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Information technology and regional development – global village or rural backwater?

by

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Abstract

This paper discusses information and communication technology and regional development. A two region model is adopted to a stylized urban-rural setting and numerical simulations presented. Diffusion of information technology, modeled as a reduction in the cost of transmitting digitized producer services over geographical distances, has a dramatic impact on rural skilled workers' wages both relative to rural unskilled workers and relative to urban skilled workers. The paper presents a case study of a naval architecture and design company located in rural Norway selling their services all over the world.

"After all, the most famous modern agglomeration of industry, Silicon Valley, has occurred in the industry with the most direct access to the latest and best information technology." (Gaspar and Glaeser 1998, p. 155)

1 Introduction

Vik-Sandvik claims to be the largest independent source of ship designs and naval architectural services in Europe.[1] Its headquarters are located in Fitjar, a Western Norwegian community with just below 3000 inhabitants. The company produces ship design and engineering services delivered to customer shipyards all over the world. The company uses computer systems for its engineering and design, which are delivered electronically to customers. Vik-Sandvik has 25 years experience, it has affiliates and daughter companies in Poland, China and Iceland and the Vik-Sandvik Group employs 170 persons.

Two features of information technology have made such companies as Vik-Sandvik possible. First, new technology has made separation of goods and service production technically and commercially viable. Thus, even if shipbuilding is not competitive in a particular location, ship design and engineering can form a separate and independent business based on a different set of competitive advantages. Second, information technology, particularly telecommunications have made it possible to digitize and transport services such as engineering and design over long distances at very low cost, once the adequate infrastructure is in place. Companies producing services that can be digitized can therefore in principle be located anywhere in the world, provided that they are connected to electronic networks at reasonable costs.

Engineering, design and a number of other business services are both information-intensive and skills-intensive.[2] Skills, however, may be scarce in rural areas if skilled and professional workers are concerned about career opportunities for themselves and their skilled or professional spouses, and if skills need to be maintained through face-to-face interaction with peers. It has further been argued in the literature that companies tend to cluster in central

[1] www.vik-sandvik.com

[2] See Bresnahan, Brynjufsson and Hitt (2001) for a recent empirical study and a review of previous research on skill-biased technological progress.

locations in order to exploit access to a pool of skills and other inputs that cannot easily be transported over long distances.[3] In this paper we will explore to what extent Vik-Sandvik is the exception that confirms the rule, or to what extent and under what circumstances development of information technology provides new opportunities for regional development and decentralization of production.

The rest of the paper is organized as follows: Section two briefly reviews relevant literature on the interrelationship between location and information technology. Section 3 develops a model that focuses on the impact of changes in transaction costs of producer services such as engineering and design. The model incorporates differences in information and skill-intensity among sectors, and returns to diversity on the part of producers and preference for variety on the part of consumers. Numerical simulations of the model are included in the analysis. Section 4 presents some empirical evidence on the use of information and communication technology (ICT) in Norway as a function of geographical characteristics. In addition the Vik-Sandvik case is presented in some more detail. Section 5 summarizes and concludes.

2 Information technology and location theory

2.1 A new economy?

It has been argued that computers and ICT are in the process of augmenting brainpower in the same way as the machinery introduced during the industrial revolution augmented muscle power. Thus, recent developments in ICT are compared to the industrial revolution. ICT is used as inputs in almost every production activity in the economy, and the cost of storing, transmitting and decoding information has declined tremendously through the diffusion of ICT.[4] Recent empirical research attributes about two thirds of labor productivity improvements since 1995 in the US to the use of and production of ICT (Oliner and Sichel 2000). Not only does ICT change the cost of production through the reduction of the price of ICT itself, it also leads to changes in the organization of production within the firm and in the relations between firms, further improving efficiency. Key elements in the organizational transformation following the introduction of ICT are: focusing on core activities while outsourcing non-core activities, flexible computer-controlled automation, less hierarchical organizations, increased demand for skilled labor and electronic supply chain management.

One of the most prominent skeptics of the "new economy" is Robert Gordon (2000). He points out that the recent productivity revival in the United States is largely limited to the 12 percent of the economy engaged in the manufacturing of durable goods. He argues that although the price of computing capacity has declined tremendously over the recent past, investment in such capacity soon runs into diminishing returns due to the fixed amount of time and limited human brain power to utilize the improved computing capacity. He further argues that computers and the Internet fail to show up in productivity figures because they largely duplicate existing services and operations, and draw workers' attention away from productive work. Nevertheless, Gordon's estimates of productivity growth in the US and its sources are similar to Oliner and Sichel (2000), but Gordon argues that most of the productivity growth is due to cyclical factors and that the trend productivity growth has not changed much.

[3] See for example van Marrewijk et.al. (1997).
[4] See Dudley (1999) for a discussion.

More research is necessary in order to understand how ICT has improved productivity in the durables industries so impressively, and to what extent and under what circumstances other industries have the same potential for productivity growth. Some evidence is found at the micro level where the net marginal return to investment in computers is found to be in the area of 50 percent at company level in a sample of large US companies (Brynjolfsson and Hitt 1996). The study applied data for the period 1987-1991 and argues that the productivity paradox disappears during this period when applying firm level data. Similar results are found in a number of statistical analyses of samples of firms and case studies reviewed in Brynjolfsson and Hitt (2000).

To summarize the discussion so far, the evidence of a "new economy" in the sense that productivity has reached a permanently higher growth rate is at present mixed. There is, however, more evidence that a new economy is emerging in the sense that new products and services are introduced at a high speed, and that ICT induces new ways of managing firms as well as changes in the way businesses relate to each other. Changes in the division of labor and dispersion of activities in time and space should also be expected as a result of ICT. These are the focus of the analysis in this paper.

2.2 ICT and location

In a recent paper Lipsey et. al. (1998) argue that the diffusion of ICT will lead to accelerated urbanization in the same way as the establishment of factories led to the growth of industrial cities during the industrial revolution. The agglomeration forces at work during diffusion of ICT stem from the notion that although electronic communication reduces the cost and improves the quality of information transmission over large geographical distances, it complements rather than substitutes for face-to-face communication. Furthermore, as the introduction of ICT reduces the costs of procurement and transactions related to procurement, inventories are kept at a minimum throughout the supply chain and timely deliveries become crucial. Therefore, firms tend to locate close to their largest customers, which most often are other firms.

In Norway purchases of intermediate inputs typically account for 60-70 percent of total sales value in manufacturing industries, and between 30-55 percent of total sales value in the service sectors. Producer services in turn account for about 15 percent of the market for intermediate inputs in the manufacturing sector and between 40 and 70 percent in the services sectors.[5] This reflects a substantial market for intermediate goods and services and possibly an increase in the extent of specialization and outsourcing over time.

There is a vast body of literature on the gains from outsourcing and increased division of labor. The literature builds on the idea that a firm is more productive the better access it has to a broad variety of intermediate goods and services. A firm will, for example, have lower costs if it can make use of a broad variety of financial instruments designed for different purposes than if the company has access to only a few "one size fits all" instruments. Likewise, a shipyard is more productive if it can purchase a broad variety of steel qualities than if there is only one or a few types of steel sheets on the market. Such returns to diversity will lead to clustering or agglomeration of firms in certain locations under two conditions. The first condition is that there are increasing returns to scale in the production of intermediate inputs such that each firm must reach a minimum scale of production and sales

[5] Data on intermediate purchases is taken from the input-output table of the Norwegian economy in 1995.

in order to break even. Obviously, the establishment of a large number of such firms requires a large market. The second condition that is necessary for clustering to take place is significant transport costs that increase with geographical distance.

Information technology affects both these conditions for clustering in cities to take place. Empirical evidence suggests that ICT is associated with a decline in average firm size.[6] This is due to a reduction of the minimum efficient scale in many manufacturing industries and the emergence of a number of specialized niche firms, particularly in the services sectors. However, in the ICT *producing* sectors markets are characterized by very large firms both in the hardware and the software markets. ICT also reduces transaction costs as the cost of computers, computer software and telecommunications has declined steeply over the past few decades. This is particularly relevant for services that can be digitized and transported over electronic networks. But ICT also reduces transaction costs related to trade in intermediate goods through lower search costs, better market information, more effective financial transactions and in many cases automated procurement processes. Even the cost of physically moving a product has declined to some extent following the introduction of ICT in the transport sector. This has improved transport efficiency and thereby contributed to higher efficiency in all sectors (Nordhaus 2001). These two empirical observations suggest that ICT should weaken agglomeration forces and thus dampen the trend towards urbanization.

However, less than 10 percent of total intermediate service purchases in the Norwegian economy were imported in 1995, suggesting that most services are not easily tradable over long geographical distances or cultural and language barriers. At least this was the situation in the mid 1990s. When electronic communication is complementary to rather than a substitute to face-to-face communication, specialization and outsourcing may take place in a limited geographical area. The frequency of face-to-face communication probably depends on the complexity of ideas and technology. As long as face-to-face communication is conducted in all relationships, the net effect of increasing the number of relationships may be increased face-to-face interactions with other firms.[7] The decision whether to make or buy an input therefore involves weighing returns to diversity and transaction costs against each other. When a decision to buy is taken, the decision of who and where to buy from must take into account transport costs, and the need for direct communication with the supplier.

Transaction costs consist of determining the price, quality and other properties of the product in question, to search for suppliers/customers, and costs related to the actual transfer of the good or service and the payments thereof. Electronic financial services have reduced the costs of financial transactions associated with procurement. The introduction of modern ICT, whether Internet-based business to business (B2B) electronic commerce or closed networks such as electronic data interchange (EDI) lowers the cost of information related to search. Electronic commerce may thus work as a virtual warehouse bringing a large number of buyers and suppliers together, providing one-stop shopping. In addition B2B electronic commerce brings together buyers and sellers to negotiate prices and other characteristics of a product. This is particularly valuable in commodity markets where products can be bought unseen and where demand and prices are volatile.[8] Furthermore, B2B electronic commerce provides the opportunity for smaller companies to pool their purchasing power and obtain volume

[6] See Brynjolfsson and Hitt (2000) for a review.
[7] See Gaspar and Glaeser (1998) for a discussion.
[8] See Kaplan and Sawhney (2000) for a discussion. They define the virtual warehouse function of electronic commerce as the aggregation function while they identify the process of negotiating prices and quality as the matching function of electronic commerce.

discounts in the same manner as large companies with significant bargaining power.[9] Finally, as already mentioned, electronic commerce in many cases automates the procurement process and thereby reduces transaction costs substantially.

In spite of the huge potential gains from e-commerce, only 0.4 percent of total B2B transactions in the US economy were conducted over the Internet in 1998 (Goldman Sachs 1999). One of the reasons may be that not all relevant information can be digitized. The problems with B2B e-commerce are illustrated by a study by Garicano and Kaplan (2000). They studied B2B trading of used cars from rental agencies and leasing agencies to car dealers and found that B2B e-commerce reduced transaction costs by 38 percent for each car. The savings were mainly due to a reduction of the time it took to sell a car and reduced transport costs because the car could go directly from the rental agency to the car dealer without going to a physical auction site in between. However, the Internet auction did not attract a sufficient number of buyers to make it profitable. The number of cars actually sold over the Internet was only 24 percent of the cars laid out for sale. The unsold cars were eventually sold through traditional auctions and the cost of delaying the sale of 76 percent of the cars outweighed the gain from selling the 24 percent through the Internet. The net effect for this particular B2B business was a net *increase* in costs of about 7 percent compared to traditional auctions. This example illustrates the importance of liquidity in e-commerce markets and that a cost reduction on the part of the seller may be seen as a cost increase on the part of the buyer, and the expected extension of the market does not materialize.

Data on the use of ICT in Norwegian businesses presented and discussed in section 4 below indicates that although the use of ICT provides small and medium sized firms in rural areas with a vehicle to reach a large market with their products, such firms have not taken this opportunity to the same extent as larger companies located in urban areas. This suggests that the introduction of ICT also has a cost element that may have constituted a barrier to adoption in small and medium-sized companies in rural areas. Such adoption costs are often related to the need for organizational changes and more skilled labor, as discussed in Bresnahan et. al. (2001). In fact, their study finds that organizational change, skilled labor and ICT are complementary and reports that introduction of ICT without the two other elements may not improve productivity in the firm in question. Furthermore, complementary investments in organizational change and skills upgrading may be 5-10 times higher than investments in computers, software and related telecommunication equipment on the part of the firm. Shortages of adequate skills may be a problem for firms in rural areas, and thus an impediment to the introduction of ICT.[10]

The small market share of foreign producer services in Norway indicates that tradability of services remains low, although the figure probably underestimates the role of foreign producer services firms since the local sales of Norwegian affiliates of foreign firms are not counted as imports. If tradability is low, producer services firms will probably cluster around their major customers. By the same token, restructured and focused firms that have already hived off a number of intermediate services are more likely to locate in areas where producer services are readily available from the market.

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[9] Vik-Sandvik participates in such a procurement network (Personal interview with Ketil Fykse 22.02.01).

[10] Vik-Sandvik confirms that the cost of upgrading the organization is higher than the cost of the ICT technology and that shortage of adequate skills is a problem in its location. The skills problem has partly been solved by a greenfield investment in Poland. In addition to servicing the Polish shipyards, the staff in the Polish daughter company participates in projects at the headquarters in Fitjar.

Finally, organizational changes have placed the cost of transport and inventory and supply chain management at the center of cost cutting efforts, and just-in-time delivery has become the industry standard. In such a setting the relative importance of geographical distance may in fact increase as timeliness becomes essential for the smooth operation of production and marketing systems.

Some of the same mechanisms as just described for businesses probably apply to individual people and their choice of where to live. First, transport costs induce them to settle close to work. Second, it has been shown that there are gains to the individual from working with other people with similar skills. Third, people as consumers prefer to have access to a broad variety of consumer goods and services. Some consumer services are not easily traded over geographical distances, and tend to be produced only in cities. Finally, the housing market tends to be more flexible, liquid and diversified in central areas, where families can choose to rent or buy a flat or a house. In contrast, owner-occupied houses are the norm in rural areas. Factors drawing in the other direction are consumer demand for recreation, un-spoilt natural environment and high property prices in urban areas.

To conclude the brief literature survey, there are a number of forces working in different directions that determine location, and also income distribution between urban and rural areas or center and periphery. The forces working towards agglomeration and urbanization are:

- The interplay between increasing returns to scale in the production of intermediate inputs such as producer services and the costs of transporting such services over geographical distances;
- The complementarity between tradable services and essential non-tradable inputs;
- The importance of timeliness in supply chain management;
- Technological complexity requires more direct communication;
- Consumer demand for a variety of goods and services.

The forces working towards decentralization and the revitalization of rural and remote areas are:

- A decline in the minimum efficient scale and therefore a decline in the average size of firms;
- Digitization of services makes them tradable at very low cost;
- More services are separable from goods production and form the basis for new industries;
- Cost of congestion both to firms and consumers.

It appears that ICT may have contributed to *reducing the disadvantages of a remote location*. At least it may have improved remote regions' opportunity to exploit the comparative advantages that they already have more effectively. This is particularly the case for regions that have a relatively low-cost skilled labor force, and thus a comparative advantage for production of services that can be transported over electronic networks. The much publicized emergence of a computer software industry in Bangalore, India, and the exceptionally high growth in Ireland during the 1990s are examples that locations far from the major markets may catch up with the market leaders through the adoption and/or production of ICT. Our Vik-Sandvik case is another case in point at the microeconomic level. However, we have not found evidence that ICT creates new comparative advantages for rural areas.

The net effect of ICT on location by firms and individuals depends on the relative strength of the centripetal and centrifugal forces listed above and it is an empirical question not yet resolved. We therefore need a formal model that captures the interrelationship between technology change and location in order to assess the relative importance and net effects of these forces. Harris (1998) developed a model where the Internet opens the service sectors to trade over large distances. The introduction of the Internet makes services perfectly tradable in his model. We take the Harris model as a point of departure and discuss the relative importance of centripetal/centrifugal forces in the context of regional development in Norway in the next section.

3 The model

The model developed in this section is inspired by Harris (1998). However, while Harris uses a small, open economy setting where prices are exogenously given in the world market, we use a two-region model framework in which prices are determined endogenously. This allows us to introduce consumer preferences into the model, a factor that we think is important for industrial structure and location patterns. Furthermore, there is no such thing as a world market price for producer services. Our general equilibrium framework allows us to analyze the interrelationship between firms' location decisions and skilled workers' preference for where they want to live. We start in section 3.1 by establishing the autarky general equilibrium. In section 3.2 we introduce two regions and exchange of goods and services between the two regions. Since, as usual in such models, a complete analytical solution cannot be found, numerical simulations are presented and discussed.

The economy has three sectors, labeled Y, X and Z. Sector Y 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. The Y and Z sectors both use skilled labor, while unskilled labor is only required in the "traditional" Y-sector. Individual firms in the Y-sector of course purchase intermediate inputs from other firms, but intermediate purchases are netted out at the aggregate level. Products from sector Y are costlessly traded over geographical distances. The X-sector represents high-technology firms or firms that have gone through the organizational transition as discussed in section 2. They have outsourced non-core activities to other firms and their main activity is to assemble the inputs produced by other firms. In order to focus our analysis we assume that the only activity of X-sector firms is assembly of intermediate services. Using a Dixit-Stiglitz type framework the output is more than the sum of the individual inputs, due to returns to diversity. Furthermore we assume that the X-sector firms are located close to their customers and their products are not traded over long geographical distances. Finally the Z sector consists of *n* firms producing the intermediate services assembled by the X sector. The number of firms is determined endogenously in the model by the size of the market of the X-sector. Intermediate services can be traded over geographical distances but at a cost. This cost is related to the availability and cost of ICT. We start by exploring the properties of the model in autarky.

3.1 Autarky equilibrium

We assume a geographical area within which skilled workers are fully mobile between sectors and firms, and within which producer services can be costlessly traded. The production function of the Y sector is a standard Cobb-Douglas constant returns to scale production function:

$$Y = L^{\alpha} S_y^{1-\alpha} \tag{1}$$

The symbol L represents unskilled labor, while S represents skilled labor. The high-technology assembly industry's production function is given by equation (2):

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

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

$$z_i = f + \frac{1}{b} s_i \tag{3}$$

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:

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

The Cobb-Douglas form or 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 recreational value of un-spoilt land areas and other non-commercial benefits from rural lifestyle.[11]

We start by determining the autarky equilibrium of this economy, when endowments of skilled and unskilled labor are given outside the model. We 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:

$$q = \frac{bv}{\rho} \tag{5}$$

where v is the unit cost of skilled labor. We 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:

[11] A useful extension of the model would be to endogenize A, making it a decreasing function of population density.

$$q = \frac{fv}{z} + bv \tag{6}$$

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

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

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

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

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

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

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

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

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

$$S_y + S_s = S \tag{12}$$

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

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

Allocation of skilled labor in other words depends on the technology in the Y sector, i.e., its skill intensity, and consumer preferences. The more skill 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 producer service sector Z. The number of services produced in the economy is determined by (10) and (13):

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

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 X. 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 intermediate 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 ρ 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.[12]

The skill premium, defined as the income earned by skilled workers over and above that of unskilled workers, can be found by using (11), (13) and setting the wage rate of unskilled labor the numeraire, i.e., $w = 1$.

$$v = \frac{\left((1-\alpha)\sigma + (1-\sigma)\right)L}{\left(1-(1-\alpha)\sigma + (1-\sigma)\right)S} \qquad (15)$$

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 factor supply.

Having presented the model and the workings of the model in a closed economy, we now introduce a second region. The two regions are distinct in the sense that each region constitutes a closed labor market. Skilled workers can move between sectors within the region but not across regions, and unskilled workers cannot move across regions. Each region constitutes a closed market for the X-sector. Finally, intermediate services can be traded at no cost within each region, but a cost is incurred when services are traded across regions. The two regions are interpreted as two regions within the same country, but they could also be interpreted as two countries.

3.2 The two-region case

We label the two regions urban and rural respectively. The two regions have the same production technology described by equations (1) – (3), and their endowments of unskilled and skilled labor are exogenously given and are initially not mobile between rural and urban areas. We start by assuming that intermediate services are transported between the two regions subject to an iceberg transport cost, $t > 1$, while transport of intermediate services *within* regions is costless. One interpretation of this is that face-to-face interaction is possible within regions but not across regions. In order to transport a producer service across regions, investments in communication technology have to be made. We model this as an

[12] In the model presented here the returns to variety correspond to the elasticity of substitution, and the market outcome corresponds to the social optimum. However, as pointed out by Benassy (1996) and discussed by de Groot and Nordås (2001) in the context of trade in information services, returns to variety correspond to the elasticity of substitution only in special cases, and the externality need not be fully internalized in the market solution.

exogenously given iceberg transport cost, and analyze how trade and income distribution between and within the two regions respond to changes in the transaction cost.

Since final goods are freely traded between the two regions, the price of final goods must be the same in both regions. This gives us the equilibrium condition:

$$\left(\frac{w}{\alpha}\right)^{\alpha}\left(\frac{v}{1-\alpha}\right)^{1-\alpha}=\left(\frac{w^*}{\alpha}\right)^{\alpha}\left(\frac{v^*}{1-\alpha}\right)^{1-\alpha} \text{ or } \left(\frac{w}{w^*}\right)^{\alpha}=\left(\frac{v^*}{v}\right)^{1-\alpha} \qquad (16)$$

All variables related to the rural region are denoted with an asterisk. Equilibrium in the market for skilled labor in the two regions can be derived by using (10) 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 the rural region. This yields the equilibrium condition:

$$\frac{n}{n^*}\frac{v}{v^*}=\frac{\alpha vS+(1-\alpha)wL}{\alpha v^* S^*+(1-\alpha)w^* L^*} \qquad (17)$$

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:

$$\frac{1-\alpha\sigma}{\alpha\sigma}=\frac{vS+v^*S^*}{wL+w^*L^*} \qquad (18)$$

We finally look at the balance in the market for each service. As is well known from the literature[13], the X-sector's demand for each intermediate service can be derived from the first-order conditions of maximizing profits. The urban high-technology firms' demand for intermediate services produced in the urban region is given by:

$$\frac{q^{-\varepsilon}}{nq^{1-\varepsilon}+n^*\left(q^*t\right)^{1-\varepsilon}}(1-\sigma)(wL+vS)$$

where the denominator represents the price index of intermediate services facing the urban producer of X. Note that the price of intermediate services produced in the rural region is multiplied by *t*, the iceberg transport costs, in order to account for losses during transit. We get similar expressions for urban demand for rural producer services, rural demand for urban producer services and rural demand for rural producer services. Supply of each service, whether produced in the urban or the rural area is as before given by equation (7) assuming that the technology is the same in both regions. We can then combine the four demand conditions to yield service market equilibrium:

[13] See for example Helpman and Krugman (1985) chapter 10.

$$\frac{q^{-\varepsilon}}{nq^{1-\varepsilon}+n^*\left(q^*t\right)^{1-\varepsilon}}(1-\sigma)(wL+vS)+\frac{q^{-\varepsilon}}{n(qt)^{1-\varepsilon}+n^*q^{*1-\varepsilon}}(1-\sigma)(w^*L^*+v^*S^*)t=$$
$$\frac{\left(q^*t\right)^{-\varepsilon}}{nq^{1-\varepsilon}+n^*\left(q^*t\right)^{1-\varepsilon}}(1-\sigma)(wL+vS)t+\frac{q^{*-\varepsilon}}{n(qt)^{1-\varepsilon}+n^*q^{*1-\varepsilon}}(1-\sigma)(w^*L^*+v^*S^*) \quad (19)$$

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

$$\frac{n}{n^*}=\tilde{n};\ \frac{v}{v^*}=\tilde{v};\ \frac{w}{w^*}=\tilde{w}\ \frac{\mathrm{L}}{\mathrm{L}^*}=\tilde{L};\ \frac{\mathrm{S}}{\mathrm{S}^*}=\tilde{S}$$

We then reorganize equations (16), (17) and (19), using (18) and define $\tau=t^{1-\varepsilon};0<\tau<1$. This definition makes it more convenient to analyze and present graphically changes in the endogenous variables as a consequence of changes in transaction costs for the full range of transaction costs from unity to infinity. Note that there are no transaction costs when $\tau = 1$, and infinite transaction costs when $\tau = 0$. The reorganization of equations yields the following system of three equations in three independent variables.

$$\tilde{w}=\tilde{v}^{(\alpha-1)/\alpha} \quad (20)$$

$$\tilde{n}\tilde{v}=\frac{(1-\alpha\sigma)\left(\tilde{w}\tilde{L}+1\right)\tilde{v}\tilde{S}-(1-\alpha)\sigma\left(\tilde{v}\tilde{S}+1\right)\tilde{w}\tilde{L}}{(1-\alpha\sigma)\left(\tilde{w}\tilde{L}+1\right)-(1-\alpha)\sigma\left(\tilde{v}\tilde{S}+1\right)} \quad (21)$$

$$\frac{1-\tilde{v}^{-\varepsilon}\tau}{\tilde{n}\tilde{v}^{1-\varepsilon}\tau+1}\,\frac{\tilde{n}\tilde{v}^{1-\varepsilon}+\tau}{\tilde{v}^{-\varepsilon}-\tau}=\frac{\alpha\sigma\left(\tilde{v}\tilde{S}+1\right)\tilde{w}\tilde{L}+(1-\alpha\sigma)\left(\tilde{w}\tilde{L}+1\right)\tilde{v}\tilde{S}}{\alpha\sigma\left(\tilde{v}\tilde{S}+1\right)+(1-\alpha\sigma)\left(\tilde{w}\tilde{L}+1\right)} \quad (22)$$

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.[14] The most interesting case from an urban-rural point of view is the asymmetric case when one region (urban) has a much larger population than the other (rural) region, and the share of the population being skilled is much higher in the largest region. Table 3.1 presents parameter values and endowments of skilled and unskilled labor in a stylized example of an urban and a rural economy.

Table 3.1 Endowments and parameters

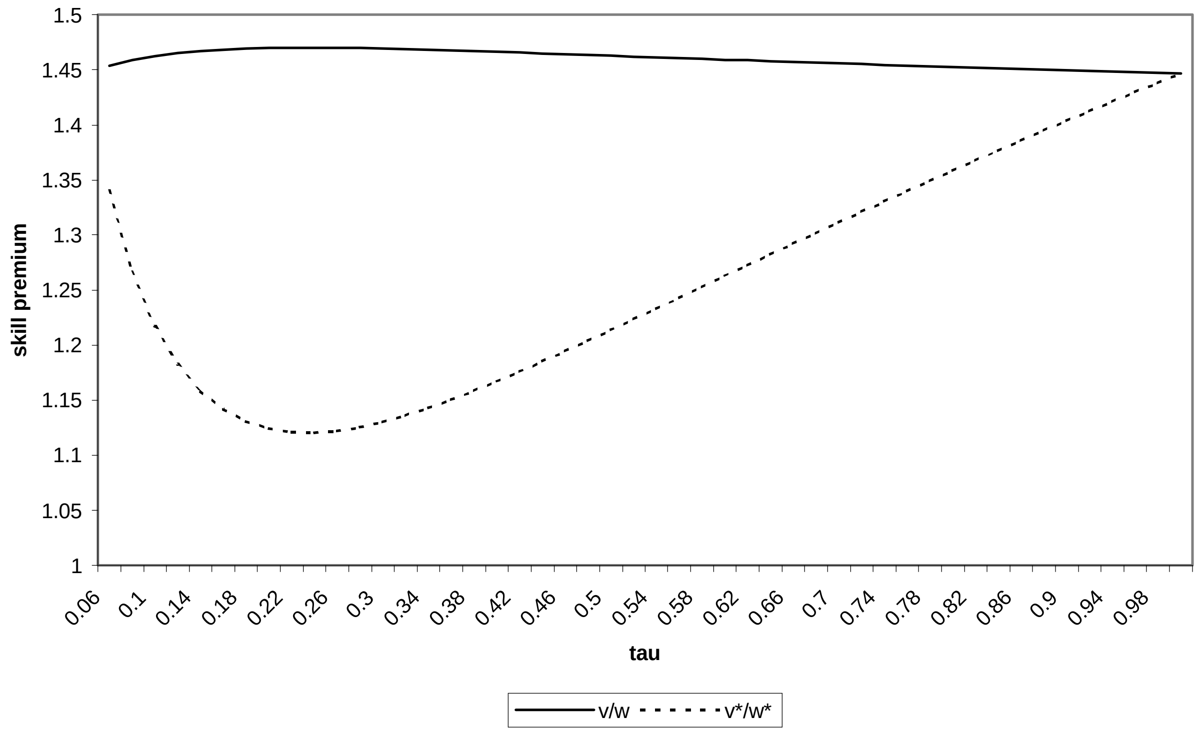
Variable/parameter	Urban	Rural
Skilled labor	500	25
Unskilled labor	500	50
α	0.7	0.7
ρ	0.75	0.75
σ	0.6	0.6

The decline in ICT costs is exogenous and we assume that it is captured by a decline in transaction costs, represented by an *increase* in the value of the parameter τ. Defining the numeraire $w = 1$ as in the closed economy case, it is possible to find the absolute levels of all

[14] The numerical simulations are run in the GAMS programming software.

the endogenous variables in the equation system measured in units of unskilled labor in the urban region. Figures 3.1-3.3 depict the solution to the equation system (20)-(22) for the endowments and parameter values presented in table 3.1 and $w = 1$. Let us start by analyzing how the recent sharp decline in the cost of ICT affects income distribution *within* the two regions, i.e., changes in the skills premium in the two regions. Figure 3.1 shows how a decline in transaction costs between regions affects the skill premium in each region. Transaction costs are given along the horizontal axis, and decline as we move from the left to the right.

Figure 3.1: Skill premium in the two regions as a function of transaction costs

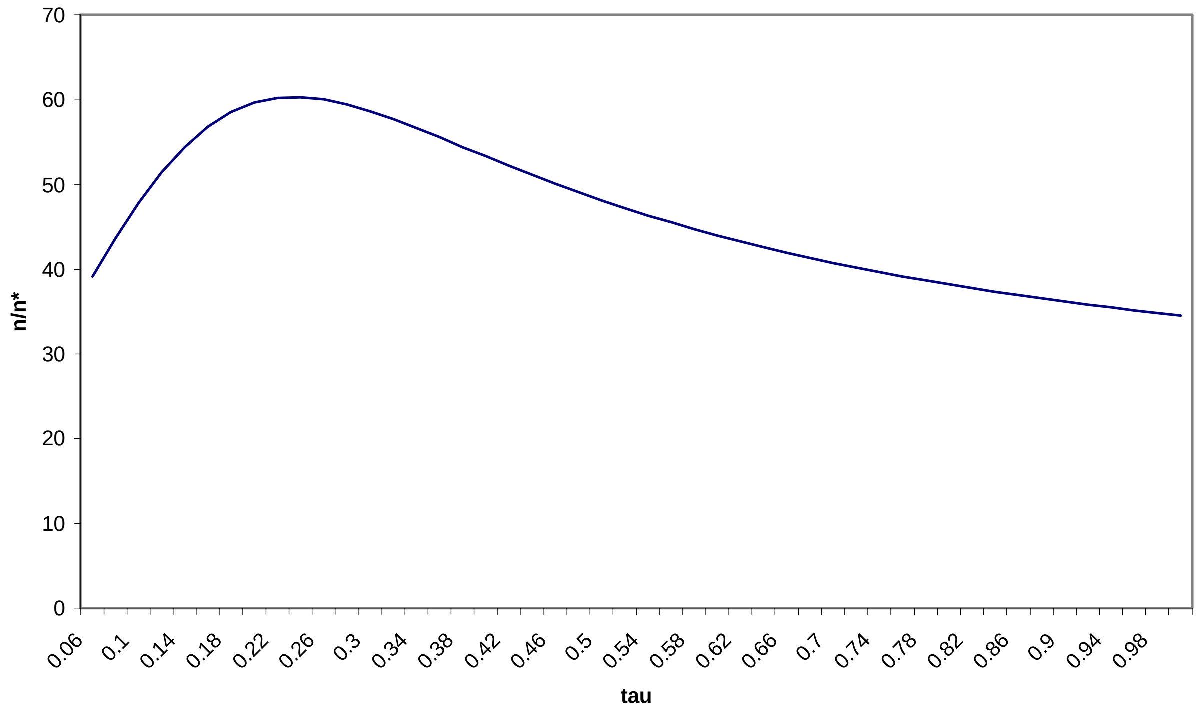


Given the relative endowments presented in table 3.1 above, the rural area has the highest skill premium in autarky, i.e., when $\tau = 0$ as indicated by equation (15). As transaction costs come down and the two regions start to trade in producer services, the skill premium immediately starts to fall sharply in the rural region and the income distribution between skilled and unskilled workers becomes more equal within the rural region as transaction costs come down. At a certain point when transaction costs are still relatively high in the numerical example chosen here, the skills premium reaches a minimum. As transaction costs decline further, the skills premium starts to rise again and thus inequality increases in the rural region. The skills premium eventually reaches the same level as in the urban region when transaction costs are totally eliminated. The development of the skills premium in the urban area follows a much less dramatic, but opposite path; it first increases and then starts to decline. What happens is the following:

Because of returns to diversity, the X-producers in both regions will use all varieties of producer services, both the locally produced and the varieties produced in the other region, even if the varieties purchased from the other region are expensive due to the transaction costs. However, since the rural region has fewer producer service firms (see figure 3.2), and therefore purchases a larger number of services from the other region, the relative importance of transaction costs is higher in the rural area. Consequently, the change in the cost index of the X sector is larger in the rural area. In both regions trade in producer services leads to an increase in the X-sectors' purchases of producer 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 the urban region, while this is not the case in the rural region. New service firms are established in the urban region, while existing firms go out of business in the rural region. There is in other words a tendency towards agglomeration of producer services in the urban region. 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 the urban region while it declines in the rural region.

The process is reversed when a point is reached where the increased market share in the urban region more than compensates for the loss of market share in the home region for the rural Z-sector, and employment in the sector starts to increase. Developments in the relative number of producer services are depicted in figure 3.2.

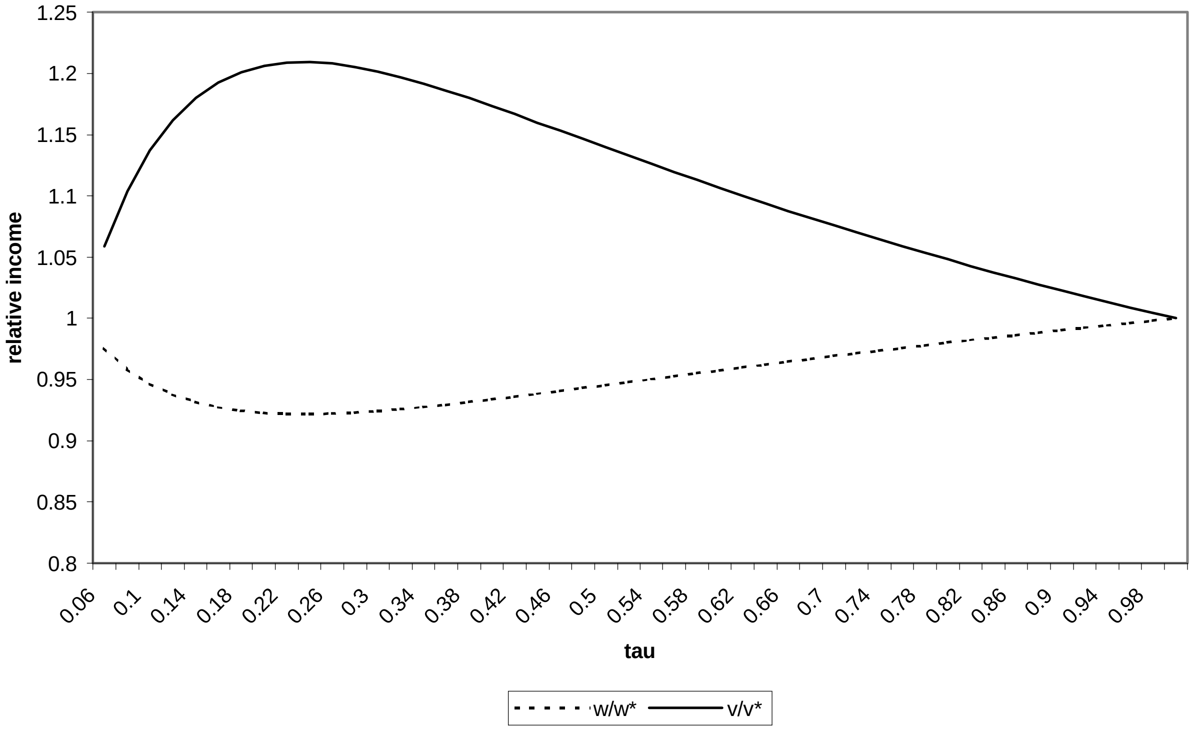
Figure 3.2. Relative number of producer services



The figure illustrates the reallocation of skills taking place during the transition from high transaction costs to the eventual elimination of transaction costs. The curve peaks at the same transaction cost level as the skill premium curves peak/bottom out.

We have seen how a decline in transaction costs in the trade of producer services affects income distribution *within* the two regions. We now turn to the impact on income distribution *between* the two regions. This is illustrated by figure 3.3, which shows the relative wages of both skilled and unskilled labor.

Figure 3.3 Relative wages for skilled and unskilled workers



It is worth noticing that rural unskilled workers earn a higher nominal income than their unskilled urban colleagues, while the opposite is true for skilled workers as long as $\tau < 1$. Relative wages 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. Comparing figures 3.2 and 3.3, it is clear that the adjustments induced by lower transaction costs of producer services mainly fall on rural skilled labor. The findings so far are summarized in table 3.2.

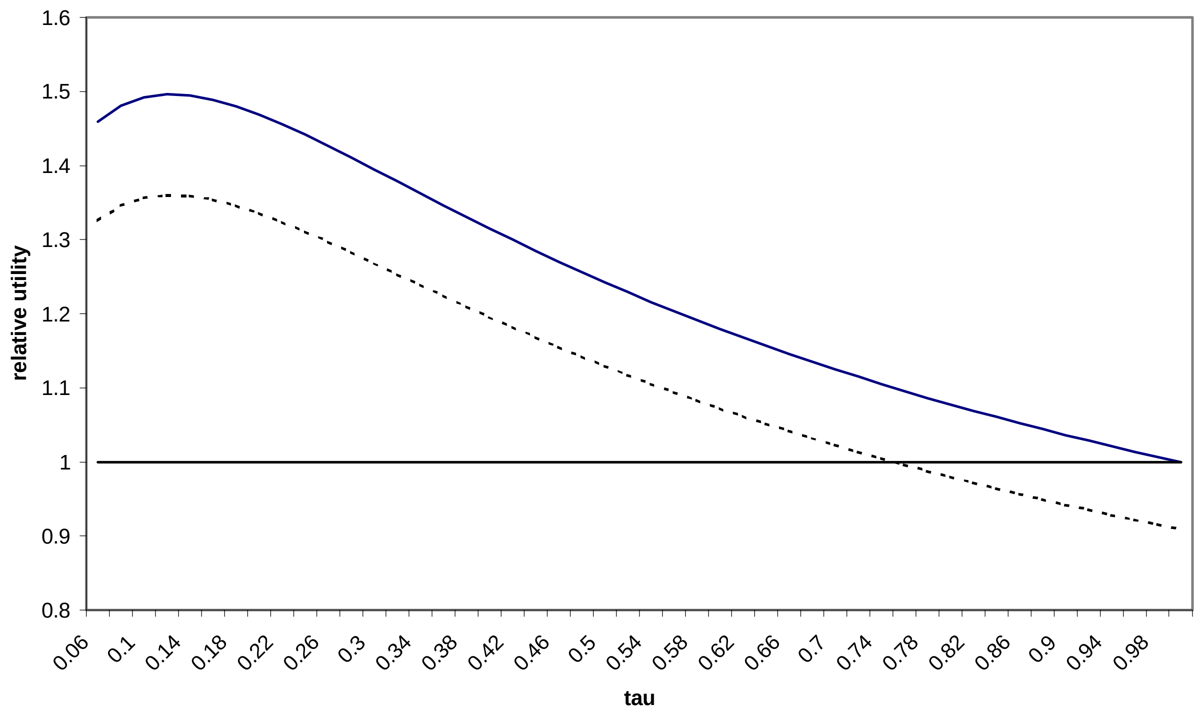
Table 3.2. Income distribution as a function of τ.

	$0<\tau<\tau^*$	$\tau^*<\tau<1$
Skills premium urban	+	-
Skills premium rural	-	+
Relative wage unskilled (w/w*)	-	+
Relative wage skilled (v/v*)	+	-
Wage rate unskilled rural	+	-
Wage rate skilled urban	+	-
Wage rate skilled rural	-	+

The critical level of transaction costs denoted τ^* corresponds to the turning point of the curves presented in figures 3.1-3.3. The wage rates presented in the last three rows of the table are all relative to the wage rate of unskilled workers in the urban region. Who the winners and losers from lower transaction costs, and therefore a higher degree of economic integration are depends on whether we are to the left or to the right of τ^*. Assuming that there is a time dimension to the change in transaction costs such that transaction costs decline over time, skilled workers in the rural region are the big losers early in the process when producer services have just become tradable, but at a high cost. Likewise, skilled rural workers are the big winners at a later stage of integration. For the other groups the changes are much less dramatic.

If we somewhat speculatively interpret the range (0, τ^*) as the period during which universal access to telecommunications such as fixed line telephones and first and second generation mobile telecommunications is provided, while the range (τ^*, 1) represents the period during which universal access to broadband and wireless Internet occurs, and if we relax the assumption that workers can not move between regions, then we can ask the question: will the rural region lose its skilled workers as the transaction cost parameter moves from zero to τ^*? And will broadband and WAP bring them back? In order to analyze this question we compare the utility level of an individual skilled worker in each location and assume that he or she will move if the utility level is higher in the other region. The relative utility level, U/U* is depicted in figure 3.4 below.

Figure 3.4. Relative utility, urban/rural skilled workers



Both curves show the relative utility level of a skilled worker if he lives in the urban region compared to the utility if he lives in the rural region. As long as the curve lies above the unity line, the worker is better off if he lives in the urban region. The uppermost curve is drawn for the parameter values presented in table 3.1 and the A parameter in equation (5) equal to unity for both regions. Clearly, if the two regions were equally attractive in terms of recreation facilities and other non-market goods, skilled workers would certainly move from the rural to the urban area. Moreover, as workers move from the rural to the urban area, the utility gap will increase because the relative market size of the X-sector will increase (the curve in figure 3.2 will shift upward) and lead to the establishment of more producer service firms in the urban area. Only when transaction costs are totally eliminated will the skilled worker be indifferent between living in the rural and the urban region.

The lower dotted curve presents relative utility if the value of the non-market variable A is 10 percent higher in the rural region than in the urban region. Then the answer to our question is, yes, the Internet will lead to an exodus of skilled workers from rural to urban regions, and yes, introduction of broadband Internet access will bring them back.

The next question is then whether there is sufficient demand for broadband access to justify such investment in the rural region. We leave that question to future research, but notice that a connection to broadband networks will lead to an increase in the fixed cost of producer service firms while substantially lowering the transaction costs. The increase in the fixed cost will mean that each producer service firm has to be larger in order to break even. How much the fixed cost will increase, depends on the number of other firms that will connect to the broadband network. Incorporating this fixed cost and network externalities in the model would be interesting extensions of the model. Another interesting area for further research is empirical estimates of τ^*, since the impact of changes in τ will be opposite, depending on which side of the critical level the present τ is.

4 Some empirical evidence

4.1 Aggregate data for the Norwegian economy

A recent survey of the use of ICT in Norwegian businesses finds that the use of ICT is widespread, but usage varies between industries, company size and regions (Pilskog and Sverrbo 2000). The survey compiled data on various uses of ICT in a sample of companies. The published results present data on ICT use by company size, by sector and by county. Among industries, the financial sector has the highest usage with 100% of all businesses surveyed using ICT, while Transport and Hotels and Restaurants had the lowest usage with 79 and 77% respectively. Turning to company size, the usage of ICT increases monotonically with company size. Only 55% of companies with less than 10 employees use ICT, while 98% of companies with more than 100 employees use ICT. Finally, the region with the highest ICT use is Nord-Trøndelag with 99% and the lowest is Telemark with 76%. The use of Internet in companies follows the same pattern as the usage of ICT in general, but the difference between small and large businesses is bigger and the regional differences are greater.

The survey also asked companies what they use ICT for. The financial service sector is the sector with the highest score on almost all accounts as far as use of ICT is concerned. However, interestingly, in the sector with the lowest usage (Hotel and Restaurants) 98% of all businesses with access to the Internet also had their own websites. Furthermore, Hotels and Restaurants is the sector with the highest share of companies conducting e-commerce. It is also interesting to note that according to the survey, the share of total sales being conducted over the Internet is higher for small and medium-sized companies and that it is also the small and medium-sized companies that receive the highest share of total orders from abroad over the Internet. Internet in other words appears to be an important channel for marketing in export markets for small and medium-sized companies.

In order to get an impression of the use of ICT as a channel for information flows and transactions in rural areas, we ran a regression where the share of companies having their own website is the dependent variable. We used the Pilskog and Sverrbo (2000) data on use of ICT by county (19 observations). The sample is therefore too small for drawing bold conclusions or for experimenting with explanatory variables. In order to capture the possible agglomeration effect discussed above, we included a measure of urbanization (the share of the population living in towns or villages with a population of more than 2000 inhabitants). In addition we included the distance from the largest city or town in the county to Oslo, the capital of Norway, as a measure representing transport costs. We could also include regional income per capita, but that turned out to be almost perfectly correlated with the degree of urbanization.[15] Finally we wanted to control for sectoral differences in ICT use by including the financial sector, wholesale trade and manufacturing share of total output produced in the county. These three sectors were the sectors with the highest share of companies having their own website. The results are presented in table 4.1.

Table 4.1. Share of companies having their own website

Variable	Regr. 1	Regr. 2	Regr. 3
Constant	30.6 **	30.3**	33.2
	(3.84)	(3.65)	(1.86)
Urbanization	0.29 *	0.14	0.29*
	(2.35)	(1.87)	(2.21)
Distance from Oslo	-0.01 **	-0.01*	-0.01*
	(2.91)	(2.84)	(2.19)
Share of financial services in gross output		0.42	
		0.30	
Share of financial services, retail and wholesale trade and manufacturing in gross output			-0.09
			(-0.16)
R^2	0.56	0.56	0.56
Observations	19	19	19

* Significant at the 5% level
** Significant at the 1% level

The first regression includes only geographical variables. Urbanized areas tend to have relatively more companies with their own website than rural areas and locations far from Oslo tend to have relatively fewer companies with their own website than locations close to Oslo. Furthermore, these geographical variables appear to explain a large portion of the variation in having a website. Differences in industrial structure among counties did not have a significant impact on having one's own web site, although including them in the regression did reduce the statistical significance of the other variables somewhat.[16] The regression thus indicates that there are indeed differences between urban and rural areas and between center and periphery, but rural areas and the periphery are lagging behind. The data thus do not indicate that firms in rural and remote areas compensate their locational disadvantage by investing in ICT. Rather, the strong correlation between the degree of urbanization and income indicates that locational disadvantages are rather compensated by relatively low wages and salaries, as our model simulations in section 3 predict.

The Vik-Sandvik company seems to be more the exception than the rule as far as the impact of location on ICT use is concerned. It is therefore interesting to take a closer look at the company in order to speculate around to what extent the company leads where others will follow in the future.[17]

[15] The correlation coefficient is 0.94.
[16] We ran regressions where we entered each of the three sectors alone and in all possible combinations, but none of the combinations were significant at a 10 percent level or better. All three sectors are positively correlated with the urbanization variable and negatively correlated by the distance from Oslo, but the correlations are weak and in some cases negligible (financial services-distance from Oslo –0.11; manufacturing- urbanization 0.07 and the other ranging between 0.30-0.53 in absolute value).
[17] There are of course other export-oriented sophisticated services firms located in remote areas, but still most such firms are found in urban areas.

4.2 A case study: Vik-Sandvik[18]

The Vik-Sandvik group consists of 7 consultancy and engineering companies specializing in naval architecture, design and engineering for fishing vessels, offshore vessels and a wide range of special-purpose vessels. The main office and the Vik-Sandvik Offshore division are both located at Fitjar, a village on the island Stord some 50 km driving distance plus a 50 minutes crossing by a car ferry south of Bergen. The company was established in 1975, but one member of the group, Skipskonsulent AS located in Bergen, was established already in 1969. Skipskonsulent has also a representative office in Shanghai, China. Vik-Sandvik has established a daughter company at Omastrand close to a shipyard building catamarans for passenger traffic, the company has established a daughter company in Gdynia, Poland and finally Skipatækni of Iceland has joined the group. The Vik-Sandvik group employs about 170 persons. The company was recently awarded its biggest contract ever. The contract was for design and engineering of 12 supply vessels for a US shipping company, and it was won in an internationally competitive market.

The 7 companies in the group have partly overlapping and partly complementary competence. The Bergen office specializes in large vessels, the Fitjar office in fishing and offshore vessels, the Poland office was established partly in order to have a presence close to one of Europe's most competitive shipyards and partly in order to get access to skilled workers at reasonable costs, as engineers with the relevant skills are scarce in Fitjar. Finally, the acquisition of the Icelandic firm was motivated by getting access to its superior technology on fishing vessels.

Fitjar is part of a region with a long tradition of coastal and ocean fishing and fish-farming. Furthermore the island where Fitjar is located hosts one of northern Europe's largest offshore yards, Aker Stord. Finally, the supply bases for some of the major offshore oilfields in Norway are found not very far from Bergen. The local market for ship design and engineering is therefore substantial and local fishing and shipping companies indeed constituted the customer base of the company in the early days and still are the most important customers. However, as the fishing and offshore customers have become more international and also to an increasing extent build their vessels abroad, the Vik-Sandvik company followed the customers abroad and also got a foothold in foreign markets through the relation to shipyards with an international customer basis.

Vik-Sandvik has been a leading company in terms of ICT use in the industry. Electronic design was introduced in 1989/90, first on individual desktop computers, later these were linked in internal networks. The most recent development is linking the Bergen office to the main office's intranet. Individual engineers can now work simultaneously on different parts of a vessel and they can see the interface with what the others are doing. The software used for design is a standard software called CAD (Computer Assisted Drawing). The package that can be bought off-the-shelf is, however, only a skeleton that needs to be filled with content adopted to the purpose of the firm. The firm has some capacity in adopting the software, but special competence from outside is needed for programming. In order for the system to operate smoothly, weekly visits from the software supplier are necessary. Vik-Sandvik bears the cost of these visits.

So far drawings have mainly been two-dimensional. However, the interface between the parts is much more easily seen in three-dimensional drawings. Vik-Sandvik is in the process of

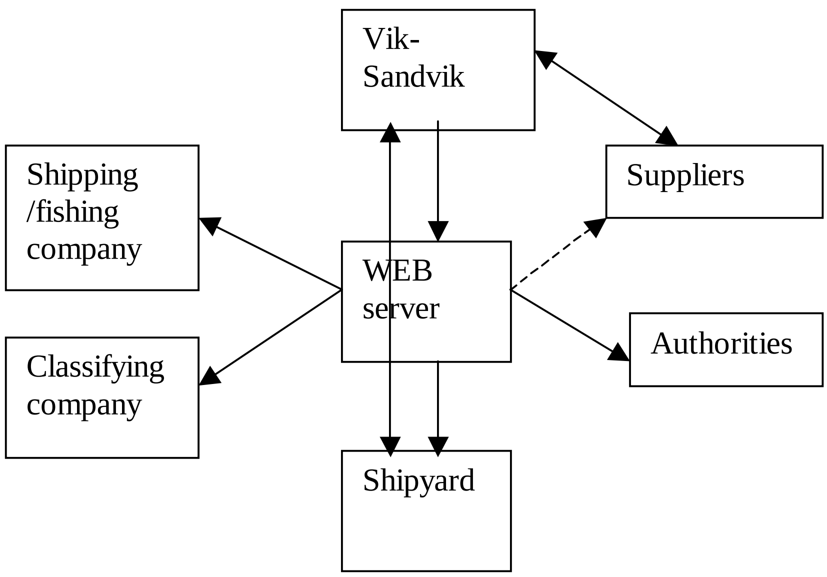
[18] The case study is based on an interview with Ketil Fykse, head of data processing at Vik -Sandvik 22.02.2001, the local newspaper "Sunnhordland", www.vik-sandvik.com and various information material provided by the firm.

introducing and adopting the necessary software in cooperation with a Dutch-Finnish software company. Again face-to-face communication and frequent visits from the software supplier is necessary.

Design and engineering of the types of vessels Vik-Sandvik specializes in are not standardized. Design, engineering and documentation are therefore done for each vessel or series of similar vessels. There is a continuous development towards making the vessels faster and more flexible while at the same time maximizing the loading capacity. Striking a balance between different and some times incompatible demands is a challenge and requires experience, close relations to and follow up of customers and some research and development (R&D). R&D is done in cooperation with SINTEF, a research institution related to the University of Trondheim. In particular, models are built and tested at the SINTEF laboratories. A challenge for the company is to institutionalize its experience and know-how. The company has hitherto been small with a sufficiently stable workforce to accumulate experience through personal interaction, but the company is now in the process of outgrowing that stage.

Although Fitjar is remote relative to the world markets, a major fiber-optic cable between Bergen and Stavanger runs across the island. The cable is twined around an electricity transmission line between the two cities. This cable gave Vik-Sandvik broadband access at a cost not very different from those incurred by companies located in Bergen or Stavanger. Access to broadband has improved the effectiveness of interaction with customers and other participants in a project. Figure 4.1 illustrates the organization of recent projects around electronic networks.

Figure 4.1. Project organization



The customer has a designated server on which Vik-Sandvik places continuously updated drawings and project documentation. The shipyard retrieves the drawings and documentation, and the drawings are fed directly into the company's computer-controlled machinery. Suppliers of materials for the ship have limited access to the web server in order to secure timely delivery while protecting Vik-Sanvik's intellectual property as far as possible. The shipping or fishing company who ordered the ship also has access to the server and can follow the engineering and building process. Finally, the authorities and the classification company who authorize the ship for its intended use have access to the server. The relevant parties are notified by e-mail when new or revised material is put on the server. This way of organizing a project has hitherto only been possible when the customer has a designated server. In projects where this has not been the case, drawings and documentation have been sent to the customer as attachments to e-mail. Using a designated server as illustrated in figure 4.1 is however much more flexible and effective for all parties involved in the project, and Vik-Sandvik plans to invest in its own server which will serve the purpose as illustrated in figure 4.1.

Vik-Sandvik uses the Internet for other purposes than transferring its product to customers. The company participates in an online procurement network where the e-commerce company negotiates prices and other terms on behalf of all the members of the network. It also notifies the members if they think they can get a better deal by changing suppliers of services such as telecommunication, electricity etc. ICT is not much used for marketing or recruitment in Vik-Sandvik. The firm has a sales office which works towards the customer base. This, combined with word of mouth has been sufficient to ensure full capacity utilization.

If we relate the Vik-Sandvik case study to the model in section 3, the company is a z-sector firm. Its fixed costs consist of skills upgrading, software and a monthly fee for broadband access, in addition to the usual fixed costs of keeping an office. The firm is clearly distinct from other firms in the same industry as it develops its own designs and solutions. Its customers are both local firms, firms located in Bergen or other Norwegian cities and foreign firms. However, these firms are mainly in the Y-sector, so in order to fully capture this case study we would need to introduce intermediate inputs to the Y-sector as well. This is done in several papers,[19] and it does not change the main conclusions that we made in section 3. The model thus predicts that the lower the cost of transferring the products to the customers, the higher the wages Vik-Sandvik can afford to pay if we are to the right of τ^* in figure 3.1, improving the likelihood that the company can remain in its present location.

Frequent visits to the shipyard by Vik-Sandvik staff have been necessary in order to follow up and assist during the building process, indicating that electronic communication indeed needs to be supplemented by face-to-face communication also in this industry. In section 2 we argued that this constitutes an agglomeration force that would induce firms of the Vik-Sandvik type to locate near its major customers. This is also what the company has done through the establishment of the Vik-Sandvik Group, which has companies in three Norwegian locations in addition to Poland, China and Iceland. Vik-Sandvik has in fact become a rural-based, small multinational company.

5 Summary and conclusions

This study suggests that both relative and absolute income of skilled workers living in rural areas will be dramatically affected by the diffusion of ICT in the economy, while other groups are less affected. Early in the process of ICT diffusion when transaction costs are still high, skilled workers in rural areas fall behind, and probably dramatically so, inducing them to leave for the cities. At a later stage this development is reversed. Those rural areas that have

[19] See for example van Marrewijk et. al. (1997)

managed to develop sufficient infrastructure and can offer non-market goods such as recreation and good quality public services, broadband and wireless Internet services may bring skilled workers back.

The model developed in section 3 does not entail any policy parameters, but the transaction cost parameter τ and utility parameter A are obviously determined by investments in infrastructure and education as far as the τ is concerned and in public services and conservation of environmental and recreational assets as far as the A is concerned. We have seen that low-cost transport and communication infrastructure is of utmost importance if rural areas are to keep and/or attract knowledge-intensive industries. In an open relatively small economy, high transport and transaction costs have to be counterbalanced by lower wages of skilled personnel for the region to be able to sell its products to customers in the larger region or city. In Norway there is indeed evidence that the income level is significantly lower in rural areas than they are in urban areas as the discussion in section 4 shows. Furthermore, the regressions suggest that the use of ICT is more widespread in urban areas.

We have presented a case study that shows the potential of knowledge-based industrial development in a region that actually has good communications, and a knowledge-base that has developed over a long period of time. Thus, the region in which Vik-Sandvik is located has a long tradition of marine activities such as shipbuilding and building of oil platforms. These industries are, however, on a declining trend as the Norwegian petroleum sector is maturing, the Far East and Eastern Europe gain comparative advantage in shipbuilding and subsidies to such industries are being scaled back in the OECD countries. As a result, the region is in a process of transition and the local governments in the area are greatly concerned with diversifying the local economy and avoid losing competence to the neighboring cities, Bergen and Stavanger. The policy measures taken so far have focused on development of transport infrastructure, improving the quality and efficiency of public services, skills upgrading in cooperation with the regional university located in the area and not least assistance to entrepreneurs, first and foremost in terms of coaching them through the bureaucracy facing start-ups. In addition, it has been a policy objective to encourage and facilitate network building among local firms.[20] These policy measures do affect both the location choice of firms and skilled individuals, but only if they change the *relative* attractiveness of the region.

[20] Interview with Gro Jensen Gjerde, Samarbeidsrådet for Sunnhordland, 04.01.2001

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