Working Paper No. 32/01

Trade in Information Services and Economic Development:

On the implications of ICT for less developed countries

by

Henri L.F. de Groot
Hildegunn Kyvik Nordås

SNF Project No. 4420
WTO/GATS and Economic Development: Key to the new economy

The project is financed by the Research Council of Norway

FOUNDATION FOR RESEARCH IN ECONOMICS AND BUSINESS ADMINISTRATION
Bergen, July 2001
ISSN 0803-4028

Trade in Information Services and Economic Development:

On the implications of ICT for less developed countries

By Henri L.F. de Groot[a] and Hildegunn Kyvik Nordås[b1]

[a] Vrije Universiteit, Dept. of Spatial Economics

De Boelelaan 1105, 1081 HV AMSTERDAM, The Netherlands

E-mail: hgroot@econ.vu.nl

[b] SNF

Department of Economics, NHH, Helleveien 30 N-5045 BERGEN, Norway

E-mail: hildegunn.nordas@snf.no

Date: July 11, 2001

Abstract. This paper focuses on both the positive and negative consequences of reductions in costs of trading information services for economic development, with a special focus on less developed countries. We develop a workhorse model that captures the key characteristics of trade and production of information services. We subsequently modify and extend the model in several ways to study various aspects of trade in information services and the consequences of lower transaction costs for economic development. First, we consider the consequences of non-unitary income elasticities for the demand for services for economic development. Second, we analyse the consequences of declining transaction costs for the relative wealth of nations in various trade regimes. Finally, we study the first-best supply and demand for information services and policy measures that can be employed to decentralise the first-best social optimum.

JEL-codes: F12, H40, O11
Key-words: international trade, information services, economic development, welfare

[1] Henri de Groot is grateful to the Chr. Michelsen Institute and the Norwegian Business School for their hospitality during his stay at the Institute and Business School as a visiting research fellow from which this paper resulted. Useful comments by Gert-Jan Linders on an earlier version of the paper are gratefully acknowledged. Of course, the usual disclaimer applies.

1. Introduction

Information plays a crucial role in modern economic life. It is, in the words of Evans and Wurster (2000) '…the glue that holds value chains and supply chains together' and one of the key strategic inputs in production processes. One of the most important developments in the information industry is the drastic decline in the costs of exchange and gathering of information that has taken place over the last decade. The invention of the microprocessor and the possibilities it created for the widespread use of the Internet has evidently enabled this development.[2] For less developed countries, these developments have taken place at a breath-taking pace. They create opportunities and challenges as well as risks and problems.

Information services have several stylised characteristics. First, considering their production, they are costly to produce but cheap to reproduce. Or, stated differently, the initial (fixed) cost of developing a particular service is high (and to an important extent sunk) but the (variable) costs of reproduction are low. An implication of this characteristic is that the industries producing information services are characterised by imperfect competition. Second, both production of information services and the use of information in producing and marketing final products are relatively intensive in human capital. Furthermore, information services are essential intermediate inputs in the production and marketing of final products. Third, the efficiency with which information services can be used depends strongly on the available infrastructure that is required to transport the services (think of the Internet and the cables needed to cheaply transport information from one place to another). Furthermore, information is often of a strategic and time-sensitive nature; a factor that underlines the importance of effective infrastructure. The infrastructure has important characteristics of a public good and requires government intervention for its provision. Fourth, the demand for final products that are intensive in information services depends on the level of development of the country or region under consideration. More specifically, information intensive products have an income elasticity of demand exceeding unity implying that the relative demand for these goods increases as a country grows rich (see, for example, Deaton, 1980, Maddison, 1991). Finally, over the last decade the costs of transporting information services have declined dramatically and these developments are foreseen to continue over the next decade with the arrival of new,

[2] In many popular contributions to the literature on the role of information services, the central role of Internet has been emphasized. In the end, however, this development was only made possible by the invention and widespread application of the micro processor which can be labeled the 'general purpose technology' that underlies the recent developments.

faster and more efficient microprocessors and transmission networks. These developments have articulated the importance of the role of trade in information services in the process of economic development.

This paper explores the impact of lower transaction costs of information and better access to information services for economic development, with a special focus on less-developed countries. The rest of the paper is organised as follows. In Section 2, we discuss and present a simple workhorse model capturing the essential characteristics of information services, being the high set-up costs of production and the low variable costs of reproduction.[3] Subsequently, we extend this workhorse model in various directions to analyse the other issues raised before, one at a time. Section 3 focuses on the typical development of the demand for information services during the development process of countries. It emphasises the relevance of non-unitary income elasticities for the demand for goods with different information intensities. Section 4 extends the basic model to a multi-sector two-country model in which there is trade in information services. The comparative static characteristics of this model are explored in Section 5, emphasising the determination and development of relative wages, the allocation of labour and welfare. In Section 6, we elaborate on the patterns of specialisation that can emerge once we allow for trade in both final goods and information services. The first-best welfare characteristics are the topic of discussion in Section 7. We determine the first-best social optimum and discuss policy measures that allow for the decentralisation of this first-best optimum. Section 8 concludes.

2. A simple model on the role of information services in economic development

We model an economy consisting of two sectors: a final goods sector (which can be thought of as an assemblage industry) in which final goods are produced (assembled) under perfect competition and an intermediate goods sector in which information services are produced. The final goods sector is composed out of a given number of sub-sectors (indexed j=1, …, J). Each sector produces a homogeneous consumption good (Y_j) using labour (L_{Yj}) and a composite (M_j) of information services as inputs:

(1) $$Y_j = L_{Yj}^{\beta_j} M_j^{1-\beta_j},$$

[3] The aim of this paper is not to address and incorporate all characteristics of information services in one single encompassing model. This would, in our view, add little to the understanding of the mechanisms that are crucial when studying the role of information services in economic development.

where β is allowed to differ between the various sub-sectors. This captures in a stylised way the fact that the information intensity (1-β) of final consumption goods may differ. The composite of information services is defined as:

$$(2) \qquad M_j = N^{\kappa}\left[\frac{1}{N}\sum_{i=1}^{N}\left(HI_{ij}\right)^{(\varepsilon-1)/\varepsilon}\right]^{\varepsilon/(\varepsilon-1)}$$

in which N is the number of information services (indexed i=1, …, N) used in production, I_{ij} is the amount of intermediates of variety i used in sector j, H captures the productivity of information services[4] (HI represents information services in efficiency units), κ represents the returns to diversity of information services, and ε is the elasticity of substitution between any pair of information services (in efficiency units). We assume that the elasticity of substitution between information services is larger than one (ε>1). An important characteristic of this aggregator of information services is that it exhibits returns to variety. This is a characteristic that seems to fit well with modern conceptions on information (for example, Shapiro and Varian, 1999). Note that we explicitly single out returns to diversity from the elasticity of substitution.[5] We will return to the importance of this distinction in Section 7.

Maximisation of profits gives rise to cost shares of labour and information services equal to β and 1-β, respectively:

$$(3) \qquad \frac{M_j P_{Mj}}{L_{Yj} W} = \frac{1-\beta_j}{\beta_j}$$

and a downward sloping demand curve for information services:

$$(4) \qquad I_{ij} = M_j\left(\frac{P_{Ii}}{P_{Mj}}\right)^{-\varepsilon} H^{\varepsilon-1}, \text{ where } P_{Mj} = \frac{1}{H} N^{\frac{\varepsilon}{\varepsilon-1}-\kappa}\left[\sum_{i=1}^{N} P_{Ii}^{1-\varepsilon}\right]^{\frac{1}{1-\varepsilon}}.$$

Producers of information services produce under increasing returns to scale due to the presence of a fixed cost (which we will express in terms of labour). This is a characteristic of

---

4 We think of this productivity of information services (H) as essentially being endogenous. It crucially depends on the infrastructure through which information can be exchanged. For the aim of this paper, we just assume it to be constant and exogenously given. In future research, we intend to focus in more detail on the determination and importance of this infrastructure, where this infrastructure should be thought of in a broad sense. It can also include, for example, human capital that is crucial for being able to process information services in an effective way.

5 We refer to, for example, Benassy (1996) and de Groot and Nahuis (1998 and 2001) for a discussion on this way of modeling and generalizing the concept of 'taste for diversity' as pioneered by Dixit and Stiglitz (1977) and Spence (1976).

information services that fits well with modern conceptions on information according to which information services are expensive to produce, but cheap to reproduce (see, for example, Shapiro and Varian, 1999, for a characterisation of information services). The relevance of this characteristic will become clear later. The (marginal) labour requirement to produce one unit of information service is equal to γ. The fixed cost is taken to be equal to L_f. Maximising profits ($\pi_i = I_i P_{Ii} - W(L_{Ii}+L_f)$) subject to the demand curve for information service *i* gives rise to mark-up pricing:

(5) $$P_{Ii} = \frac{\varepsilon}{\varepsilon - 1}\gamma W.$$

Firms thus put a mark-up of ε/(ε-1)(>1) over unit costs of production (γ*W*). The mark-up negatively depends on the elasticity of substitution: the better information goods can be substituted, the less market power the producers of information services have and the lower the mark-up that they can put on unit costs will be. To close the model, we specify demand for the final consumption goods, impose labour market equilibrium and assume that all firms producing information services exactly break even. We assume that consumers maximise a Stone-Geary utility function:

(6) $$\max_{Y_j} U = \prod_{j=1}^{J} (Y_j - \overline{Y}_j)^{\sigma_j} \qquad \text{s.t.} \qquad \sum_{j=1}^{J} Y_j P_j \leq WL,$$

in which $\overline{Y}$ reflects a subsistence requirement. This formulation is an analytically attractive way to introduce the empirically relevant phenomenon of non-unitary income elasticities of demand for different goods to which we will return in Section 3. For the time being, we assume the subsistence requirements to be equal to zero resulting in the familiar Cobb-Douglas utility function. Performing optimisation then results in consumers who spend fixed shares of their income on the final consumer goods that are available:[6]

(7) $$Y_j P_j = \sigma_j WL, \text{ where } P_j \equiv \left(\frac{W}{\beta_j}\right)^{\beta_j}\left(\frac{P_M}{1-\beta_j}\right)^{1-\beta_j}.$$

[6] This is evidently a strict assumption in a context in which goods differ in terms of their information intensity. We discuss a more realistic version of the model in this respect in Section 3, where we solve the model for the more general case of a Stone-Geary utility function and analyze the development of the demand for information services as an economy matures.

Furthermore, we assume that the labour market always clears and that labour is in fixed supply (equal to L):

$$(8) \qquad L = \sum_{j=1}^{J} L_{Yj} + \sum_{i=1}^{N} (L_{Ii} + L_f)\,.$$

Free entry and exit of firms producing information services results in zero (excess) profits and determines the size of firms producing these services:

$$(9) \qquad \pi_i = P_{Ii} I_i - W(L_f + \gamma I_i) = 0 \quad \Leftrightarrow \quad I_i = \frac{(\varepsilon - 1) L_f}{\gamma}\,.$$

The production of information services thus positively depends on the fixed costs and the elasticity of substitution. These comparative static characteristics are easily understood. High fixed costs require – ceteris paribus – a large production to recover the fixed costs. A large elasticity of substitution implies low market power, a low price and a huge required production volume to recover the fixed costs. From this relationship, we derive employment per information service firm as $L_{Ii} = L_f + \gamma I_i = \varepsilon L_f$. The model is now closed and we can determine the number of information services that is supplied and the allocation of labour over the two sectors of the economy. This yields

$$(10) \qquad N = \frac{L\left[1 - \sum_{j=1}^{J} \beta_j \sigma_j\right]}{\varepsilon L_f}, \quad L_Y = L \sum_{j=1}^{J} \beta_j \sigma_j\,.$$

The number of service-producing firms that can be sustained in equilibrium thus positively depends on the size of the economy and negatively on the elasticity of substitution, the fixed costs and the labour-intensity of the sectors in the economy (weighted with their respective shares as represented by σ). The last result is understood by the fact that the number of firms that can be sustained is constrained by the demand for information services. This completes the workhorse model, and we now turn to extensions of it.

3. Demand for information services and economic development

When comparing developed with less developed countries, the assumption of similar and homothetic utility functions is evidently too simple. Income elasticities for different groups of consumer goods are well-known to be a function of average income per capita, where the general tendency is that income elasticities are low for traditional agricultural goods while they are high for information intensive service goods (for example, Deaton and Muellbauer, 1980).

As a result, countries tend to spend an increasing share of their income on information-intensive final goods, as they grow rich at the expense of more traditional labour intensive goods. We capture this stylised pattern of consumer behaviour by using the general Stone-Geary utility function (6) where we now set $\bar{Y}_j \geq 0$ for all goods, with inequality for at least one good. This results in non-unitary income elasticities in a mathematically tractable way (see, for example, de Groot, 1998). Equation (7) now modifies to:

$$Y_j = \bar{Y}_j + \frac{\sigma_j \left[WL - \sum_{i=1}^{J} \bar{Y}_i P_i \right]}{P_j}.$$

So expenditures on goods from sector *j* are equal to expenditures that are required to fulfil subsistence requirements plus a share σ of the income that is left after all subsistence requirements have been fulfilled. Income elasticities of demand are a negative function of subsistence requirements. Hence, the larger the subsistence requirement, the lower the income elasticity of demand will be.

An important implication of this generalisation of the model is that the number of high-tech goods that can be sustained in equilibrium becomes dependent on the stage of development of an economy. This is easily understood by looking at 10. The introduction of subsistence requirements essentially endogenises the spending shares describing how much of income consumers spend on goods from different sectors. If - as seems to be empirically relevant - spending shares at low (high) levels of development are high for those goods with a low (high) information intensity (a high (low) value for β), the number of firms that can be sustained declines. The relevance of this will recur later in the analysis.

4. A two-country version of the model

Let us now turn to a two-country version of the workhorse model. The two countries are denoted home and foreign. Variables related to the home country are represented by upper cases, while variables related to the foreign country are represented by lower cases. Input of information services in foreign production of final goods is denoted with a star. We start with a market structure where there is trade – subject to transport costs – in information services, while there is no trade in final goods (compare, for example, Markusen, 1989, and Francois, 1990). Of course, this is a highly simplified representation of reality. However, developments in world trade and investment patterns have moved into the direction of increased trade in intermediate goods and services, and production of final goods near the home markets (for example, Reich, 1991, and Porter, 1990). In our first analysis of trade in information services we thus develop a stylised model capturing this stylised development pattern. We aim at pursuing the consequences of these developments for economic development, relative welfare and real wages, specialisation patterns, etc.

Let us now briefly characterise the equations as they apply in the foreign country, referring to Section 2 for discussion. Final goods are produced according to the production function (compare equation 1):

(11) $$y_j = l_{Yj}^{\lambda_j} m_j^{1-\lambda_j}.$$

The aggregate of information services in the two countries now constitutes of services produced locally as well as imported services (compare equation 2):

(12a) $$M_j = (N+n)^{\kappa} \left[\frac{1}{N+n} \left(\sum_{i=1}^{N} \left(HI_{ij} \right)^{(\varepsilon-1)/\varepsilon} + \sum_{i=N+1}^{N+n} \left(Hi_{ij} \right)^{(\varepsilon-1)/\varepsilon} \right) \right]^{\varepsilon/(\varepsilon-1)},$$

(12b) $$m_j = (N+n)^{\kappa} \left[\frac{1}{N+n} \left(\sum_{i=1}^{N} \left(hI_{ij}^{*} \right)^{(\varepsilon-1)/\varepsilon} + \sum_{i=N+1}^{N+n} \left(hi_{ij}^{*} \right)^{(\varepsilon-1)/\varepsilon} \right) \right]^{\varepsilon/(\varepsilon-1)}.$$

The corresponding price index for the M-aggregate in the two countries equals (compare equation 4):

(13a) $$P_{Mj} = \frac{1}{H} (N+n)^{\frac{\varepsilon}{\varepsilon-1}-\kappa} \left[\sum_{i=1}^{N} P_{Ii}^{1-\varepsilon} + \sum_{i=N+1}^{N+n} \left(p_{ii} t \right)^{1-\varepsilon} \right]^{\frac{1}{1-\varepsilon}},$$

(13b) $$p_{Mj} = \frac{1}{h} (N+n)^{\frac{\varepsilon}{\varepsilon-1}-\kappa} \left[\sum_{i=1}^{N} \left(P_{Ii} t \right)^{1-\varepsilon} + \sum_{i=N+1}^{N+n} p_{ii}^{\,1-\varepsilon} \right]^{\frac{1}{1-\varepsilon}}.$$

Transport costs are assumed to be of the iceberg type so $t \geq 1$. So foreign goods essentially get an 'additional mark-up' on their unit cost due to the fact that only a fraction of the goods shipped arrives and can effectively be used in production at home. The productivity parameters h and H capture differences in economic fundamentals of technological capability with which intermediates (either produced at home or abroad) are transformed into final consumption goods.

The utility function in the foreign country reads (compare equation 6):

(14) $$u = \prod_{j=1}^{J} \left(y_j - \bar{y}_j \right)^{\varphi_j}.$$

We set $\bar{Y}_j = \bar{y}_j = 0 \;\; \forall\, j$ in this section so preferences are of the Cobb-Douglas type. When imposing symmetry among the goods produced in either the home or the foreign country, the number of services produced in each country can be determined by the simultaneous equilibrium in the final goods market and the labour market in the same way as in the closed economy case:

$$(15) \qquad n = \frac{l(1-\sum_{j=1}^{J}\lambda_j \varphi_j)}{\varepsilon l_f}.$$

Relative wages and relative prices of information services in the two countries can be found from the balance in the information service market stating that total consumption of information in the two countries should equal total production of information services in the country of origin (which is derived from the zero-profit condition):[7]

$$(16) \qquad \begin{aligned} &\left[\frac{P^{-\varepsilon}}{NP^{1-\varepsilon} + n(pt)^{1-\varepsilon}} Q + \frac{(Pt)^{-\varepsilon}}{N(Pt)^{1-\varepsilon} + np^{1-\varepsilon}} qt\right] = \frac{(\varepsilon - 1)L_f}{\gamma}, \\ &\left[\frac{(pt)^{-\varepsilon}}{NP^{1-\varepsilon} + n(pt)^{1-\varepsilon}} Qt + \frac{p^{-\varepsilon}}{N(Pt)^{1-\varepsilon} + np^{1-\varepsilon}} q\right] = \frac{(\varepsilon - 1)l_f}{\gamma}, \end{aligned}$$

where Q and q are total expenditure on information services in the home and foreign country, respectively. For the time being, we assume that the technology for producing information services is the same in both countries implying equal fixed costs and labour productivity in the information-service sector. The relationship between relative prices of local and foreign differentiated information services (which is equal to relative wages) and the transport cost parameter then reads:

$$(17) \qquad \frac{1-\tilde{W}^{-\varepsilon}\tau}{\tilde{N}\tilde{W}^{1-\varepsilon}\tau + 1} = \frac{\tilde{W}^{-\varepsilon} - \tau}{\tilde{N}\tilde{W}^{1-\varepsilon} + \tau}\tilde{Q},$$

where a tilde represents the value of a variable at home relative to its value abroad (for example, $\tilde{W} = W / w$, etc.) and $\tau \equiv t^{1-\varepsilon} (0 < \tau < 1)$. The last expression has merely been introduced for presentational convenience. At the one extreme of no transport costs (t=1), τ

---

[7] Note that demand for information services in a country other than the country of origin of the service should be pre-multiplied by t in order to account for the amount of information services that is lost during transit. Furthermore, note that the marginal productivity of labor in producing intermediates is assumed to be equal to γ in both countries. The only difference in the production structure of the two countries is in terms of the fixed cost requirement.

equals one, whereas at the extreme of infinite transport costs ($t \to \infty$) it equals zero (note that $\varepsilon>1$). Expenditures on information services are given by:

(18) $$Q = \sum_j (1-\beta_j) P_j Y_j = \sum (1-\beta_j)\sigma_j WL \text{ and } q = \sum_j (1-\lambda_j) p_j y_j = \sum_j (1-\lambda_j)\varphi_j wl.$$

Equations (10), (15), (17) and (18) constitute a uniquely determined system of equations. The system cannot be solved analytically, and comparative static characteristics of the model will therefore be analysed by means of numerical examples in Section 5.

5. Comparative static characteristics[8]

In this section, we discuss the comparative static characteristics of the two-country model presented in the previous section. We present a three-sector version and focus the attention on the role of transportation and transaction costs. We start with a base line scenario where the countries are symmetric in all respects. In this case, declining transaction costs affect the two countries in the same way and do not affect their relative positions. The output of final goods and the real wage increase in both countries as transport costs decline. The price-deflators used for determining real wages are $\prod_{j=1}^{3} (P_j / \sigma_j)^{\sigma_j}$ and $\prod_{j=1}^{3} (p_j / \varphi_j)^{\varphi_j}$ for the home and foreign country, respectively, which are the true price indices (in the absence of subsistence requirements as we assume in the analysis in this section).

We next introduce asymmetries between the two countries, one at a time and analyse the impact of declining transaction costs in each case. Table 5.1 presents the parameter values and the levels of the exogenous variables in each case.[9]

[8] All numerical results presented in this and subsequent sections have been obtained by solving the model with a numerical solver (GAMS). Details and listings are available upon request from the authors.

[9] In all scenarios, $\gamma=0.01$ and $L_f = 1$. Furthermore, $\kappa=\varepsilon/(\varepsilon-1)$ so we have the Dixit-Stiglitz case for returns to diversity. We return to this in Section 7 when we discuss the welfare characteristics of the model.

Table 5.1 Parameter values, comparative statics

Variable/parameter	*Base line*	*Asym. labour*	*Asym. Techn.*	*Asym. pref*
L	100	**150**	100	100
l	100	**100**	100	100
β_1	0.925	0.925	**0.9**	0.925
β_2	0.9	0.9	**0.875**	0.9
β_3	0.85	0.85	**0.825**	0.85
λ_1	0.925	0.925	0.925	0.925
λ_2	0.9	0.9	0.9	0.9
λ_3	0.85	0.85	0.85	0.85
σ_1	0.333	0.333	0.333	**0.2**
σ_2	0.333	0.333	0.333	**0.3**
σ_3	0.333	0.333	0.333	**0.5**
φ_1	0.333	0.333	0.333	0.333
φ_2	0.333	0.333	0.333	0.333
φ_3	0.333	0.333	0.333	0.333

We start with the base line scenario where two countries that are equal in every respect trade in information services. Figure 5.1 depicts real wage in the two countries as a function of τ. The real wage increases monotonically as transaction costs decline (moving from the left to the right on he horizontal curve), but at a declining rate.

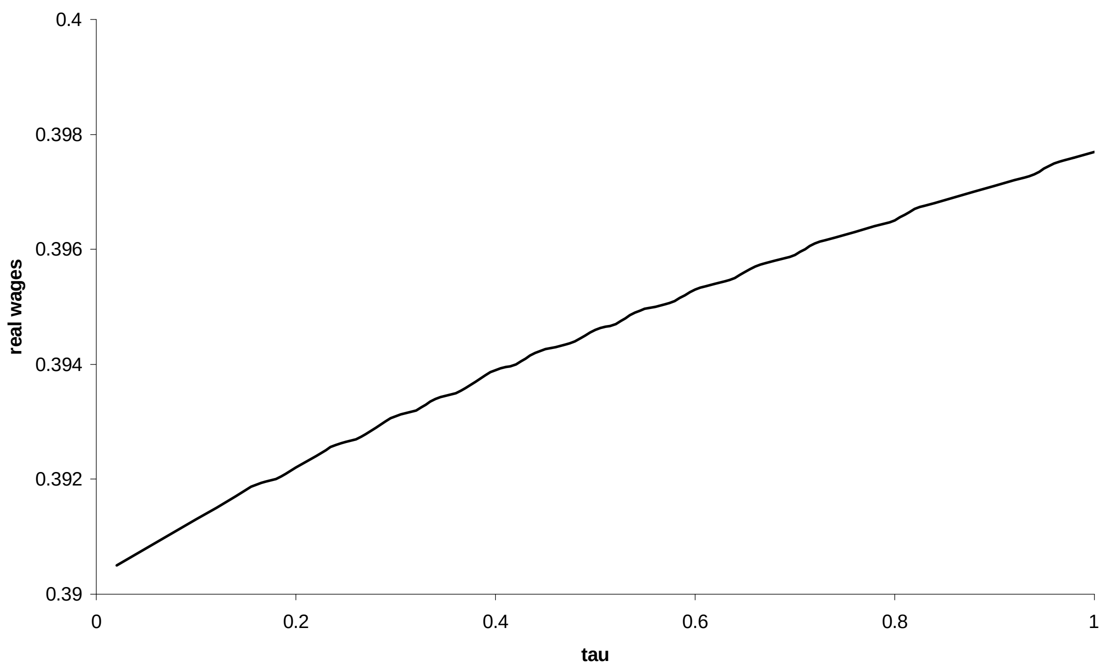

Figure 5.1 Real wage, symmetric countries

We now turn to the asymmetric cases. We leave the parameters and exogenous endowment related to the foreign country remain constant, while varying the endowment and the parameters related to the home country, one at a time. We start with two countries that are different in market size, represented by different sizes of the labour force. Alternatively, these may be interpreted as different productivity levels when interpreting labour as measured in efficiency units. Figure 5.2 below depicts the real wage in the two countries (left hand vertical axis) and relative real wages (right-hand vertical axis) as functions of τ in the case when the home country has a 50 percent larger labour force than the foreign country. For comparison we have also included the autarky real wage in the symmetric case (that is, the base line scenario when $\tau = 0$).

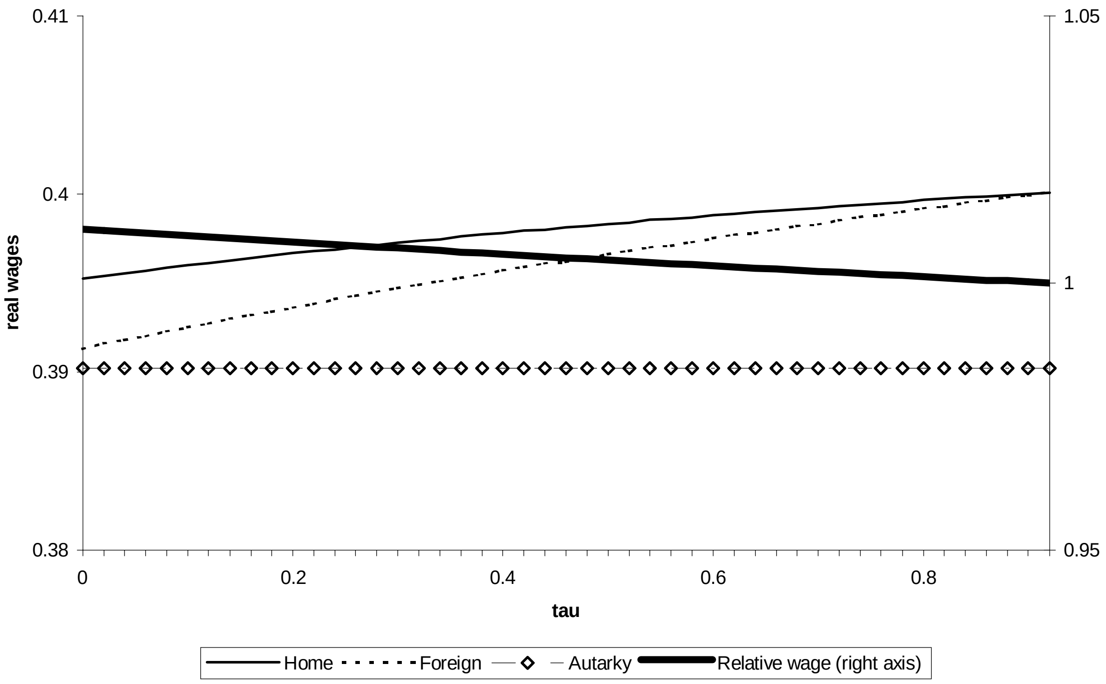

Figure 5.2 The home country has a larger labour force

As expected, the larger country has the highest real wage as long as there are transaction costs related to trade in information services. This is due to the relatively large number of intermediates that can be sustained in the large country that gains most from this in the presence of transaction costs. This is caused by the presence of returns to diversity of intermediates that characterises the model. However, as transaction costs decline the real wages converge and relative real wages reach unity when transaction costs are eliminated altogether despite the fact that the countries are different in size: in the absence of transport costs, the size of the *integrated* market is all that matters for real wages. Thus, given that the two countries have the same technology and the same preferences, the smaller (or poorer) country gains the most from declining trade barriers in information services, whether these are political or technical. Note that the real wages are always higher in the foreign country than in autarky: it also gains from the increased diversity of intermediates that is available.

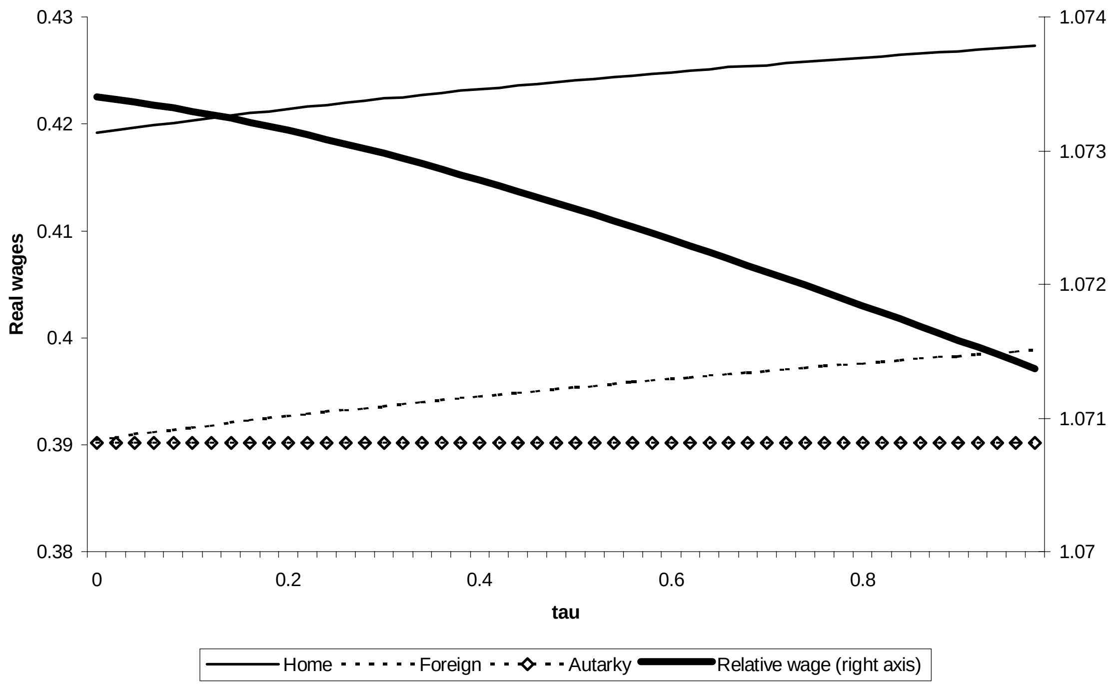

Figure 5.3 The home country has a more information-service intensive technology

Figure 5.3 depicts the case when the home country has a more information-service intensive technology in all final goods sectors than the foreign country. Again we show the foreign country autarky real wage for comparison. We note that both countries gain from declining transaction costs related to trade in information services, and that the real wage gap narrows as transaction costs come down, but the home country earns higher real wages even when transaction costs are totally eliminated. Producing the intermediate-intensive goods is attractive because of the larger use of intermediates that are characterised by increasing returns to diversity. The foreign country will also gain in this scenario compared to autarky due to the larger number of intermediates that can be sustained.

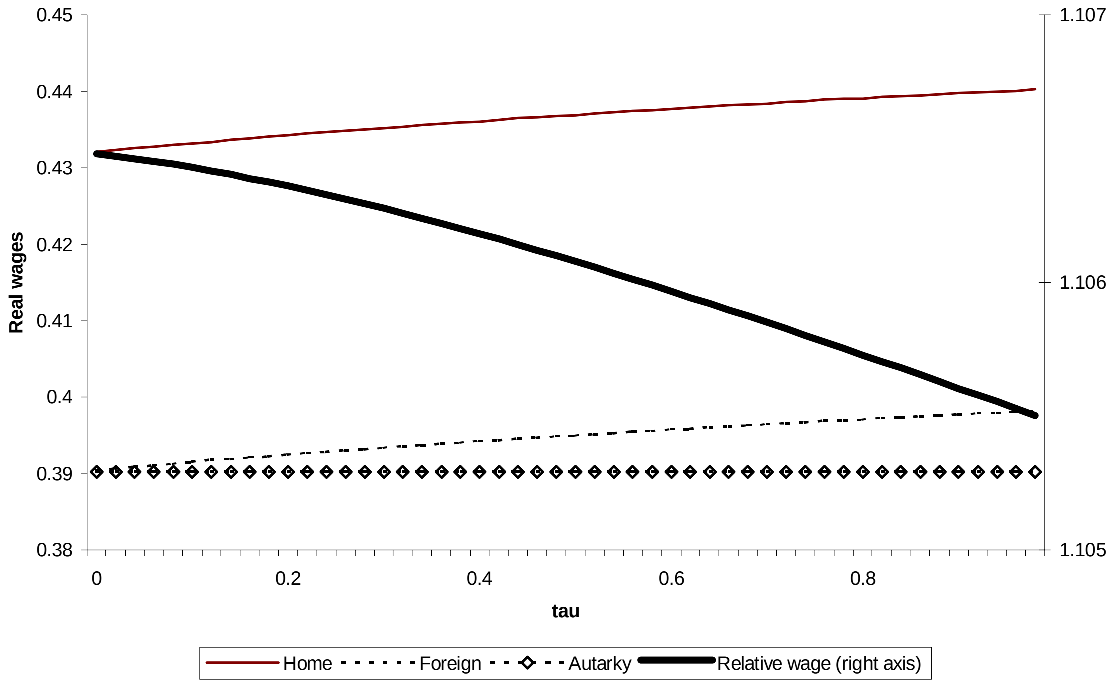

Figure 5.4 The two countries have different preferences

Finally, figure 5.4 presents the case where the consumers in the home country have a stronger preference for information-service intensive goods. This induces a higher real wage in the home country, everything else equal. This reflects the market-size effect that is associated with the change in preferences: stronger preferences for intermediate goods imply a relatively large market for information services and an associated large number of services that can be sustained. Again both countries gain from declining costs of trade in information services, and again real wages converge, but not fully.

We also ran the model with different productivity levels of information services (that is, *H*). As expected, the country with the highest productivity level has the highest utility level, but relative productivity levels do not change with declining transaction costs, since these affect both countries proportionally.

If we interpret the foreign country as a developing country facing the choice whether to and to what extent it should liberalise its trade in information-intensive services, the results of the comparative static analysis can provide some guidance in this respect. If transaction costs stemming from technical barriers to the transmission of information services are high, the gains from liberalisation for the less developed country are minor. This is further reinforced if these countries have relatively information extensive production processes and small preferences for information intensive final goods. If, on the other hand, transaction costs are mainly politically determined and can relatively easily be lowered, the prospects of liberalisation are more promising. A proper further analysis of these issues would require us to further endogenise and model (changes in) transaction and transportation costs which is beyond the scope of the current paper and is left for future research.

6. Trade in goods: an analysis of possible trade regimes

So far, we have assumed trade in information services only. In this section, we turn to a discussion in which we also allow for trade in final goods. We limit the discussion to the simple case where there is only one final product sector (J = 1), and both countries have the same technology in both sectors. Trade is in this case driven by returns to diversity; the larger the number of differentiated information services the lower the price index of intermediate inputs. Producers of final goods will consequently distribute their procurement on all available varieties, including foreign varieties when they are tradable. We have a model of one primary factor of production and two sectors, which means that the pattern of specialisation and trade is indeterminate in the model. The discussion therefore starts by deriving the equilibrium conditions in the market for intermediate services, the market for final goods and the labour market under the following trade regimes:

R1. Both countries produce both goods;

R2. The foreign country is specialised in intermediate services while the home country produces both goods;

R3. The foreign country is specialised in final goods while the home country produces both goods;

R4. The foreign country is specialised in intermediate services and the home country is specialised in final goods.

Full specialisation in one or both countries is a feasible trade regime only for a limited range of relative endowments of labour, since intermediate information services account for a relatively small share of total expenditure on inputs by producers of final output. We therefore derive the feasibility constraints related to each trade regime and compare the level of welfare measured by consumption of final goods per capita, for each trade regime. These are also compared to the results of the comparative static exercises of the previous section where only intermediate services were traded.

Free trade in final goods implies that the final good fetches the same price in both countries. Equilibrium in the market for final goods is given by $P_Y(Y+y)=WL+wl$, while labour market equilibrium requires:

$$\frac{\beta P_Y Y}{W}+N\varepsilon L_f=L \text{ and } \frac{\beta P_Y y}{w}+n\varepsilon L_f=l,$$

for the two countries, respectively. These two market equilibrium conditions can be combined and reduced to one equation in three variables ($\tilde{W}, \tilde{Y}$ and $\tilde{N}$), which represent relative wages, relative production of final output and relative number of information service firms, respectively:

$$(19) \qquad \frac{\tilde{W}\tilde{L}+1}{\tilde{Y}+1}\left(\frac{\tilde{Y}}{\tilde{W}}-\tilde{N}\right)\beta=\tilde{L}-\tilde{N}, \text{ or, equivalently } \frac{\tilde{w}\tilde{l}+1}{\tilde{y}+1}\left(\frac{\tilde{y}}{\tilde{w}}-\tilde{n}\right)\beta=\tilde{l}-\tilde{n},$$

where $\tilde{w}=w/W$, etc.[10] Equation (17) representing the equilibrium condition in the information service market, where $\tilde{Q}=\tilde{Y}$ [11] and equation (19) constitute a system of two equations in three unknowns, and the system is indeterminate as already mentioned. We therefore present numerical solutions to all conceivable trade regimes using the following parameter values: ε=5 reflecting a relatively high elasticity of substitution between different varieties of information services, β=0.9 reflecting the relatively small share of information services in final goods producers' cost function, and L_f=1 and γ=0.01, reflecting economies of scale with small marginal costs relative to the fixed cost (which are equal in both countries). The values also correspond to the base line scenario in the previous section. Our focus is on a developing country trading with a more developed country. We set labour endowments to *L*=900, *l*=100 (note that the labour endowments should be interpreted in terms of efficiency units).[12] Again this corresponds to the foreign country's endowment in the previous section. Finally we set *H*=*h*=1, since this section focuses on additional gains from opening to trade in final goods compared to trading in intermediate services only. We start by analysing trade regime a) where both countries produce both goods.

---

[10] It is useful to express the equations both in terms of home relative to foreign (uppercase letters with tildes) and the inverse (lowercase letters with tildes), since trade regimes R2-R4 result in production being equal to zero in one sector (in one country which can be either home or foreign).

[11] From equation (18) we see that when both countries have the same technology in the production of final goods and final goods are freely traded, relative expenditure on information services corresponds to relative output of the final goods sector.

[12] We set this labor endowment such that all the feasibility constraints can be satisfied. This eases the comparison between the various regimes.

R1. Both countries produce both goods

When final goods are produced in both countries, the unit production costs (see equation (7)) must be the same in both countries. From setting unit cost of production in the final goods sector in each country equal to each other and using (13) we get:

(20) $$\tilde{W}^{\beta} = \left(\frac{\tilde{N}\tilde{W}^{1-\varepsilon}\tau + 1}{\tilde{N}\tilde{W}^{1-\varepsilon} + \tau} \right)^{(1-\beta)/(1-\varepsilon)} \quad \text{or} \quad \tilde{w}^{\beta} = \left(\frac{1 + \tilde{n}\tilde{w}^{1-\varepsilon}\tau}{\tau + \tilde{n}\tilde{w}^{1-\varepsilon}} \right)^{(1-\beta)/(1-\varepsilon)}.$$

This equation closes the model for the trade regime of incomplete specialisation in both countries. Notice that factor price equalisation need not occur when $\tau < 1$. A lower price index of information services in the largest country, which imports a smaller number of services and therefore incurs lower transport costs, allows for higher wages in that country. Notice also from (17) that the location of the sectors becomes indeterminate when $\tau = 1$. In that case we essentially have one integrated market. The trade regime is feasible both for symmetric and asymmetric countries. In the case of symmetry (that is, the countries also have the same endowments of labour), welfare in terms of output of final goods per capita is the same whether final goods are traded or not. Turning to the case with asymmetries, Figure 6.1 below presents real wages in the two countries as a function of τ. For comparison we have also included the foreign real wage in the case with trade in information services only, and the autarky real wage of the foreign country in order to assess gains from trade, both estimated with the same parameter values and endowments as those used for the trade in both goods regime.[13]

[13] The trade in services only case is run with only one final goods sector.

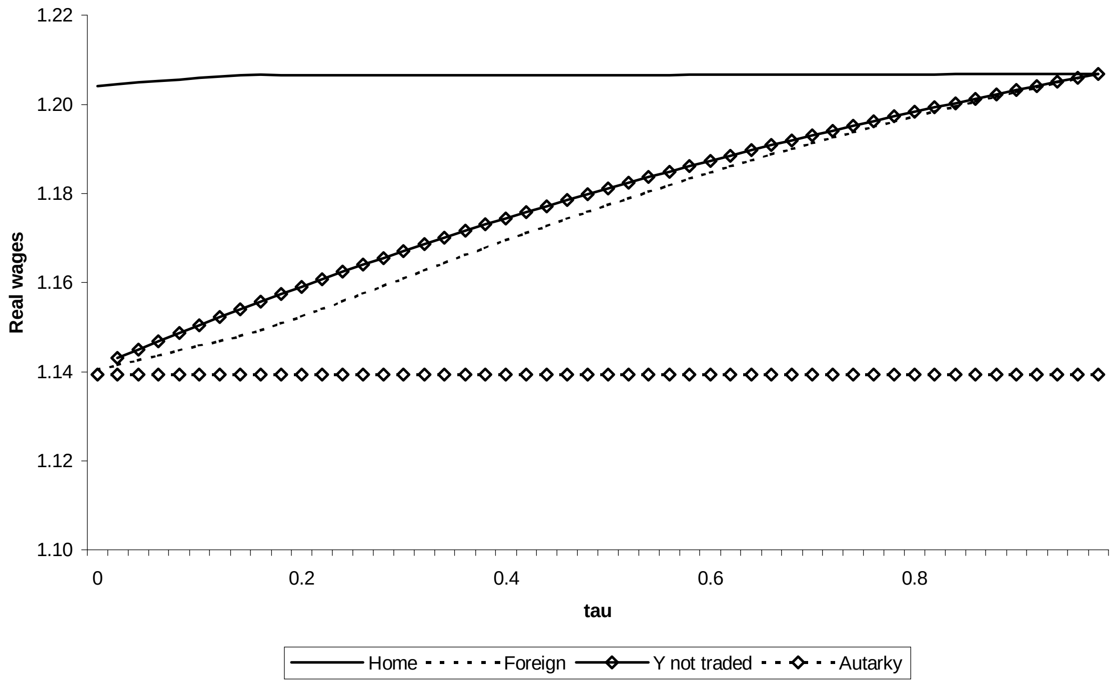

Figure 6.1. Real wages when both countries produce in both sectors

As expected, the largest country has the highest real wage level when transport costs are present, since the unit cost of intermediate services is lowest in this country. Real income converges as transport costs decline and reaches the same level when the two economies are fully integrated as far as the service market is concerned. Compared to the trade regime where only services are traded, there are no additional gains to the foreign country from opening to trade in final goods when $\tau < 1$. Compared to autarky, however, both countries gain from trade. Before markets are opened to trade in final goods, the price of final goods is highest in the largest country. Yet, the real wage is higher in the larger country because the higher wage reflects higher productivity due to a lower price index of intermediate information services as discussed above. When markets open to trade in final goods, the relative number of information services is no longer uniquely determined by the relative endowments of labour (see equations (10) and (16)). The price of final goods will settle somewhere between the home and foreign price, and thus increase in the smaller country, while it declines in the larger country. The general equilibrium effect is a reallocation of labour from the final goods sector to the intermediate services sector in the largest country in order to bring costs of final output down, while the opposite happens in the smaller country. For the parameters chosen here, $\tilde{N}$ increases steeply as transaction costs come down, and very little production of intermediate services is left in the small country when τ has reached about 0.2, moving from left to right in Figure 6.1. The fact that more intermediate services is produced in the largest country in this trade regime means that total transport costs in the world economy, and total world output is higher, but less equally distributed in the trade regime compared to the regime where services only are traded.

R2. Foreign country specialised in intermediate services, home country produces both goods

Since intermediate information services account for a small share of total costs in the production of final goods, a trade regime where one country is completely specialised in intermediate services is only feasible when that country is small relative to its trading partner. For this trade regime it is possible to find an analytical solution. Inserting $\tilde{y} = 0$ in the equilibrium conditions (17) and (19) yields $\tilde{w} = \tau^{1/\varepsilon}$ and $\tilde{n} = \tilde{l} \Big/ [1-\beta(\tau^{1/\varepsilon}\tilde{l}+1)]$. The solution is feasible (that is, $\tilde{n} > 0$) whenever $\tilde{l} < (1-\beta)/\beta\tau^{1/\varepsilon}$. The feasibility constraint implies that full specialisation in information services may occur in the foreign country when the relative size of the labour force is smaller than the ratio of expenditure shares in production of final goods, adjusted for transport costs. As before, relative wages are unity when transport costs are eliminated, while relative wages approach zero when transport costs approach infinity. For all values of τ < 1, the smaller country earns the lowest wages.

Figure 6.2 depicts real wages as a function of transaction costs in the same way as figure 6.1. Clearly, the smaller country gains substantially as transport costs come down, while the larger country gains only marginally. It is also clear that complete specialization in information services on the part of the small foreign country leaves it at a lower income level than in autarky, except for very low levels of transaction costs.

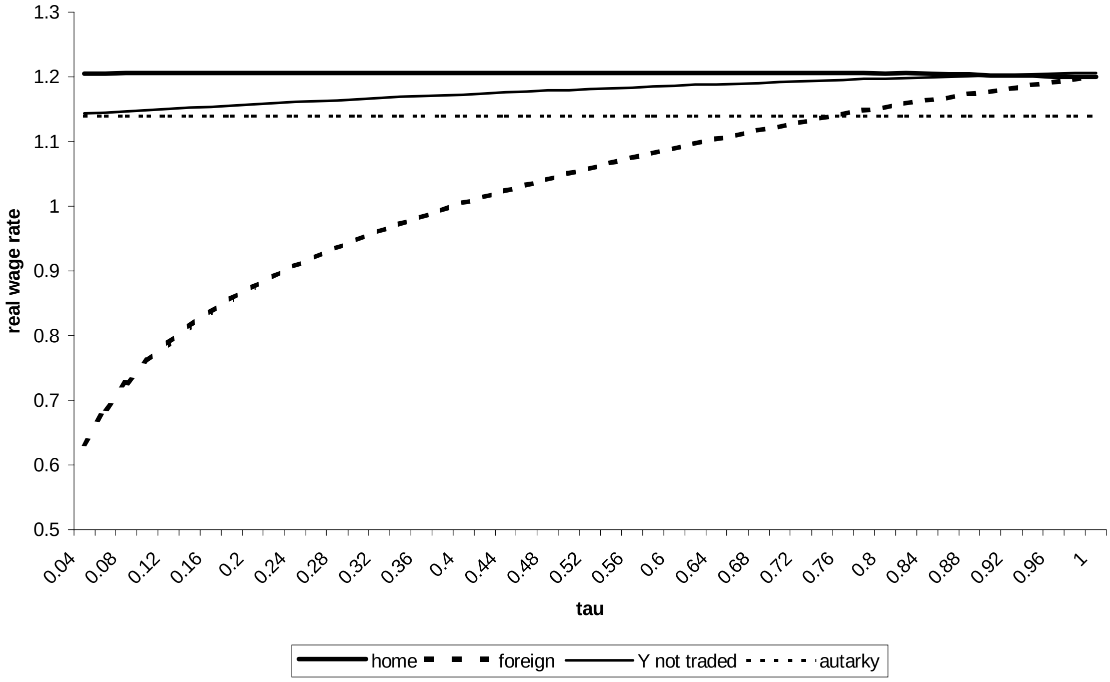

Figure 6.2 Real wages when foreign is specialised in information services

For the parameter values chosen here, the home country produces only a few varieties of information services. Thus, a large proportion of the services produced in the world economy is traded and a significant share is lost in transit, accounting for the lower absolute level of real wages in this trade regime compared to the previous one.

R3. The foreign country is specialised in final goods, the home country produces both goods

The next conceivable trade regime is the case when the foreign country is specialised in final goods while the home country produces in both sectors. Setting n = 0 in equations (17) and (19) yields:

$$1-\tilde{w}^{-\varepsilon}\tau = \frac{\left(\tilde{w}^{-\varepsilon}-\tau\right)}{\tau}\tilde{y},$$

and

$$\tilde{y} = \frac{\tilde{w}\tilde{l}}{\beta-(1-\beta)\tilde{w}\tilde{l}},$$

respectively. These combine to give relative wages as a function of the parameters as follows:

$$(21) \qquad \frac{1-\tilde{w}^{-\varepsilon}\tau}{\tilde{w}^{-\varepsilon}-\tau} = \frac{\tilde{w}\tilde{l}}{\tau\left(\beta-(1-\beta)\tilde{w}\tilde{l}\right)}.$$

An analytical solution cannot be found to this system, so we explore its properties by means of a numerical example. First, we note that the left-hand side of the equation is positive for $\tau^{1/\varepsilon} < \tilde{w} < \tau^{-1/\varepsilon}$, while the right-hand side is positive for $\tilde{l} < \beta/(1-\beta)\tilde{w}$. Combining the two yields the feasibility constraint $\tilde{l} < \beta\tau^{1/\varepsilon}/(1-\beta)$. Notice that the feasibility constraint of this trade regime is the inverse of the feasibility constraint for one country being completely specialised in intermediate services in section b) above. The results are presented in figure 6.3.

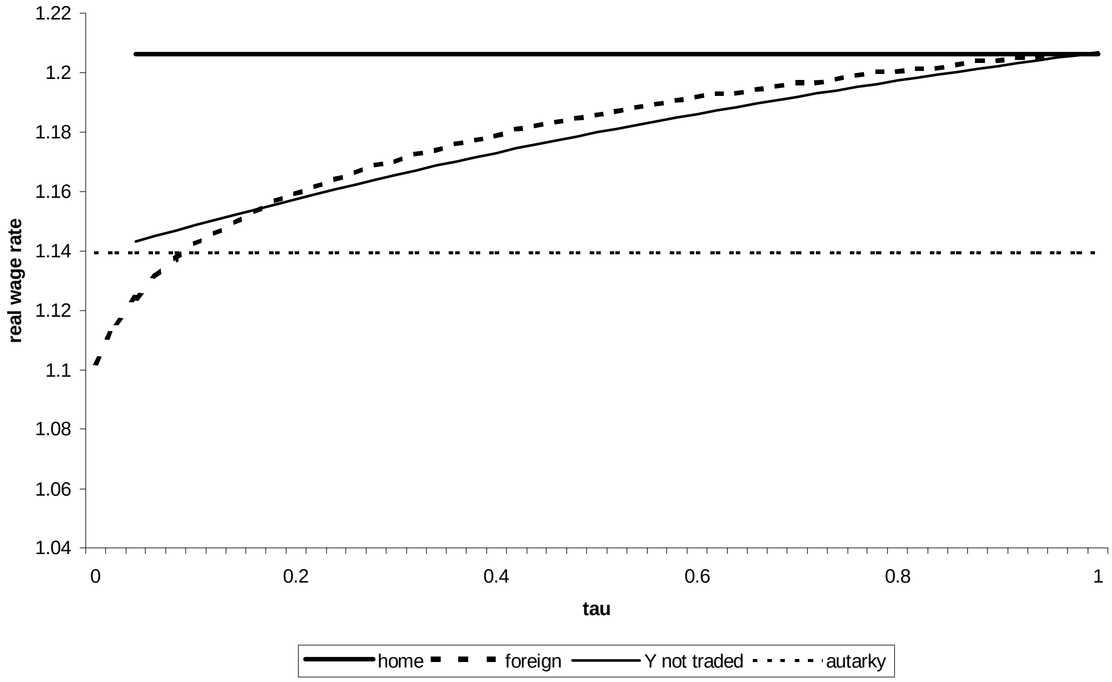

Figure 6.3 Foreign country specialised in final goods

Also in this trade regime the small foreign country gains the most from declining transaction costs. As opposed to trade regime b), the foreign country is better off in autarky only at very high transaction costs when the alternative to autarky is trade regime c).

R4. The foreign country is specialised in intermediate services and the home country is specialised in final goods.

Finally we analyse the trade regime where both countries are fully specialised, the home country in final goods and the foreign country in intermediate services. The combined labour market and final goods market equilibrium given in (19) now reduces to:

$$(22) \qquad \tilde{w} = \frac{1-\beta}{\beta \tilde{l}},$$

which uniquely determines relative wages. Note that relative wages are independent on transaction costs in this trade regime. There is in other words no convergence of relative income as trade costs come down. Note also that $\tilde{w}>1$ if $\tilde{l} < (1-\beta)/\beta$. However, entrepreneurs could establish service firms in the home country and undercut foreign producers' prices even in the absence of transport costs when $\tilde{w}>1$, so the trade regime is not commercially viable unless $\tilde{w}\leq 1$. The relative endowments and β we have applied throughout this section is such that $\tilde{w}=1$.

The number of services produced in the foreign country depends on the endowment of labour in the foreign country such that $n = l/\varepsilon L_f$. Inserting this in equation (11) using (9) and (12) when N = 0 and dividing by t in order to account for the services lost in transition, yield final output in the home country as follows:

$$(23) \quad Y = L^{\beta} l^{\varepsilon(1-\beta)/(\varepsilon-1)} \left[\frac{\varepsilon - 1}{\varepsilon \gamma t} \left(\frac{1}{\varepsilon L_f} \right)^{1/(\varepsilon-1)} \right]^{1-\beta}.$$

This output is distributed to consumers in the two countries according to relative wages given in equation (22), which in our numerical example is unity. Figure 6.4 depicts consumption per capita in the two countries.

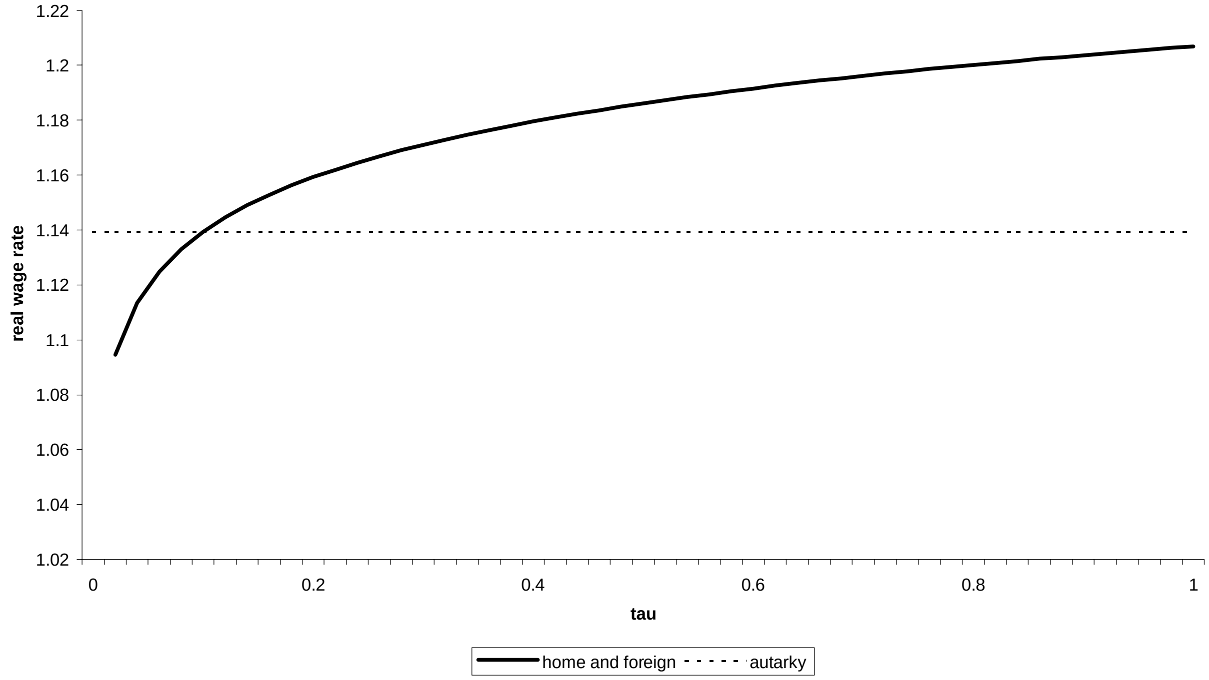

Figure 6.4 Complete specialisation

The findings of Section 6 are summarised in Table 6.1. We present the welfare level as measured by consumption per capita of each country in each trade regime for an intermediate level of transport costs τ = 0.5, and for τ = 1.

Table 6.1. Consumption per capita

Trade regime	Feasibility constraint	Consumption per capita, Home		Consumption per capita, Foreign	
		τ =0.5	τ =1	τ =0.5	τ =1
R1. Both countries produce in both sectors	None	1.207	1.207	1.176	1.207
R2. Foreign specialised in services, home not specialised*	$\tilde{l} < (1-\beta)/\beta\tau^{1/\varepsilon}$	1.206	1.206	1.051	1.201
R3. Foreign specialised in final goods, home not specialised	$\tilde{l} < \beta\tau^{1/\varepsilon}/(1-\beta)$	1.207	1.207	1.184	1.207
R4. Both specialised	$\tilde{l} < (1-\beta)/\beta$	1.186	1.207	1.186	1.207
Only services are traded		1.206	1.207	1.180	1.207
Autarky		1.204		1.139	

* The feasibility constraint does not hold when τ=1. The relative labor force is equal to the relative cost shares in that case. We therefore present consumption per capita at τ=0.98 for this trade regime.

7. First-best welfare analysis[14]

The model that we have discussed so far is characterised by two market distortions that result in the decentralised market equilibrium that we have focused upon so far being inferior to a first-best social optimum. These two market distortions are (i) mark-up pricing by the producers of information services which distorts the price of information services relative to the price of labour and (ii) sub-optimal entry due to the fact that firms do not take into account the effect that their entry decision has on productivity which is associated with the returns to diversity. The aim of this section is to derive the first-best social optimum and to show that a combination of an output subsidy and a lump-sum tax levied on producers in the information sector can be used to decentralise the first-best social optimum.

7.1 The first-best social optimum

In this section, we simplify the model by assuming two fully symmetric countries producing one final good and a planner maximising utility in each country.[15] The problem for the planner in this case looks like

$$\max Y = \left[(2N)^{\kappa - \frac{\varepsilon}{\varepsilon-1}} \left[N h^{\frac{\varepsilon-1}{\varepsilon}} \left\{ I^{\frac{\varepsilon-1}{\varepsilon}} + i^{\frac{\varepsilon-1}{\varepsilon}} \right\} \right]^{\frac{\varepsilon}{\varepsilon-1}} \right]^{1-\beta} \left[L - N(I + ti) - NL \ \right]^{\beta}.$$

The first-order conditions for an optimum are

$$\frac{\partial Y}{\partial I} = \frac{\partial Y}{\partial i} = \frac{\partial Y}{\partial N} = 0.$$

Performing optimisation yields

$$L_Y^{FB} = \frac{\beta L}{1 + (1-\beta)(\kappa - 1)}, \quad N^{FB} = \frac{(1-\beta)(\kappa-1)L}{\left[1 + (1-\beta)(\kappa-1)\right]L_f}, \quad L_I^{FB} = \frac{L_f}{\kappa - 1}, \quad \frac{I^{FB}}{i^{FB}} = t^{\varepsilon}.$$

These results reveal that the optimal amount of labour to be employed for assemblage negatively depends on the returns to diversity, while the optimal number of brands of information services depends positively on the returns to diversity. Finally, the optimal amount of information services produced at home and used in production relative to the amount of information services produced abroad depends positively on both the transport cost of information services and the elasticity of substitution between different brands of information

---

[14] This analysis closely resembles the analysis in Benassy (1996) and de Groot and Nahuis (1997 and 2001), but now in the context of a two-country model.

[15] There are evidently more interesting settings that can be thought about in which there is strategic interaction between the governments in the two countries. These extensions will be left for future research.

services. Comparing the first-best solutions with the outcomes in a decentralised market equilibrium (as given in equations 9 and 10) reveals that there is no value for the parameter capturing the returns to variety for which the decentralised equilibrium replicates the first-best social optimal. With low returns to diversity, the market sustains too many brands of information services being produced in too small amounts, while the reverse holds when returns to diversity are large. In intermediate cases, the produced amount of information services can be too low, while the amount of brands is too low as well.

7.2 Decentralising the first-best social optimum

Having determined the first-best social optimum, we can now turn to a policy that can support the first-best social optimum as a competitive equilibrium. We introduce two policy instruments, namely an output subsidy on information services and a lump-sum tax levied on firms producing these services. We assume that the revenues that are needed to finance the subsidies are generated in a non-distortionary way. After the introduction of these instruments, the profits of the firms that produce information services are equal to

$$IP_I(1+s)-(L_I+L_f)-T.$$

Following the procedure for solving the model as in Section 4, the optimal output subsidy and lump-sum tax can straightforwardly be derived

$$s=\frac{1}{\varepsilon-1},\quad T=\left[\frac{\varepsilon}{\varepsilon-1}-\kappa\right]\frac{L_f}{\kappa-1}.$$

The output subsidy basically corrects for the price-distortion that results from mark-up pricing while the lump-sum tax corrects for the inefficient entry of firms in the information services producing sector. The results reveal that the lump-sum tax negatively depends on the returns to diversity and changes into a subsidy when returns to diversity become large (that is, when $\kappa>\varepsilon/(\varepsilon-1)$).

8. Conclusion

The diffusion of information and communication technology has reduced cost of information substantially in recent years. Even in the poorest countries in the world, the share of the population with access to telecommunications and the Internet has increased at double-digit growth rates during the last few years. Privatisation, deregulation and liberalisation of trade and investment in the service sectors have further contributed to this development. This paper has analysed the impact of better access to information services on development. For this purpose we developed a model of trade in differentiated intermediate services, which captures some of the most significant properties of information services, and explored the effects of better access to information services under various assumptions on technology, preferences and relative size of the two countries.

Our results suggest that there are significant welfare gains from liberalisation of trade and investment in information services, and that small, poor or labour-intensive countries gain the most in all our scenarios. Small developing countries will benefit a lot from better access to information services, while developing countries in which consumers have relatively low preference for information-intensive goods are less likely to obtain large benefits. We have further shown that improvements of infrastructure and increases in human capital in one country improve welfare in both countries. Thus, investments in rich countries to some extent spill over to poorer countries, which get access to a broader variety of services. We finally derive the welfare optimum and the taxes that reproduce the social optimum as a competitive equilibrium.

References

Aghion, P. and P. Howitt (1998): *Endogenous Growth Theory*, MIT Press, Cambridge, MA.

Barro, R.J. (1990): 'Government Spending in a Simple Model of Endogenous Growth', *Journal of Political Economy*, 98, pp. 103-125.

Benassy, J.P. (1996): 'Taste for Variety and Optimum Production Patterns in Monopolistic Competition', *Economics Letters*, 52, pp. 41-47.

Deaton, A.S. and J. Muellbauer (1980): *Economics and Consumer Behaviour*, Cambridge University Press, Cambridge.

Evans, P. and T.S. Wurster (2000): *Blown to Bits: How the New Economics of Information Transforms Strategy*, Harvard Business School Press, Harvard.

Francois, J. (1990): 'Trade in Producer Services and Returns due to Specialization under Monopolistic Competition', *Canadian Journal of Economics*, 23, pp. 109-124.

Groot, H.L.F. de (1998): *The Determination and Development of Sectoral Structure,* CentER Discussion Paper, no. 98125, Tilburg.

Groot, H.L.F. de and R. Nahuis (1998): 'Taste for Diversity and the Optimality of Economic Growth', *Economics Letters*, 58, pp. 291-295.

Groot, H.L.F. de and R. Nahuis (2001): ‘Optimal Product Variety and Economic Growth’, *Journal of Economics*, forthcoming.

Grossman, G. and E. Helpman (1991): *Innovation and Growth in the Global Economy*, MIT Press, Cambridge, MA.

Harris, R.G. (1999): ‘The Internet as a GPT: Factor Market Implications’, in: E. Helpman (ed.), *General Purpose Technologies and Economic Growth*, MIT Press, Cambridge, MA.

Helpman, E. and P. Krugman (1985): *Market Structure and Foreign Trade: Increasing Returns, Imperfect Competition and the International Economy*, MIT Press, Cambridge, MA.

Helpman, E. (1999, editor): *General Purpose Technologies and Economic Growth*, MIT Press, Cambridge, MA.

Maddison (1991): *Dynamic Forces in Capitalist Development*, Oxford University Press, Oxford.

Markusen, J.R. (1989): ‘Trade in Producer Services and in Other Specialized Intermediate Inputs’, *American Economic Review*, 79, pp. 85-95.

Marrewijk, C. van, J. Stibora, A. de Vaal and J-M. Viaene (1997): ‘Producer Services, Comparative Advantage, and International Trade Patterns’, *Journal of International Economics*, 42, pp. 195-220.

Porter, M.E. (1990): *The Competitive Advantage of Nations*, MacMillan Press, London.

Reich, R.R. (1991): *The Work of Nations*, Alfred A. Knopf Inc., New York.

Shapiro, C. and H.R. Varian (1999): *Information rules. A Strategic Guide to the Network Economy*, Harvard Business School Press, Boston.