . In all our simulations, Z-sector firms cluster in Big as transformation costs decline from infinity to a critical level represented by the peak in figure 4.1. When transformation costs decline further, the agglomeration process is reversed, and Z-sector firms start moving back to Small, taking advantage of the lower wages for skilled workers there. Developments in relative wages are presented in figure 4.2.

Figure 4.2. Relative wages for skilled and unskilled workers

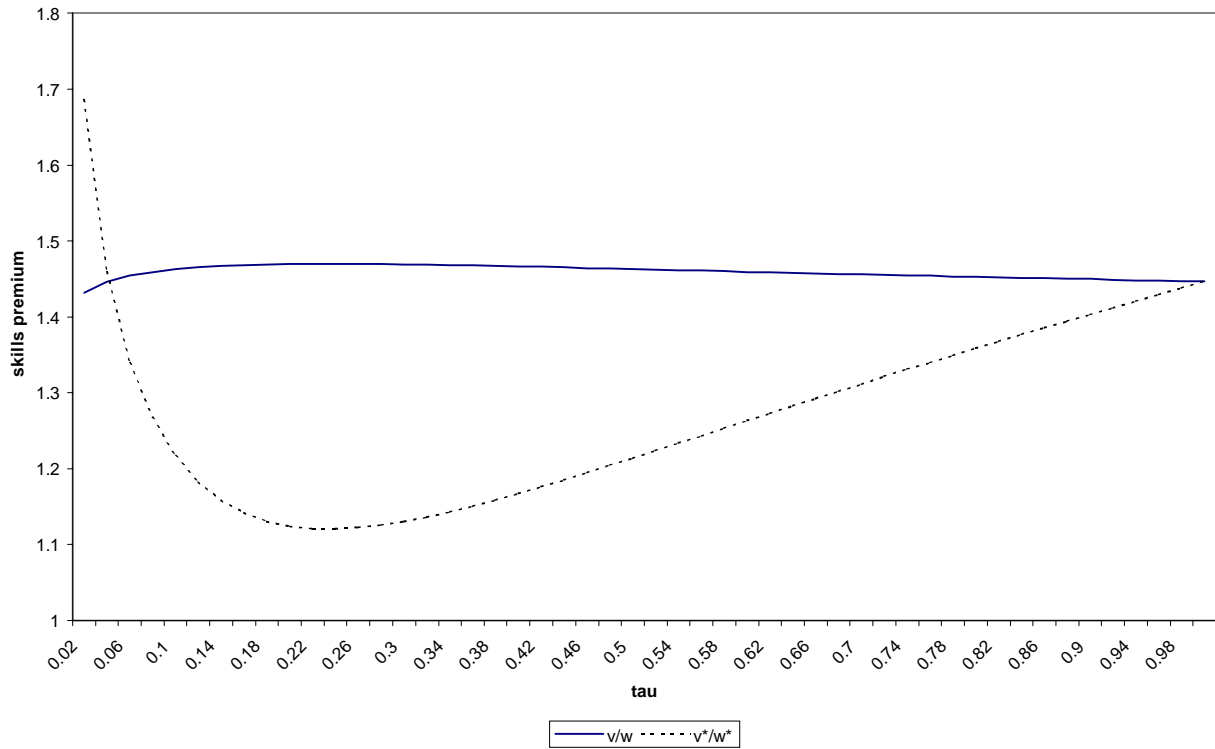


We notice from equations (24) – (26) that relative wages are independent on the fixed costs. In autarky and at very high transformation costs, skilled workers are better paid and unskilled workers are less paid in Small than in Big. However, this is reversed after a short interval as we move along the horizontal axis. After having reached a peak/bottom, relative wages for skilled/unskilled workers converge as transaction costs come down, and since the wage gap was largest for skilled workers, the change in relative income is largest for this income group. We can interpret this as the impact on income distribution between the two regions as a consequence of integration of the two regions' Z-sector markets.

Market integration also has an impact on income distribution *within* the regions. Figure 4.3 depicts the skills premium in the two regions. The skills premium change dramatically in Small as the skills scarcity is gradually alleviated through imports of the skills-intensive intermediate services from Big.



Figure 4.3. Skills premium in the two regions



The development depicted in figures 4.1-4.3 can be explained as follows. Because of returns to diversity, the X-sector producers in both regions will use all varieties of producer services, both the locally produced and the varieties produced in the other region. However, since Small has fewer producer service firms (see figure 4.1), and therefore purchases a larger number of services from the other region, the increase in the number of varieties and the relative importance of transformation costs are higher in Small. Consequently, the change in the cost index of the X-sector is larger in Small. In both regions trade in services leads to an increase in the X-sectors' purchases of services from the other region, at the expense of local producers. At high transaction costs, exports to the other region more than outweigh the decline in local demand for producer services in Big, while this is not the case in Small. New service firms are established in Big, while existing firms go out of business in Small. Since the skills premium is determined by employment in the Y-sector,  $v/w = (1 - \alpha)L/\alpha S_y$ , the skills premium increases in Big while it declines in Small.

The process is reversed when a point is reached where the expansion of the market more than compensates Smallian Z-sector firms for the loss of market share in their home market. We label the transformation cost level associated with the turning point  $\tau^*$ . From this analysis it is clear that the adjustments induced by integration of the Z-sector services markets

mainly fall on Smallian skilled labor. We further notice that the richness of the Smallian X-sector (i.e., the number of Z-sector services assembled) increases tremendously as trade in the Z-sector is opened between the regions. Even for the highest level of  $g$  in our example, the number of services assembled increased 9-fold, while there is only a marginal increase in the number of services assembled in Big.

In order to obtain the solution in this section it was implicitly assumed that there is a coordinated entry into the other region's market. If we instead look at each individual firm's decision whether to enter the other region or not when the initial situation is autarky, the outcome will be different. The individual firm will not take its own actions' impact on prices into account. Thus, a Bigian firm will break out of autarky and start exporting to Small if its mark-up on sales to Small covers the fixed cost  $g$ :

$$\frac{b}{\rho} \frac{q^{-\varepsilon} \tau}{P_x^{*1-\varepsilon}} E^* > g \quad \text{where } P_x^{*1-\varepsilon} = n^* q^{*1-\varepsilon}$$

Inserting the price index in the entry condition, we get:

$$\tilde{v}^{-\varepsilon} \frac{b}{\rho} \frac{\tau}{n^* q^*} E^* > g .$$

$E^*/n^* q^*$  represents purchases per local firm in Small in autarky and is given by equation (7). This yields:

$$\tau > \tilde{v}^{-\varepsilon} \frac{g}{f} (1 - \rho)$$

We have from (15) that in autarky the relative wages of skilled workers are  $\tilde{v} = \tilde{w}\tilde{L}/\tilde{S}$  and relative wages of unskilled workers (when measured in physical units of sector Y goods) are  $\tilde{w} = (\tilde{S}/\tilde{L})^{1-\alpha}$ . The condition for the first Bigian firm breaking out of autarky is then given by:

$$\tau > \left( \frac{\tilde{L}}{\tilde{S}} \right)^{\alpha\varepsilon} \frac{g}{\varepsilon f} \tag{27a}$$

and equivalently the first Smallian firm will break out of autarky and start exporting when

$$\tau > \left( \frac{\tilde{L}}{\tilde{S}} \right)^{-\alpha\varepsilon} \frac{g}{\varepsilon f} \quad (27b)$$

Clearly, for the relative factor endowments applied here, the entry barrier to the other region is higher in Small than in Big.<sup>4</sup> The findings here are similar to those of the Big-push literature (Murphy, Shleifer and Vishny, 1989) where the solution with trade is sustained in the market once it is established, but no single firm would break out of autarky on its own before transmission costs have come significantly down.

#### 4.2 Some firms in Big export

We consider case 2 and 3 in this section, starting with case 2. When all firms in Small and some firms in Big export,  $\theta^* = 1$  and  $0 \leq \theta \leq 1$ . We insert these values in equation (25). Equation (24) still applies, while since there are no firms servicing the Smallian market only, equation (19c) does not apply. Relative wages are determined from (19a), (19b) and (19d) which yields:

$$\tilde{v} = \left[ \frac{(g+f)\tau}{g+f\tau^2} \right]^{1/\varepsilon}; \quad \tilde{w} = \left[ \frac{(g+f)\tau}{g+f\tau^2} \right]^{(\alpha-1)/\alpha\varepsilon} \quad (28)$$

We note that relative wages now do depend on the fixed costs, but not on the share of firms that engage in exports. The relative wages of skilled workers increase with  $\tau$  (declines with  $t$ ) when  $\tau < (g/f)^{1/2}$  and decline with  $\tau$  when  $\tau > (g/f)^{1/2}$ , while the opposite is true for relative wages of unskilled workers. The development is thus similar to that represented in figure 4.2 and table 4.2, when  $\tau^* = (g/f)^{1/2}$ . We also notice that  $\tilde{v} > 1$  when  $g/f < \tau$ , i.e., when the ratio of fixed costs of setting up a firm and entering the foreign market is smaller than the transformation cost parameter. We further notice that if  $g < f$ , there is a reversal of relative factor prices between the two regions at  $g/f = \tau$ . At lower values of  $\tau$  (higher transformation costs) the Smallian skilled workers earn the highest wages, while at higher values of  $\tau$  the

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<sup>4</sup> For the parameters and endowments chosen in our numerical simulations, a Bigian firm will break out of autarky for  $\tau = 0.014$  for  $g = 0.4$ ,  $\tau = 0.035$  for  $g = 1$  and  $\tau = 0.053$  for  $g = 1.5$ , while a Smallian firm will break out of autarky for  $\tau = 0.70$  for  $g = 0.4$  while it will not enter at all when  $g = 1$  and  $g = 1.5$ .

Biggian skilled workers earn the highest wages. If on the other hand  $g > f$ , there will be no relative factor price reversals, and skilled workers in Small will always earn at least as much as their Bigian colleagues. We finally notice that for  $\tau = 1$ ,  $\tilde{w} = \tilde{v} = 1$  and thus relative income converges as transformation costs come down.

In case three, where  $\theta^* = 0$ ,  $0 \leq \theta \leq 1$ , there are no exporting firms in Small and equation (19b) does not apply. We can then find relative wages by combining (19a), (19c) and (19d) which yields:

$$\tilde{v} = \left( \frac{\tau f}{g} \right)^{1/\varepsilon} \quad \text{and} \quad \tilde{w} = \left( \frac{\tau f}{g} \right)^{\alpha-1/\alpha\varepsilon} \quad (29)$$

We notice that also in this case  $\tilde{v} > 1$  when  $\tau > g/f$ . We also notice that factor prices are equalized when the transformation cost parameter equals the fixed cost, and that this point marks a factor price reversal. Finally, we notice that factor prices are not equalized when  $\tau = 1$  (unless  $f = g$ ).

A solution where no Smallian firms export will not be a stable equilibrium if a single Smallian firm would be able to cover the fixed cost if entering the Bigian market on its own. In so doing it will not take the impact of its own actions on relative wages and the price index of the X-good into account. It will enter the Bigian market if the mark-up on the quantity exported is at least sufficient to cover the fixed cost of entering the export market:

$$\frac{b}{\rho} \frac{q^{*-\varepsilon} \tau}{P_x^{1-\varepsilon}} E > g \quad \text{where} \quad P_x^{1-\varepsilon} = nq^{1-\varepsilon}$$

Inserting the price index in the entry condition, we get

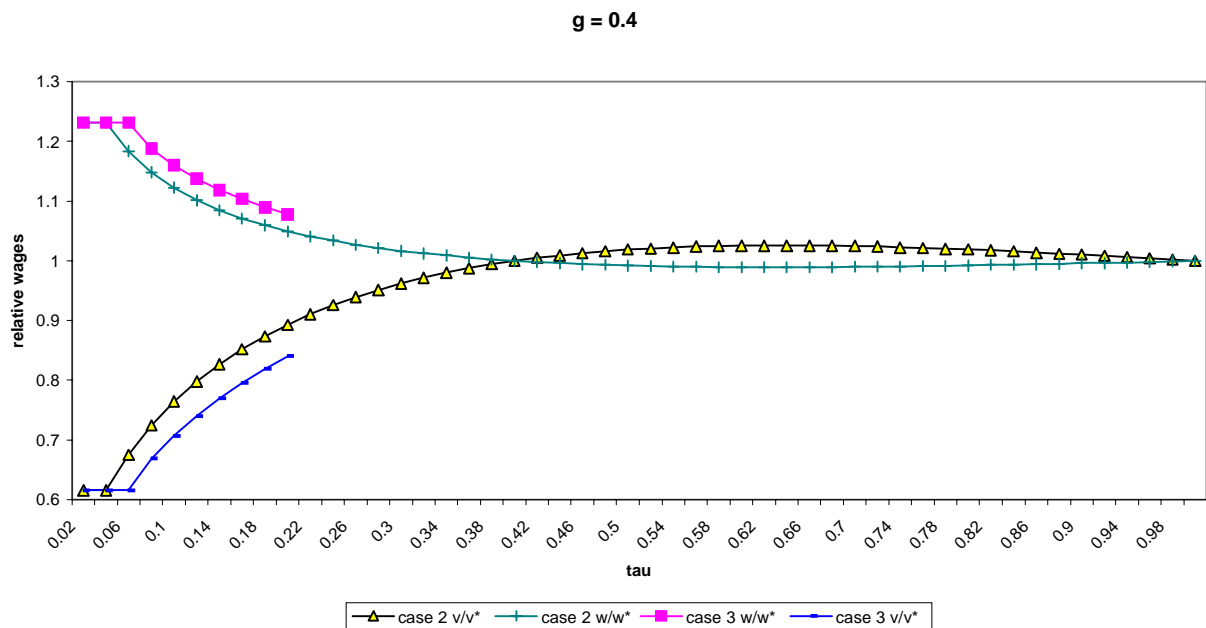
$$\tilde{v}^\varepsilon \frac{b}{\rho} \frac{\tau}{nq} E > g .$$

Relative skilled wages are given by (29), while  $E/nq$  represents purchases per local firm in Big and is given by equation (7). This yields the condition:

$$\tau \geq \frac{g}{f} \left( \frac{1}{\varepsilon} \right)^{1/2} \quad (30)$$

One-way trade in intermediate services will in other words only take place when the transformation cost parameter is below the level indicated by (30). Once condition (30) is satisfied, all active Smallian firms will start to export and there will be a switch to case 2. This threshold value of  $\tau$  is higher than the lowest level of  $\tau$  for which case 2 is economically feasible. A coordinated entry into the Bigian market would in other words be economically feasible at a lower value of  $\tau$  than what would be feasible for individual Smallian companies. These results are presented in figure 4.4, where the first chart depicts the case where  $g = 0.4$  and the second chart depicts the case where  $g = 1.5$ . The horizontal part of the curves shows the range of transformation costs where even a coordinated entry is not economically feasible and autarky will prevail. We notice that the autarky range is broader the larger is the fixed entry cost  $g$ . We also notice that the Bigian firms are able to break even when entering the Smallian market at a lower level of  $\tau$  when all Smallian firms export than when no Smallian firms export. Smallian exports in other words lower the entry barrier for Bigian firms in the Smallian market. Comparing the two charts we see that the factor price reversal point and the level of  $\tau$  where condition (30) is satisfied with equality are further to the right the larger is  $g$ .

Figure 4.4 Relative wages, some Bigian, and all or no Smallian firms export



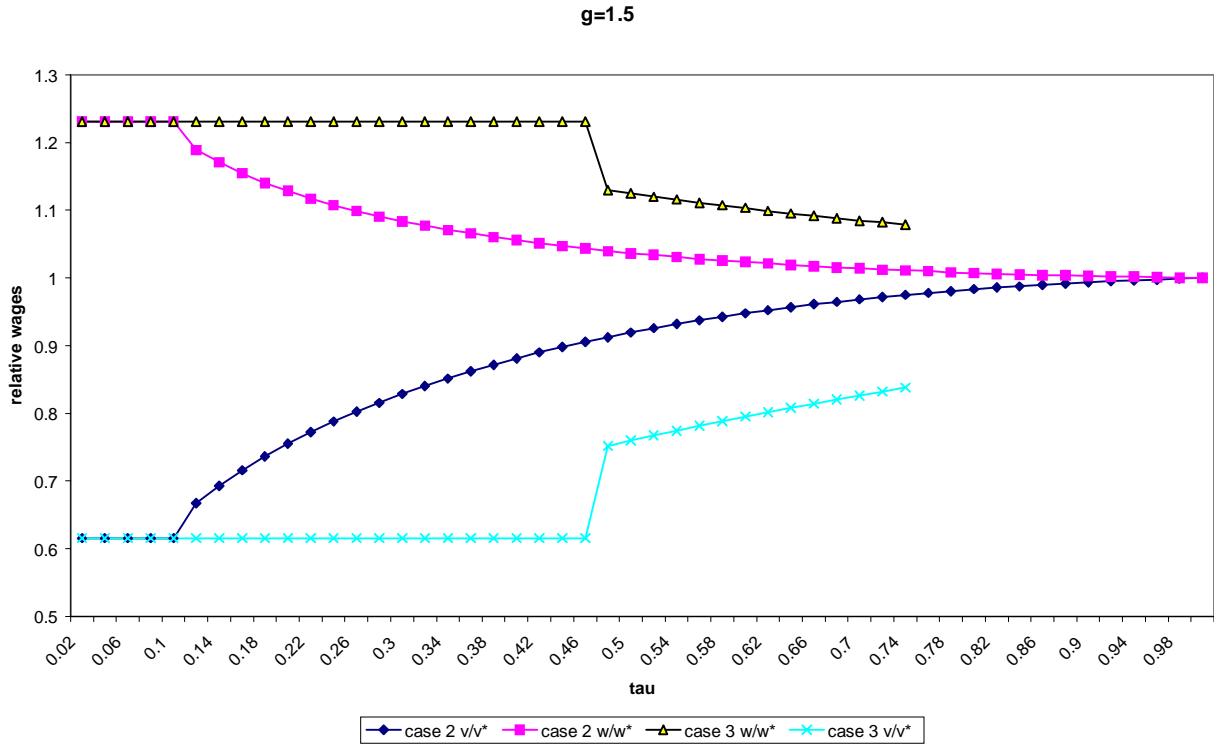
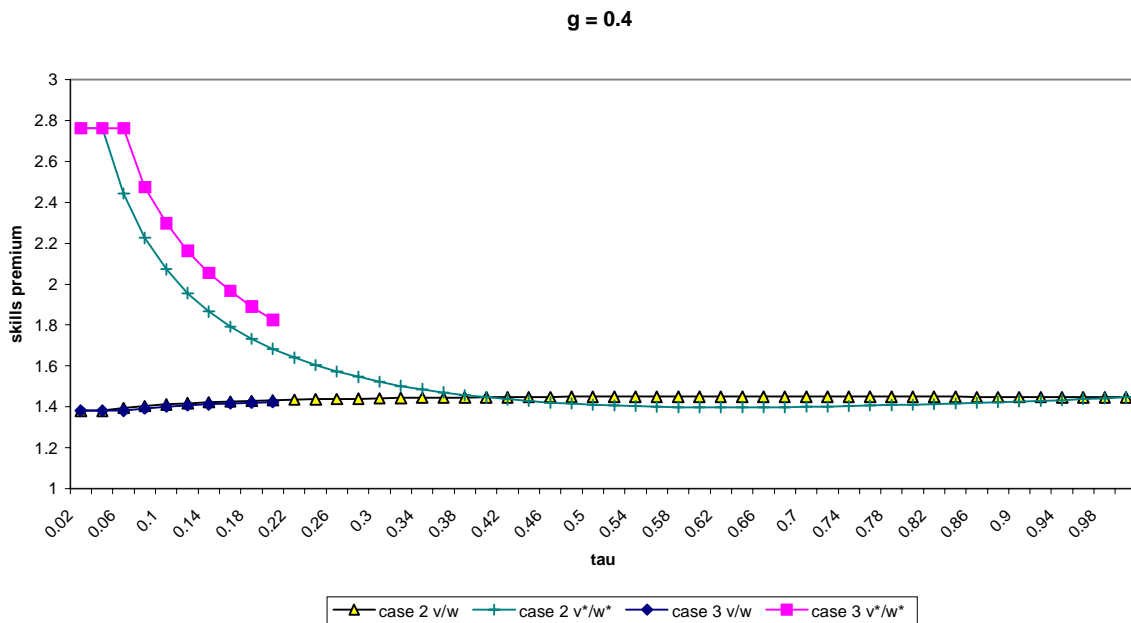


Figure 4.5 depicts the skills premium in the two regions for the two levels of fixed cost. We confine ourselves to presenting the case where  $g = 0.4$  in the rest of the paper.

Figure 4.5. Skills premium, some Bigian, and all or no Smallian firms export

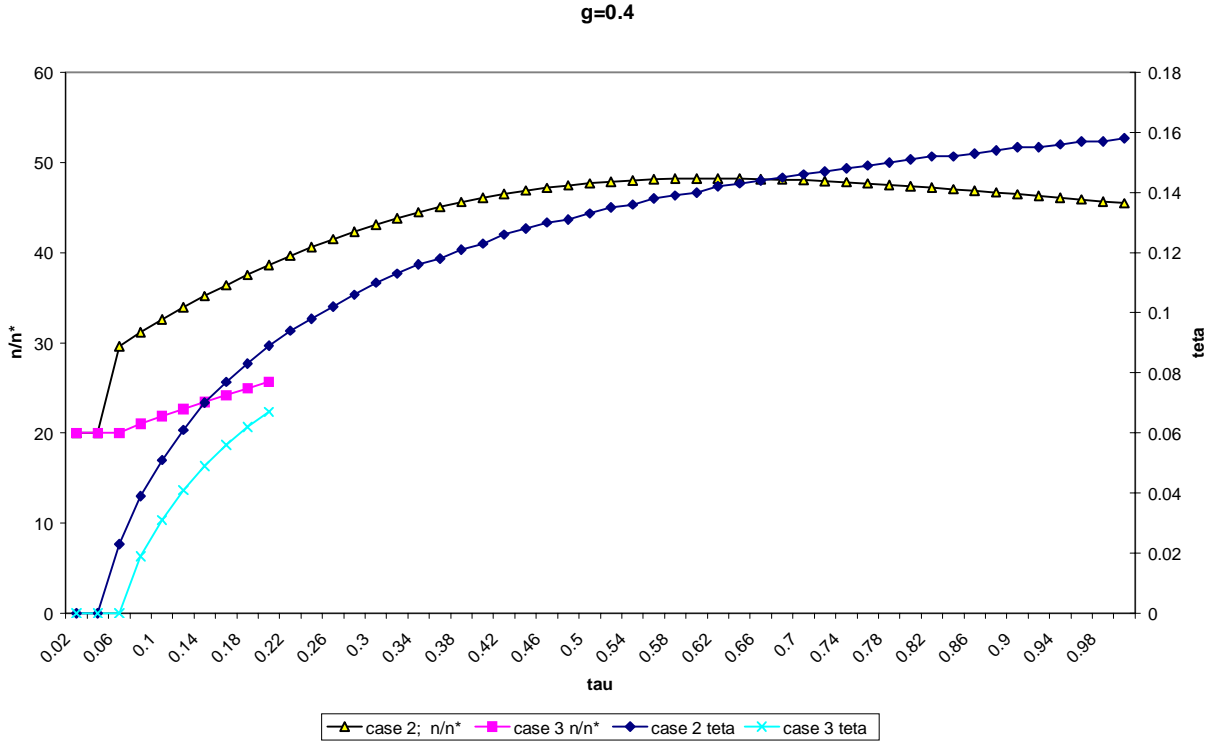


We notice that while the skills premium is little affected by trade regime and transformation costs (and  $g$ ) in Big, there is a dramatic decline in the skills premium in Small, which

eventually converges to the level in Big. Trade in Z-sector services has in other words alleviated the skills scarcity in Small.

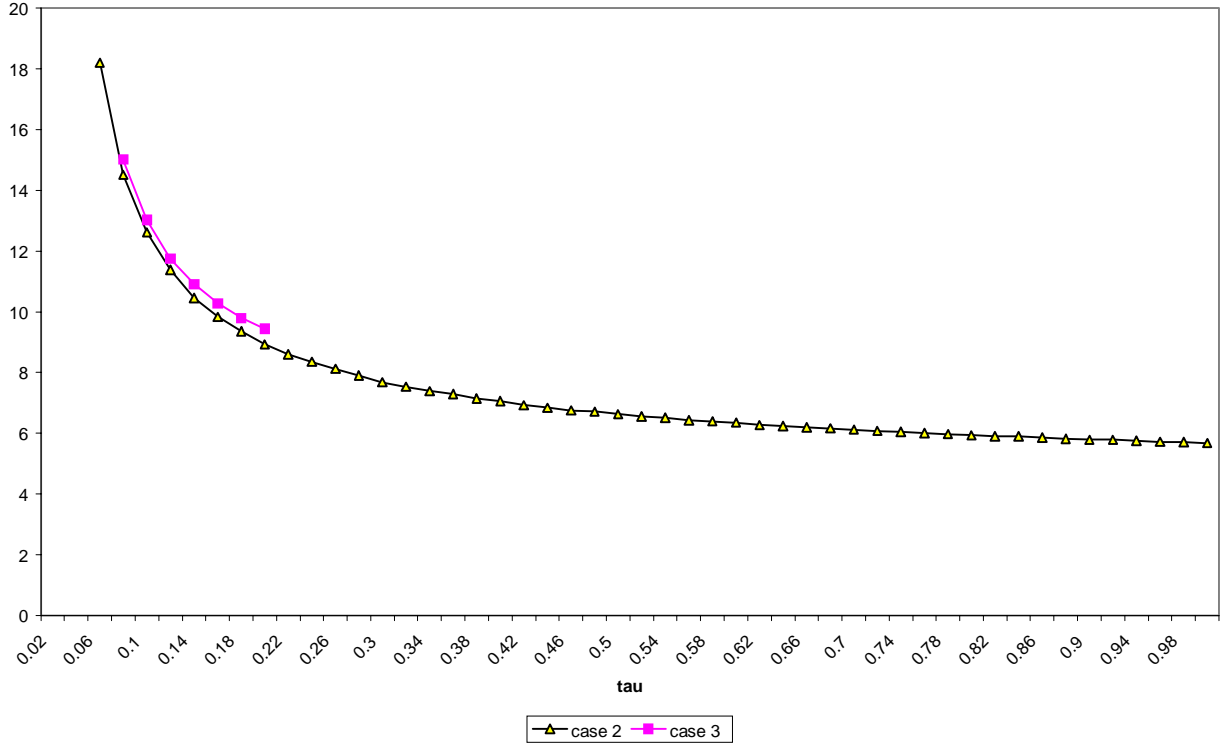
The number of Z-sector firms in each region and the share of such firms in Big that will export can be found by combining (19a), (19b), (25) and (28). The level of the fixed cost  $g$  strongly affects the share of existing firms in Big that will enter the Smallian market. The higher is  $g$  the lower is  $\theta$  for a given  $\tau$ . Interestingly, while  $\theta$  increases with  $\tau$ , it never reaches unity, not even in case 2 where all Smallian firms export. There will in other words not be a spontaneous shift to case 1, and the development as transformation costs decline is path-dependent. The relative number of firms in the two regions (left-hand scale) and the share of Bigian firms exporting (right-hand scale) is depicted in figure 4.6.

Figure 4.6. Relative number of Z-sector firms and share of Z-sector firms exporting



We observe agglomeration of Z-sector firms in Big until the relative number of firms in Big peaks at critical level of  $\tau$ . This level is further to the right the larger is  $g$ . For  $g > f$  (not shown), agglomeration of Z-sector firms continues throughout the range  $\tau \in (0,1)$ . The relative richness of X-sector services is represented by the relative number of services assembled in the X sector in the two regions,  $(n + n^*) / (\theta n + n^*)$  in case 2 and  $n / (\theta n + n^*)$  in case 3 in figure 4.7.

Figure 4.7. Relative richness of X-sector services in Big and Small



Although the Z-sector intermediate service producers agglomerate in Big as the transformation costs decline, the richness of services consumed in Small becomes more similar to that in Big as transformation costs come down. Note however that the “richness gap” remains substantial even for low entry costs ( $g = 0.4$ ) and no transformation cost.<sup>5</sup>

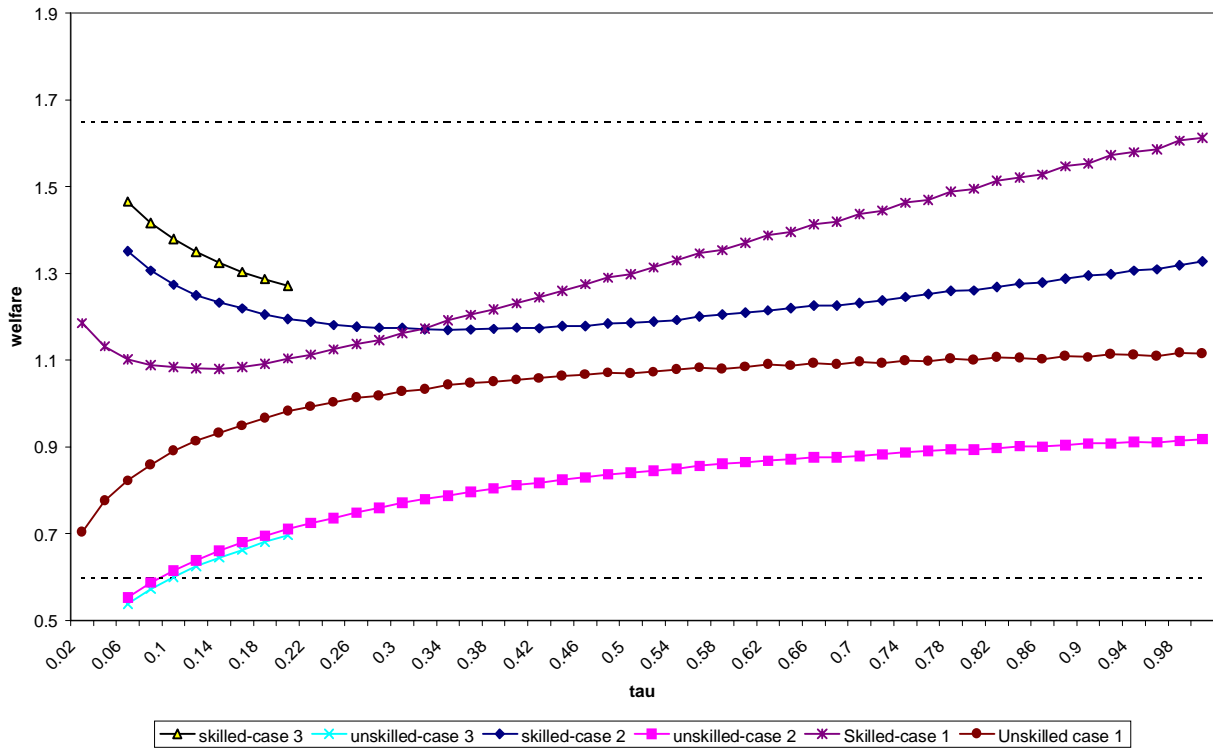
### 4.3 Welfare

We finally present the level of welfare of skilled and unskilled workers in the various trade regimes. Since the welfare implications are small for Bigian workers, we confine the analysis to Small. Welfare levels are measured by inserting the quantity consumed of X and Y in the utility function (4) for skilled and unskilled workers respectively. The quantity consumed in turn is given by  $Y_{unskilled}^* = \sigma w^* / P_y$ ,  $Y_{skilled}^* = \sigma v^* / P_y$ ,  $X_{unskilled}^* = (1 - \sigma) w^* / P_x$  and  $X_{skilled}^* = (1 - \sigma) v^* / P_x$ . Figure 4.8 depicts the welfare levels in the three trade regimes when  $g = 0.4$ .

<sup>5</sup> When  $g = 1.5$  (not shown) the X-sector assembles more intermediate services in Small is case 2 than in case 3. For this high level of entry costs, the local number of non-exporting service firms in case 2 is larger than the sum of local firms and Bigian exporters in case 3.



Figure 4.8. Welfare levels Small



The dotted lines depict welfare levels in autarky. We notice that skilled workers are better off in autarky than in any trade regime, while unskilled workers are worse off in autarky than in any trade regime except when transmission costs are very high. Comparing the three trading regimes, Case 3 where some firms in Big and no firms in Small export, clearly yields the most unequal outcome and the highest level of welfare of skilled workers at high transmission cost levels. This trade regime, however, breaks down as transmission costs reach the critical level given by expression (30). In all trade regimes the welfare of unskilled workers increases continuously with the lowering of transmission costs, while the welfare of skilled workers declines as transmission costs move from very high to an intermediate level from which welfare starts to rise again. The clear winners of switching from autarky to trade in intermediate services are unskilled workers in Small, while the losers are skilled workers in Small. The latter get their skill premium undermined by competition from abroad, and their skills become less scarce.

## 5 Summary and conclusions

This study has analyzed the impact of trade in information-intensive services, which are used as inputs in health, education and entertainment- services. Trade in intermediate services

arises as a result of ICT developments, which allows for digitization and transmission of services. Over time the cost of digitization and transmission declines. Education, health and to a lesser extent entertainment are crucial both for development and for demand for skilled labor. Skills are typically scarce in rural areas and in poor countries, which may have contributed to a more unequal distribution of income there than in urban areas and rich countries. The model developed in this paper demonstrates that access to intermediate service inputs into key consumer services sectors will enhance the richness of these services, alleviate the skills scarcity in the periphery and thereby undermine the skills premium. Unskilled workers' welfare will improve significantly as a result, while skilled workers in the periphery will see their welfare decline compared to autarky.

The impact on welfare and income distribution is largest when all intermediate service-firms in both regions engage in trade. This outcome will, however, only materialize if there is a coordinated entry into export markets. A policy intervention is probably necessary to bring about this solution. In the absence of a coordinated entry, firms at the center are able to enter export markets earlier in the information age than their counterparts in the periphery. At this early stage there will be agglomeration of service-firms at the center. Unless the fixed cost of exporting is very high, the periphery will still enjoy richer consumer services and improved welfare for low-income groups. As transformation costs come further down, firms in the periphery will start exporting and welfare will improve further for unskilled workers. Also skilled workers in the periphery will enjoy richer services and improve their welfare as transformation costs come further down, although they will not restore the welfare level they enjoyed in autarky. After a period of widening income disparities *between* regions, the wages of both skilled and unskilled workers converge as transformation costs come down. To conclude, this study has demonstrated that trade in intermediate services made possible by ICT developments, enhances the richness of key services in the periphery, and contributes to a more equal distribution of income both between regions and within the peripheral region.

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## References

- Bernard, A.B. and J.B. Jensen, 2001, "Why some firms export" NBER Working Paper 8349, July.
- Bresnahan, T.F, E. Brynjolfsson, and L.M. Hitt, 2002, "Information technology, workplace organization and demand for skilled labor", *The Quarterly Journal of Economics* vol. 117, no. 1, pp. 339-76.
- Harris, R.G., 1998, "The Internet as GPT: Factor market implications," chapter 6 in E. Helpman (ed.) *General Purpose Technologies and Economic Growth*, The MIT press, Cambridge, Mass.: 1998.
- Jorgenson, D.W., "Information technology and the U.S. Economy", *The American Economic Review*, vol. 91, no. 1., pp 1-32.
- Leamer, E.E, and M. Storper, 2001, "The economic geography of the Internet age," NBER Working Paper no. 8450, August.
- Murphy, K.M, A. Shleifer and R. Vishny, 1989, "Industrialization and the big push", *Journal of Political Economy*, vol. 97, pp. 1003-26.
- Roberts, M.J. and J.R Tylbot, 1997, "The decision to export in Columbia: An empirical model of entry with sunk costs," *The American Economic Review*, vol. 87, no 4., pp.545-564.
- Röller, L.H and L. Waverman, 2001, "Telecommunications infrastructure and economic development: A simultaneous approach", *The American Economic Review*, vol. 91, no. 4, pp. 909-923.
- Venables, A.J., 1994, "Integration and the export behaviour of firms: Trade costs, trade volume and welfare", *Weltwirtschaftliches Archive* 130, 118-132.