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TRADE IN THE PRESENCE OF ENDOGENOUS INTERMEDIATION IN AN ASYMMETRIC WORLD

by

Cillian Ryan

June, 1988

Series on Trade in Services

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TRADE IN THE PRESENCE OF ENDOGENOUS INTERMEDIATION IN AN ASYMMETRIC WORLD *

ABSTRACT

This paper endogenously derives intermediation services in a general equilibrium setting. It shows that, contrary to previous suggestions, technical improvements in servicing can lead to a fall in domestic output, a rise in the size of the service sector, and an increase in all agents' welfare.

It further suggests that, if there are asymmetries in production or service technology, the trading pattern under autarky may be inefficient relative to free trade due to the presence of excess capacity and "servicer self-trading". Thus, in addition to the conventional gains from free trade, there are gains due to an "as if" improvement in service technology.

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TRADE IN THE PRESENCE OF ENDOGENOUS INTERMEDIATION IN AN ASYMMETRIC WORLD

INTRODUCTION

The main body of conventional trade theory is modelled as if countries were dimensionless, and it is implicitly assumed that trade takes place between agents located at some point in space. However, dimensionality, whether it be of time or space, is a very important feature of any real economy. Indeed, it will be argued that much of the economic activity that is commonly known as 'services', is generated by the barriers created by such dimensional issues. This paper arises out of my concern with the persistent neglect of dimensionality in trade, and with the related topic of trade and services that is currently receiving much attention in both the popular press and academic circles.

One of the main reasons for the upsurge in interest in services is the desire of the United States trade representatives to have trade in services included in the next round of talks on the General Agreement on Tariffs and Trade, due to take place in Mexico in 1988. Another reason is the belief that the growth in computer technology is displacing workers in the productive sector, causing unemployment. Thus, people are looking to growth in the service sector as new sources of employment. Finally, the service sector has already become one of the most important sectors of the economy, accounting for 62% of G.N.P., according to recent estimates.[1]

As a consequence of the current interest, several authors have turned their attentions to the role that services play in economic activity. Some examples of empirical analyses are the works of R.P. Inman (1985), and J.I. Gershuny and I.D. Mills (1983). A study of the role of services in the

Canadian economy has been undertaken by Dobell, McRae and Desbois (1984).

To date, however, the theoretical study of services has not received much attention. The exceptions are papers by Deardorff (1985), Markusen (1987a) and (1987b) and Melvin (1986) and (1987). This neglect of the theory may be due to some trade theorists' belief that services can be analysed in traditional trade models in precisely the same fashion as goods. With such an interpretation services are seen either to be final goods or to be intermediate inputs into the production process. The lack of theoretical research, and the uncertainty surrounding the role of services, suggest that the question as to whether services alter traditional results is an important theoretical issue in the trade area.

While the previous work on services has been mainly concerned with producers services (such as engineering or management consulting, and computing), the primary concern of my work is with what I will term 'mediation' services. If agents are self-sufficient they consume only the goods they have produced themselves, and thus the only cost of consumption is the cost of production. However, any movement away from self-sufficiency invariably involves surmounting some barrier of space, time, or information. For example, to consume a good in another time period involves storage or trading with another individual who has output in another period, but who would like to consume now.

One of the more important services that has been considered in previous trade theory is transportation, and various papers have addressed the issue of incorporating transport costs in trade. Samuelson (1954) and Mundell (1957) assumed that transport costs were some fraction of the value of the goods traded. However, in general it is desirable that these transport costs should be determined by the forces of supply and demand for transport services. Herberg (1970) attempted to relax this assumption but he restricted each country to carrying its own imports. In Falvey (1976) the assumption that a country must carry its own imports is relaxed. He shows, not suprisingly, that a country's offer curve will shrink towards the origin when a transport industry using real resources is incorporated into the standard Hecksher-Ohlin model. He also suggests that the number of agents in the service sector will decline with an improvement in service technology. The present paper, on the other hand, shows that the opposite is possible, and thus in my model the observed rise in the importance of the service sector is consistent with technological improvement in services.

The model I develop in this paper sets out to capture the essential elements identified above. Agents employ specialized servicers in a trading environment in order to overcome barriers of time or space or barriers due to information asymmetries. Agents can costlessly consume any good they produce, but if they wish to consume any other good, they must either produce the service to surmount the barrier to trade themselves, or engage another agent to do so on their behalf. By imposing increasing returns to scale in the production of goods and services, we can ensure that agents will have an incentive to specialize, and thus we generate an endogenous service sector. The model is a three-sector, single-factor, n-agent economy. Two of the sectors, the x and y sectors, produce consumer goods x and y, respectively. The third sector produces the service that provides the link between separated producers and consumers.

The layout of the paper is as follows. Part I sets out the basic single-country model in a perfectly symmetrical world and defines the equilibrium. Part II then considers some comparative static and other single country results. In Part III we consider the effect of relaxing our symmetry assumptions and derive our two country trade model.

PART I: THE MODEL

The Production Sector

For the service sector to play a role in this economy, an agent must have an incentive to specialize.[2] Thus we assume that agents face increasing returns to scale for individual output in each sector.

We assume there are n agents with identical tastes in the economy. Each agent i is endowed with one unit of labour that can be allocated across the three production sectors, such that

$$\sum_j L_{ij} = \bar{L}_i = 1,$$

where L_{ij} is the amount of labour allocated by an agent i to sector j, $i \in \{1,\ldots,n\}$, $j \in \{x,y,s\}$.

The most general specification of the production technology allows for various degrees of returns to scale to the industry and the individual. One way of incorporating this notion into the standard individual production function is to make the output of each individual dependent, not only on his/her own labour input, but also on the total labour input into the sector as a whole. Thus the outputs of x, y and s by an individual agent are given by

$$x_i = f(L_{ix}, L_x)$$

$$y_i = g(L_{iy}, L_y)$$

$$s_i = \psi(L_{is}, L_s)$$

where $L_j = \sum_i L_{ij}$, $j \in \{x,y,s\}$ and i is the number of agents employed in the j industry. Output then depends not only on individual inputs but also on the number of agents in the industry.

In the context of this model the output of the service industry can have two interpretations. In the case of transportation-type services a commitment to a certain capacity in one direction involves a commitment to the same capacity in the other. Thus the output of the service sector is a joint product whereby servicers have the ability to carry s_i units of x from x producers to y producers and s_i units of y from y producers to x producers in any given time period. On the other hand many intermediary services, such as financial and brokeraging services, do not have this joint product nature. Thus any given quantity of services that an agent produces can be applied to trade in either direction depending upon demand.

For the economy as a whole, output is given by

$$X = \sum_i f(L_{ix}, L_x)$$

$$Y = \sum_i g(L_{iy}, L_y)$$

$$S = \sum_i \psi(L_{is}, L_s)$$

Initially we assume constant returns to scale in all sectors at the industry level, thus x_i depends only on L_{ix}. In Ryan (1987) I show that agents will choose either self-sufficiency or specialization depending on the service technology and the degree of returns to scale faced by the individual. In particular we show that producing goods and servicing will always be dominated by specialization as long as there is increasing returns to scale at the individual level in either the goods producing or the service sector. Thus in this paper we will consider only the case where agents specialize, i.e., $L_{ij} = 1$ or 0. For simplicity I assume that if $L_{xi} = 1$ then $x_i = f(1) = 1$; if $L_{yi} = 1$, then $y_i = g(1) = 1$ and if $L_{is} = 1$, then $s_i = \psi_i(1) = s$.

The above assumptions yield

(1) $$X = L_x = \sum_i L_{ix}$$

(2) $$Y = L_y = \sum_i L_{iy}$$

(3) $$S = sL_s = \sum_i sL_{is}$$

<u>Consumption</u>

Each agent's utility function is defined over the two consumer goods, x and y, and is written

$$U = U(x,y).$$

The budget constraints facing the agents in each sector are; for x producers:

(4) $$x_i = 1 = x^i + p_y^x y^i .$$

A specialized x producer is assumed to consume his/her own output costlessly, so that the production and consumption price of the good is the same. However, if he/she wishes to consume good y, he/she must pay p_y^x units of x. The budget constraint for y producers is:

$$(5) \qquad y_i = 1 = p_x^y x^i + y^i ,$$

and for servicers is:

$$(6a) \qquad (p_x^y - 1)s = x^i \quad \text{and} \quad (p_y^x - 1)s = y^i$$

where x^i is the amount of x consumed by an agent i,

y^i is the amount of y consumed by an agent i,

p_k^j is the price of a good k ε (x,y) to an agent in sector j.

Note we normalize $p_i^i = 1$.

Each agent who specializes in one of the production sectors can consume the good he/she produces at the normalized price of 1. To purchase the other good a goods producer must pay p_k^j units of the good he/she produces. The budget constraint for a servicer is determined in the following manner. He/she collects $p_y^x s$ units of x from an x producer and carries s of these units to trade with y. Thus the servicer's consumption of x is $(p_y^x-1)s$. When the servicer meets the y producer he/she exchanges s units of x for $p_x^y s$ units of y. The servicer must return with s units of y to the x producer, and thus consumption of y is $(p_x^y-1)s$.

We will note that the budget constraint in (6a) implies that

$$(6b) \qquad x^i + y^i = (p_x^y - 1)s + (p_y^x - 1)s ,$$

however (6b) does not imply (6a). In other words, servicers here are confined to consuming the bundles that they obtain by trading on behalf of the goods producers. If servicers wanted to obtain some other bundle they would have to set aside some of their service capacity in order to trade on their own behalf. For example, servicers could decide to allocate a proportion α_i, $0 \leq \alpha_i \leq 1$ of their capacity to carry some of the x they have received as payment from the x producers and trade it with y producers. In this way they could reduce their x consumption and increase their y consumption. They would then allocate $(1 - \alpha_i)$ of their capacity for the purpose of servicing producers. They would receive $p_x^y s$ units of y for the total shipment of x and they would consume $(p_x^y - \alpha_i)s > (p_x^y - 1)s$ and then return to the x producers with $(1 - \alpha_i)s$ units of y. I will refer to the phenomenon of servicers allocating some of their service capacity to alter the composition of their consumption bundle as servicer self-servicing or as servicers trading on their own behalf. However, I do not, at this point, permit self-servicing, since this introduces unnecessary complications at this early stage. It will be shown that in a symmetric world the shadow prices for the consumption of a servicer, i.e., the slope of the utility function at the equilibrium consumption bundle, will be $p_y^s = 1$ and $p_x^s = 1$. However these are not the prices at which a servicer can purchase additional units of x and y. A more detailed analysis of this problem is considered in Part III.

Equilibrium

When agents maximize their utility subject to these budget constraints, we obtain for all agents, the indirect utility function

$$v(p_x^j, p_y^j, I) ,$$

where I is the income of the agent. We assume free mobility of labour across the three sectors within any given country.

A competitive equilibrium is a labour allocation vector $L(L_{xi}, L_{yi}, L_{si})$ for each agent i, and a consumption vector for each agent i such that:

(i) the utility of all agents are equal

(7) $$V(1,p_y^x,1) = V(p_x^y,1,1) = V(1,1,(p_x^y-1)s + (p_y^x-1)s) ;$$

(ii) the commodity markets clear

(8) $$L_x x_i = L_x = L_x x(1,p_y^x,1) + L_y x(p_x^y,1,1) + L_s x(1,1,(p_x^y-1)s + (p_y^x-1)s)$$

(9) $$L_y y_i = L_y = L_x y(1,p_y^x,1) + L_y y(p_x^y,1,1) + L_s y(1,1,(p_x^y-1)s + (p_y^x-1)s) ;$$

(iii) the market for services clears

(10) $$L_s s = \text{Max} \{L_x \ y(1,P_y^x,1), \ L_y \ x(P_x^y,1,1)\} ;$$

(iv) the factor market clears

(11) $$L_x + L_y + L_s = n ,$$

where $x_i = y_i = 1$ by assumption, and $x(p_x^j, p_y^j, I)$ is the demand function of an agent in sector j. Thus

$x(1,p_y^x,1)$ is an x producers' demand for x

$x(p_x^y,1,1)$ is a y producers' demand for x

$x(1,1,(p_y^x-1)s+(p_x^y-1)s)$ is a servicers' demand for x.

The demand for y is similarly defined.

PART II: SOME COMPARATIVE STATIC RESULTS

To establish many of my trade results I must first look at the determination of equilibrium prices, sectoral factor allocations and outputs. In order to study the role of the service sector I will also consider the effect of a change in service technology on these prices, factor allocations, and outputs. Suppose, for simplicity, that in addition to our assumption that the technology for the production of goods is symmetric and that the service technology is symmetric, we also assume that utility is symmetric. A symmetric utility function is a function where $U(x_1,x_2) = U(x_2,x_1)$. Symmetry implies that $p_y^x = p_x^y = R$ in the indirect utility functions. From (7) we know that equilibrium between the x and y sector requires that

$$V(1,p_y^x,1) = V(p_x^y,1,1) \quad .$$

Thus from the assumption of symmetry we can rewrite (7) as

$$(12) \qquad V(1,R,1) = V(R,1,1) = V(1,1,2(R-1)s) \quad .$$

Furthermore, since U is symmetric, we have

$$x(1,R,1) = y(R,1,1),$$

$$x(R,1,1) = y(1,R,1),$$

and $$x(1,1,2(R-1)s) = y(1,1,2(R-1)s).$$

Substituting the above into equations (8), (9), and (11) and solving for L_s, we can determine the allocation of agents to the various sectors.[3] With some manipulation we obtain

$$(13) \qquad L_s = \frac{n}{1 + \frac{2x(1,1,2(R-1)s)}{1 - x(1,R,1) - x(R,1,1)}} .$$

In order to study how the allocation to the service sector changes as technology changes we totally differentiate (13) with respect to s and get

$$(14) \qquad \frac{dL_s}{ds} = n \left\{ \frac{1}{1 + \frac{2\,x(1,1,2(R-1)s)}{1 - x(1,R,1) - x(R,1,1)}} \right\}^2 \left(\frac{1}{1 - x(1,R,1) - x(R,1,1)} \right)$$

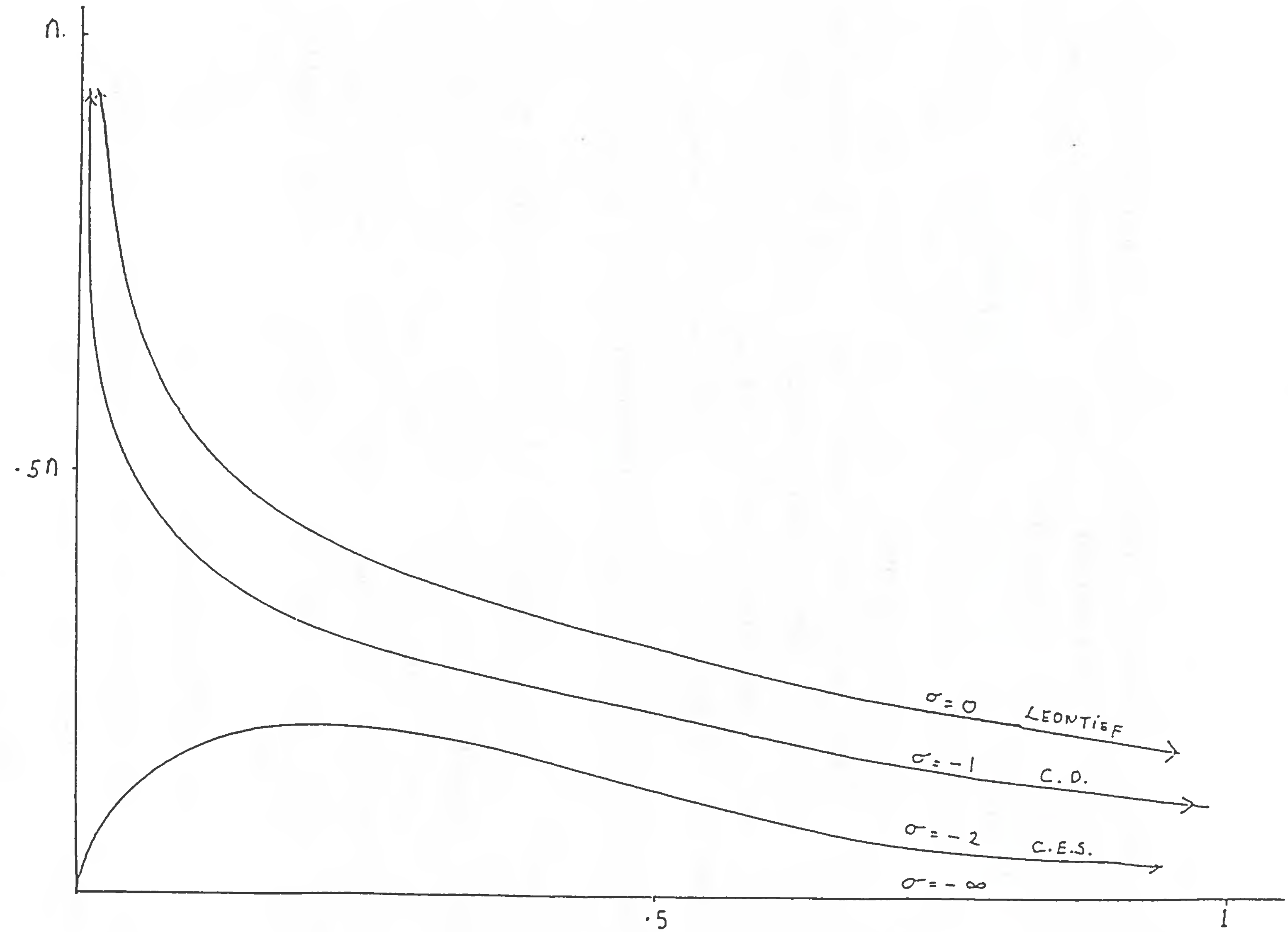
$$\left(\frac{2\,x(1,1,2(R-1)s)}{1 - x(1,R,1) - x(R,1,1)} \left[- \frac{\partial x(1,R,1)}{\partial R} - \frac{\partial x(R,1,1)}{\partial R}\right] \frac{dR}{ds} - 4\, \frac{\partial x(1,1,2(R-1)s)}{\partial (R-1)s} \left[R-1 + \frac{sdR}{ds}\right] \right)$$

The first two terms of the above equation are simple enough to sign. Both are at least weakly positive (strictly so if s is not infinite). However the final term is ambiguous. $\frac{\partial x(R,1,1)}{\partial R}$ and $\frac{\partial x(1,1,2(R-1)s)}{\partial (R-1)s}$ are strictly negative and strictly positive respectively due to the assumption of symmetrical utility and the fact that there are only two consumption goods in the model. $\frac{\partial x(1,R,1)}{\partial R}$, however, can be positive or negative depending on whether x and y are substitutes or complements. If they are complements, then the sign is unambiguously negative, and L_s falls as the service technology improves. If they are substitutes, however, the sign will depend critically upon the magnitude of the various partial derivatives. Thus the sign of $\frac{dL_s}{ds}$ will be ambiguous. This result differs from Falvey (1976) who asserts that "factors are released from the transport industry since a smaller volume of transport is now required to move any given trade volume". This result arises in Falvey's model because he does not consider the possibility of an increase in demand for transport services as price falls.

The ambiguity in equation (14) is to be expected, however. The improvement in the service technology means that trade is now relatively cheaper, leading to an increase in the total number of trades. However, the number of agents required to carry out this new higher level of trade is indeterminate. The overall effect on servicers income can lead to more of both goods being consumed by the service sector in equilibrium, and thus to more agents entering the service sector.

In Figure 1 I outline the relationship between the allocation of agents to the service sector and the service technology for four constant elasticity of substitution utility functions. We can see from the graph that the elasticity of substitution of goods x and y will determine how the L_s function behaves under CES technology. When $\sigma = 0$, that is, when the consumption technology is Leontief, the two goods are completely dependent, and thus even as $s \to 0$, L_s rises, since agents expend as much energy as possible in an attempt to get the other good. The same happens when $\sigma = -1$, that is, when the technology is Cobb-Douglas. It should be noted here that, since neither Cobb-Douglas nor Leontief indifference curves touch the axis, for L_s to approach n as s approaches 0, either agents revert to autarky for large values of R (low values of s) or strong degrees of returns to scale for

Figure 1.



The allocation of labour to the service sector under C.E.S. technology the individual are required. In particular, if an individual production set consists of points on the boundary of the positive quadrant, then agents do not revert to autarky as s approaches 0.

At the other end of the scale is the case where both goods are complete substitutes in terms of utility. Then it is always true that $\sigma = \infty$ and $L_s = 0$, since there is no incentive to trade. In this case the good produced is just as good as any other good we might be able to purchase. In between these extremes there will be L_s functions similar to the case where $\sigma = -2$. Here L_s rises initially as the service technology improves, reaches a maximum, and then approaches 0 asymptotically like the others. Further, since $L_s = n-(L_x+L_y) = n-2L_x$ (by symmetry), $\frac{dL_s}{ds} \lessgtr 0$ implies that $\frac{dL_x}{ds}$ and $\frac{dL_y}{ds}$ also have ambiguous signs, and hence that $\frac{dx}{ds}$ and $\frac{dy}{ds}$ can be positive or negative.

The effect on welfare, however, is unambiguous. All agents will always be better off with an improvement in service technology, even if total world output of goods falls. To see this we take the total derivatives of equation (12), which yields

$$V_2 \, dR = V_3[2sdR + 2(R-1)ds] ,$$

where V_i is the partial derivative with respect to the i^{th} argument of V. Rearranging, we obtain

$$(15) \qquad \frac{dR}{ds} = \frac{2(R-1)V_3}{V_2 - 2V_3 s} .$$

Now we note that $V_2 \leq 0$, $V_3 \geq 0$, and that if there were no transportation cost, R would equal unity. In other words

$$\operatorname{Lt.}_{s\to\infty} R = 1 \ .$$

Thus we always have R > 1, at least as long as the model is symmetric. Therefore

$$(15') \qquad \frac{dR}{ds} < 0 \quad .$$

The inequality (15') can be used to show that an improvement in the service technology results in an improvement in the welfare of all agents.

<u>Proof</u>:

For the x and y producers

$$(16) \qquad \frac{dV}{ds} = V_1(R,1,1)\,\frac{dR}{ds} = V_2(1,R,1)\,\frac{dR}{ds} \ ,$$

and since

$$V_1 = V_2 \leq 0$$

we have

$$\frac{dV}{ds} \geq 0 \quad .$$

For the servicers

$$(17) \qquad \frac{dV}{ds}(1,1,2(R-1)s) = 2\, V_3\{(R-1) + s\,\frac{dR}{ds}\}$$

$$(18) \qquad = \frac{2\, V_3\, V_2(R-1)}{V_2 - 2V_3 s} \geq 0$$

This is an important result. In empirical work writers have expressed concern at the fall in Western economies of the productive sector's share of GNP, relative to that of the service sector (see for example Bacon and Eltis (1978)). My model suggests that a fall in the output of final goods is quite possible with an improvement in the service technology, and that all agents will nevertheless be made better off. The fact that servicing is now relatively cheaper means that agents can obtain goods produced by others at a lower cost, and this results in an increase in the desire to trade. This increased demand for mediation services may exceed the capacity of existing servicers even with their improved capabilities. Consequently agents may leave the goods producing sector and enter the service sector. Further, in the new equilibrium, the total share of the service sector in the consumption of the final goods will rise. However, the fact that all agents, and those in the productive sectors in particular, can purchase goods they do not produce cheaper, more than compensates them for the fall in the output of final goods, and all agents are better off. Agents now have a better mix of goods.

One possible explanation for the increase in the service sectors share of GNP in developed economies that is consistent with this model is that service technology has been improving faster than has the technology for producing goods. We will see later, however, that the faster growth of service technology is not a necessary condition for increases in L_s, and that technological advancements in the productive sector can also lead to a larger service sector.

PART III: DIFFERENT SECTORAL SERVICES AND ASYMMETRIC PRODUCTION

Different Sectoral Services

Up to now I have made some very restrictive assumptions about the form of this economy. I have assumed that agents are equally efficient at producing x and y (symmetric output), that the service technology is symmetric in x and y and that tastes are symmetric in x and y. While these assumptions are important, for they allow us to solve the initial problem, they are not innocuous. I now examine the effects of relaxing these assumptions and I show their effects on the trading pattern.

First, suppose that the technologies associated with trading x and y are different from one another. How will this affect equilibrium? Consider the case where U is symmetric in its arguments. We would expect the different service technologies to affect the prices agents are willing to pay, and indeed we can formulate our model to reflect this. However, equilibrium requires that $V(1,p_y^x,1) = V(p_x^y,1,1)$. Given our symmetry assumptions, this implies that $p_x^y = p_y^x = R$ must continue to hold in equilibrium. This implies that

(19) $$x(R,1,1) = y(1,R,1) ,$$

that is, the amount of traded goods actually arriving at each producer/consumer is the same. Next, rather than focusing on the prices and income that a servicer faces (which we will later see are only shadow prices), we will refer to the servicers consumption of x and y as x^s and y^s respectively.

Recalling the goods market clearing conditions, equations (8) and (9), we can write

$$L_x = L_x\, x(1,R,1) + L_y\, x(R,1,1) + L_s\, x^s$$

$$L_y = L_x\, y(1,R,1) + L_y\, y(R,1,1) + L_s\, y^s\ .$$

The trading constraints are

$$L_x\, y(1,R,1) \leq L_s\, s_y$$

and $$L_y\, x(R,1,1) \leq L_s\, s_x\ ,$$

where s_i is the number of units of good i that can be carried by a servicer. Now there is no reason to believe from what we have shown above that $x^s = y^s$. However, it can be shown that the only way these goods market constraints and the trading constraints can simultaneously be satisfied when output and utility is symmetric in x and y, is iff $L_x = L_y$. Hence $x^s = y^s$.

To demonstrate this result we first recall that the income of a servicer is defined it to be twice (R-1)s. But in general there is no a priori reason to believe that both service constraints will be met. However, we can write down an expression for the effective usage of a service in any direction. Thus we have

$$\hat{s}_x = \frac{L_y\, x(R,1,1)}{L_s}$$

and $$\hat{s}_y = \frac{L_x\, y(1,R,1)}{L_s}\ ,$$

where $\hat{s}_i$ is the actual amount of good i carried by a servicer. Thus

$$x^s = (R-1)\hat{s}_x = \frac{(R-1)L_y\ x(R,1,1)}{L_s}$$

and

$$y^s = (R-1)\hat{s}_y = \frac{(R-1)L_x\ y(1,R,1)}{L_s} ,$$

where the total amount of y to be carried is $L_x\ y(1,R,1)$ and the total amount of x to be carried is $L_y\ x(R,1,1)$. Substituting these into the goods market clearing constraints we obtain

$$L_x = L_x\ x(1,R,1) + RL_y\ x(R,1,1)$$

and

$$L_y = RL_x\ y(1,R,1) + L_y\ y(R,1,1) .$$

Now, given that $x(1,R,1) = y(R,1,1)$ and $x(R,1,1) = y(R,1,1)$ by symmetry, it follows that $L_x = L_y$. Hence $x^s = y^s$. Further, given perfect competition and factor mobility

$$\hat{s}_x = \hat{s}_y = \text{Min } \{s_x, s_y\} .$$

Then for $s_x > s_y$ we have

$$(20) \qquad L_s\ s_x > L_s\ \hat{s}_y = L_s\ s_y = L_x\ y(1,R,1) = L_y\ x(R,1,1) = L_s\ \hat{s}_x .$$

That is, if $s_x > s_y$ there is excess capacity in carrying x, and this superior technology is not fully utilized. Thus, while the income of a servicer is nominally $(R-1)s_x + (R-1)s_y$, the additional service capacity in servicing x is not employed. This occurs because, while initially the tendency is for a servicer to try and carry more x and to trade it for profit, he will not be able to bring back sufficient y to pay for it. Thus, with $p_y^x = p_x^y$, x agents will not supply any more than $p_y^x s_y$ to any servicer. Therefore

$$(21) \qquad \frac{dR}{ds_x} = \frac{dV}{ds_x} = 0$$

$$(22) \qquad \frac{dR}{ds_y} = \frac{2(R-1)V_3}{V_2 - 2V_3 s_y} \equiv \frac{dR}{ds}$$

and

$$(23) \qquad \frac{dV}{ds_y} = \frac{2(R-1)V_2 V_3}{V_2 - 2V_3 s_y} \equiv \frac{dV}{ds} \quad .$$

The effect of a change in s_y, given that $s_x > s_y$, is equivalent to a change in s since the improvement in s_y permits the employment of some of the superior s_x technology.

It is important to appreciate the source of this excess capacity. It is not, for example, a function of the input technology. Thus allowing for a more convex input technology, for example, incorporating capital, would not, by itself, produce excess capacity. The principal elements in determining the excess capacity are the joint product dimension of the service technology and the fact that the demand for services is a derived demand. In this model we have allowed for the possibility that the service technology in each trading direction can be different, and have insisted that excess capacity in one direction cannot be transferred to the other. This is obviously true for transportation industries such as shipping, airlines and ground transportation. Once agents have committed themselves to capacity in one direction they are committed to the same capacity in the other. This does not imply that the number of units of x and y carried are equal in both directions. These assumptions, however, would not be appropriate for financial and information services. For example, time not spent servicing lenders can very easily be spent servicing borrowers.

The second element in the problem is that services are a derived demand. Consequently equilibrium is determined by the producers/consumers desire to trade, and by factor mobility. Thus, if equilibrium requires that equal numbers of each goods flow in either direction, then there is no reason for the extra services to be employed.

Somewhat different results are obtained if it is assumed that servicers service only one good, that is, if they are either x servicers or y servicers. If we are to have equivalent technology to the single-servicer case then each agent could make two trips with goods and return empty. They would then get their own supplies of the good they do not service by costlessly trading with a servicer of the opposite type. As shown in Ryan (1987), however, this adds an extra restriction on the payment to servicers, which complicates the model in a fundamental way, and alters the nature of equilibrium. In this case if $s_x > s_y$ the number of servicers in the x service sector falls, allowing them to be reallocated across all other sectors. However, relative prices in each production/consumption sector would change equiproportionally. Thus an improvement in either sector increases welfare, but excess space capacity (trucks returning empty) still exists.

Asymmetric Production

In this section we wish to consider the effect of relaxing the assumption that output technology is symmetric in the x and y sectors. While this is similar to the case where the service technology differs between sectors, this specific case is examined, for it is useful when considering trade between countries with different comparative advantages in production.

It is easy to see why the two cases are similar. Setting the output of x and y equal to 1 and the service technology equal to s is essentially a normalization, since s is simply some proportion of the output that servicers can service. Thus it is largely irrelevant whether we consider s_x and s_y to be different and the output of x and y to be the same, or vise versa. However, considering different output technologies allows us to introduce the possibility of servicers trading on their own behalf, and to examine the consequences of the symmetrical utility assumption. Thus if both output and service technology are assumed to be different in the two sectors, this can either reinforce or weaken the results, depending on whether or not the differences complement one another.

Suppose that each agent in the x sector can produce $f \geq 1$ units of x, and that each agent in the y sector can produce $g \geq 1$ units of y. The individual budget constraints for the agents in the x and y sectors are

(24) $f = x + p_y^x y$, and

(25) $g = p_x^y x + y$

The budget constraint for agents in the service sector is now more complicated. The condition necessary for equilibrium in the x and y sectors requires that

(26) $$V(1,p_y^x,f) = V(p_x^y,1,g) .$$

Depending upon the nature of the utility function we may write

(27) $$p_y^x = \phi(f,g,p_x^y) .$$

If the conditions for the implicit function theorem are satisfied, then totally differentiating equation (26) yields

$$V_2\ dP_y^x + V_3\ df = V_1\ dP_x^y + V_3\ dg .$$

Thus

(27a) $$\frac{\partial p_y^x}{\partial p_x^y} = \phi_{p_x^y} = \frac{V_1}{V_2} > 0 ,$$

(27b) $$\frac{\partial p_y^x}{\partial f} = \phi_f = - \frac{V_3}{V_2} > 0 \text{ , and}$$

(27c) $$\frac{\partial p_y^x}{\partial g} = \phi_g = \frac{V_3}{V_2} < 0 .$$

Letting $R = p_x^y$, and restricting the servicer to servicing goods for producer/consumers only, then a servicer's consumption bundle is

$$x^s = (\phi(f,g,R) - 1)s ,$$

$$y^s = (R-1)s .$$

Suppose we now relax this restriction and allow the servicer to adjust his/her consumption bundle to the prevailing prices. If the servicer delivers s units of y to x she/he will receive $\phi(f,g,R)s$ units of x in return. The servicer can then choose to consume

$$(\phi(f,g,R) - \alpha)s$$

units of x, where $\alpha \leq 1$ (since 1.s is the maximum amount a servicer can carry) and further αs (the amount of x he delivers to y) is such that $\alpha Rs \geq s$. Thus the maximum x a servicer can consume is

$$(\phi(f,g,R) - \frac{1}{R})s ,$$

which implies that $y^s = 0$. Similarly the maximum amount of y a servicer can consume is

$$(R - \frac{1}{\phi(f,g,R)})s ,$$

in which case $x^s = 0$. Thus a servicer can trade for x and y at prices R and $\frac{1}{\phi(f,g,R)}$ respectively.

Recalling the case where the production of x and y were symmetrical we see that this retrading presents no problem, given our assumption of a symmetrical utility function. This is illustrated in Figure 2. The bundle that the servicer can trade lies on the 45^{o} line. Thus with prices R for x and $\frac{1}{R}$ for y, the purchase of further units of x or y cannot yield higher utility.

When output is not symmetrical, this is no longer the case. This can be seen by considering Figure 3. When the servicer is restricted to carrying bundles that producers/consumers wish to trade, servicers receive the bundle $A = \{(\phi-1)s, (R-1)s\}$. However, if the servicer is permitted to trade for more y at the price $\phi(f,g,R)$ or x at the price R, then their consumption bundle can be altered to increase utility, for example, to point B.[4]

Given our assumption of a symmetrical utility function and the fact that in the absence of servicer trading $R \geq 1$ (= 1 in the limit as $s \to \infty$), agents will never want to purchase more x. Consequently a servicer's budget constraint is given by the line from A to the y axis. More formally, the servicer's problem (for $f > g$) is

(28) $$\max_{x,y} \quad u(x,y)$$

(29) $$\text{s.t.} \quad x + \phi(f,g,R)y = [\phi(f,g,R) + R - 2]s \ ,$$

(30) $$x \leq (\phi(f,g,R) - 1)s \ ,$$

and

(31) $$y \geq (R - 1)s$$

where $\phi(f,g,R)$ and R are taken as given. While this is a standard Kuhn-Tucker problem, solving for the usual equilibrium conditions does not yield information in a useable manner. Consequently we rewrite this problem as follows. A servicer maximizes

(32) $$U((\phi\alpha-1)s \ , (R-\alpha)s)$$

with respect to α

$$\text{s.t.} \quad \alpha \leq 1 \ .$$

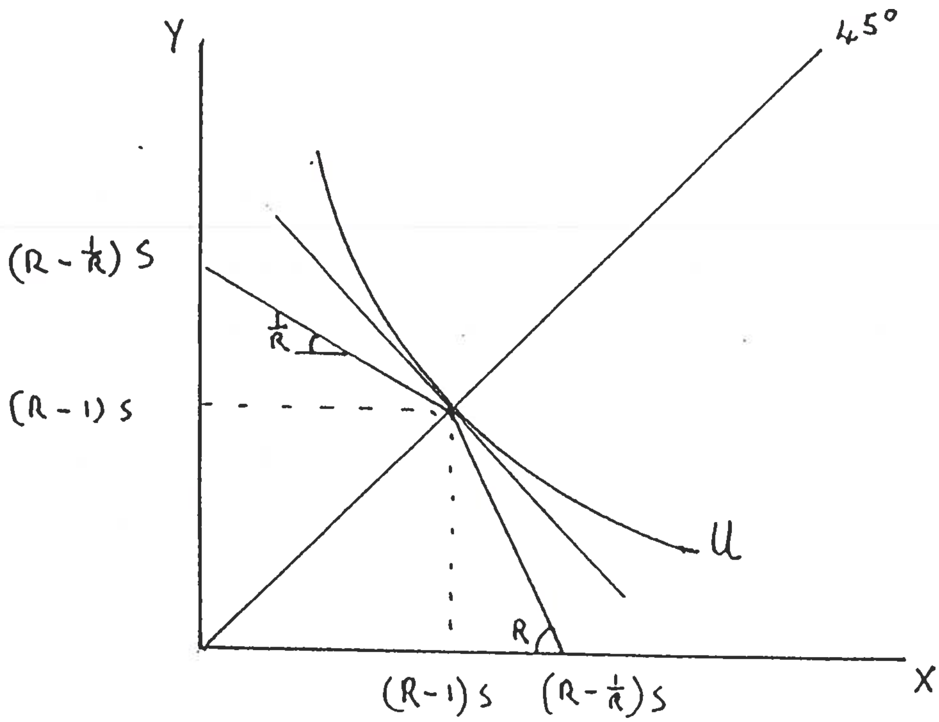


Figure 2

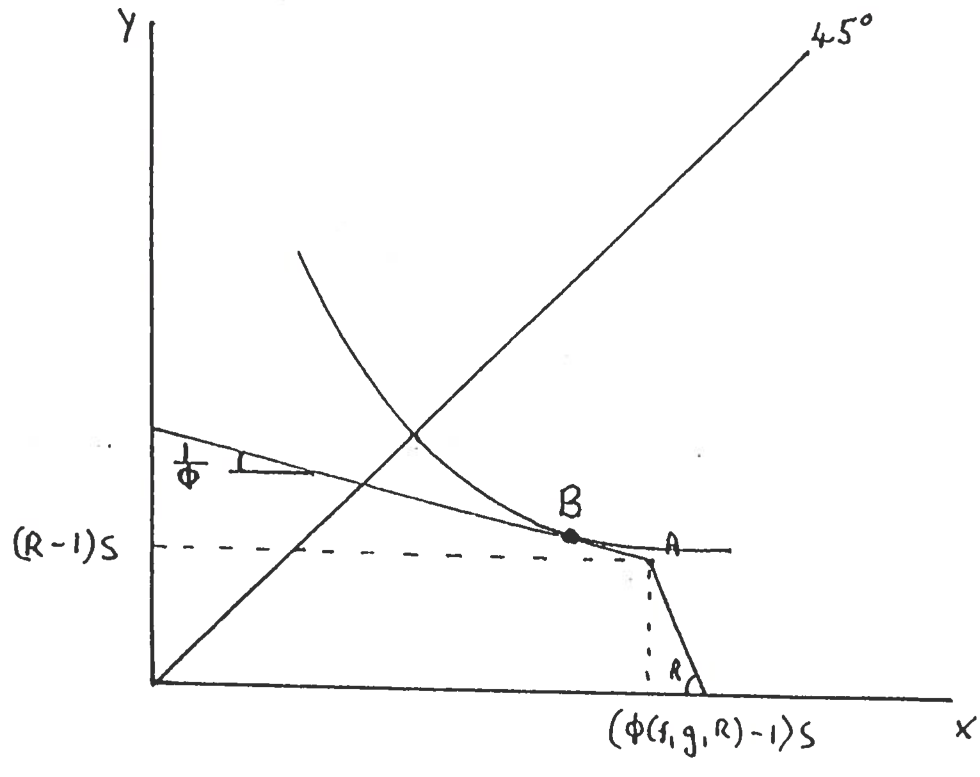


Figure 3 f > g

First order conditions imply

(33) $\quad U_1 \phi - U_2 = 0$.

If the conditions for the implicit function theorem are met then we may write

(34) $\quad \alpha = \alpha(f,g,R,s)$.

Thus general equilibrium requires that

$$V(1,\phi(f,g,R),f) = V(R,1,g)$$

(34a) $$= U[\phi(f,g,R)\alpha(f,g,R,s)-1)s,\ (R-\alpha(f,g,R,s))s\ ] .$$

Assuming these functions are continuous and differentiable, total differentiation yields

$$V_2\phi_R\, dR + (V_2\, \phi_f + V_3)df + V_2\, \phi_g\, dg$$

$$= V_1\, dR + V_3\, dg$$

$$= [U_1(\phi_R\alpha + \phi\alpha_R)s + U_2(1 - \alpha_R)s]dR$$

$$+ [U_1\phi_f\alpha s + U_1\phi\alpha_f s - U_2\alpha_f s]df$$

$$+ [U_1\phi_g\alpha s + U_1\phi\alpha_g s - U_2\alpha_g s]dg$$

$$+ [U_1(\phi\alpha-1) + U_2(R-\alpha) + U_1\phi\alpha_s - U_2\alpha_s]ds$$

Invoking the envelope theorem we can write

(35) $$\frac{dR}{ds} = \frac{U_1(\phi\alpha-1) + U_2(R-\alpha)}{V_1 - U_1\alpha\phi_R s - U_2 s} \leq 0$$

,) $$\frac{dR}{df} = \frac{U_1\phi_f\alpha s}{V_1 - U_1\alpha\phi_R s - U_2 s} \leq 0$$

(37) $$\frac{dR}{dg} = \frac{U_1\phi_g\alpha s - V_3}{V_1 - U_1\alpha\phi_R s - U_2 s} \geq 0 \quad .$$

Substituting the above and from (27a) - (27c) we obtain, with some manipulation,

(38) $$\frac{d\phi}{ds} = \phi_R \frac{dR}{ds} \leq 0 \ ,$$

(39) $$\frac{d\phi}{df} = \phi_R \frac{dR}{df} + \phi_f = \frac{\phi_f(V_1 - U_2 s)}{V_1 - U_1\alpha\phi_r - U_2 s} \geq 0 \ , \text{ and}$$

(40) $$\frac{d\phi}{dg} = \phi_R \frac{dR}{dg} + \phi_g = \frac{- V_3 \ U_2 s}{V_2(V_1 - U_1\alpha\phi_R s - U_2 s)} \leq 0 \ .$$

Further

(41) $$\frac{dV}{ds} = V_1 \frac{dR}{ds} \geq 0$$

(42) $$\frac{dV}{df} = V_1 \frac{dR}{df} \geq 0$$

(43) $$\frac{dV}{dg} = V_1 \frac{dR}{dg} + V_3 \geq 0 \ .$$

From the above we see that any change in technology, whether it be in goods producing technology or service technology, is welfare enhancing. Further, a change in service technology reduces ϕ and R (from (35) and (38)), and thus the boundary of a servicer's budget set becomes closer to being a straight line. If $f > g$ and f increases then, from (36) and (39), $1/\phi$ and R moves further apart and a servicer's budget set becomes more skewed towards the x axis. If $f > g$, and g increases then, from (37) and (40), $1/\phi$ and R move closer together, and a servicer's budget set becomes less skewed towards the x axis.

Further, if $\alpha < 1$, then servicers are operating at less than full capacity in one direction. They service αs of a producer/consumer's good (for example, x) and $(1-\alpha)s$ units of their own payment of x initially. However, on the return journey they will service only αs units of the y producer's good. Thus an improvement in service technology will lead to an increase in the total number of trades. Some of this trading, however, may now be on behalf of servicers rather than on behalf of producers/consumers. Furthermore, the presence of a differential trading technology may not be as damaging here as it was in the case of the symmetric production technology. In particular, if $\alpha s_x \leq s_y < s_x$, equilibrium will not be affected. If $\alpha s_x > s_y$ then welfare is bounded by the lower y trading technology.

International Trade

Consider a two-country version of the foregoing model, where both countries are symmetric and identical in every respect, except that one country has a comparative advantage in services. The trading process in this model allows foreign servicers to service domestic producers/consumers. Thus before trade equilibrium in country A implies

$$(44) \qquad V(1,R_A,1) = V(1,1,2(R_A-1)s_A) ,$$

and in country B implies

$$(45) \qquad V(1,R_B,1) = V(1,1,2(R_B-1)s_B) .$$

If $s_B > s_A$, then we saw that $R_A > R_B$, and we have

$$V^B > V^A , \tag{46}$$

where V^B and V^A are the indirect utilities of agents in country B and A respectively.

If we permit free trade between the two countries, then since $R_A > R_B$, agents in country A will wish to purchase their goods from servicers in country B. Assuming that there are sufficient servicers in country B, servicers in country A, unable to compete, will start producing the consumer goods x and y. Thus the world will now look like country B in terms of its technical capabilities except that the population is the sum of A's and B's population, namely $n_A + n_B$. However, as I have shown in earlier work (Ryan 1987),

$$\frac{d(\frac{L_s}{n})}{dn} = 0$$

as long as $s(L_s)$ exhibits CRS. Thus

$$\frac{L_s(n_B)}{n_B} = \frac{L_s(n_A + n_B)}{n_B + n_A} \qquad \text{as long as} \quad L_s(n_A + n_B) \leq n_B , \tag{47}$$

and the indirect utility of agents under free trade is the same as in B under autarky, that is,

$$V^{A+B} = V^B , \tag{48}$$

where V^{A+B} is the indirect utility of an agent in the free-trade world. If $L_s(n_A + n_B) > n_B$, then either the total amount of service is equal to the maximum units of service agents in B can provide, $n_B \cdot s_B$, or some agents in A must provide services. In the former case symmetry implies that $L_x = L_y = \frac{1}{2} n_A$, and thus R is determined by

$$(49) \qquad \frac{1}{2} n_A \; x(R,1,1) = n_B \; s_B \; .$$

In the new equilibrium we have $R_A > \bar{R} > R_B$ and $V^A < \bar{V}^A < V^B < \bar{V}^B$, where a bar denotes the variables in the constrained case. In this case both countries gain from trade. In the case where agents in A provide services, $R = R^A$ in equilibrium (otherwise agents in A will not service), and all the gains from trade go to country B. Thus, as in traditional Ricardian trade models, the gains from trade depend crucially on the relative size of the two countries.

We note that in this model, one country could be running a merchandise trade deficit or surplus. For example, agents from country B provide mediation services to agents in country A and receive (R-1)s units of x and y as compensation. Thus the emphasis in the United States, especially in the context of Canada-U.S. trade negotiations, on the trade imbalance on the merchandise trade account is somewhat misdirected. Indeed the desire of the U.S. to negotiate trade liberalization in services in the next round of G.A.T.T. talks may be incompatible with their desire to impose levies on countries with a merchandise trade surplus. The U.S. merchandise deficit may simply be a reflection of their comparative advantage (perceived by themselves and others) in services. While it should be pointed out that the figures for services in the U.S. current accounts would not totally account for the U.S. deficit on the merchandise account (nor would one expect them to in the presence of capital movements), several writers, including Rugman (1986), have expressed the belief that the U.S. figures for services are a grossly inadequate reflection of the true degree of trade in services. Melvin (1987) points out that one possible explanation for "a rising U.S. merchandise trade deficit combined with a falling Canadian dollar" is "that there has been an increasing surplus in service exports to Canada by the U.S."

This paper also yields some new results with respect to the Ricardian model and the gains from trade theorem. Consider a two-country world where servicers from either country can service producers/consumers from the other. Further suppose that country A has a comparative advantage in the production of x and that country B has a comparative advantage in the production of y. Service technology is identical in both countries. Under autarky, equilibrium in country A is given by

$$V(1,\phi^A(f^A,1,R^A),1) = V(R^A,1,1) \,, \qquad (50)$$

$$= U((\phi^A\alpha^A - 1)s,\ (R^A - \alpha^A)s),$$

and equilibrium in country B is given by

$$V(1,R^B,1) = V(\phi^B(1,g^B,R^B),1,g^B) \,,$$

$$= U((R^B - \alpha^B)s,\ (\phi^B\alpha - 1)s) \,, \qquad (51)$$

where ϕ^j is the price of the good in which country j has a comparative advantage,

R^j is the price of the other good in country j,

$f^A > 1$ is the output of an x producer in country A,

$g^B > 1$ is the output of a y producer in country B, and

$g^A = f^B = 1$ is the output of a y producer/x producer in countries A and B respectively.

If $f^A = g^B$

then

$$R^A = R^B , \qquad \phi^A = \phi^B$$

and

$$\phi^A > R^B , \qquad \phi^B > R^A .$$

That is, the price an x producer is prepared to pay for a unit of y in A is greater than the price an x producer is prepared to pay in B in autarky, and the price a y producer is prepared to pay for a unit of x in B is greater than the price a y producer is prepared to pay in A. If trade is then permitted, services will want to pick up x in country A and trade with y producers in country B. The new equilibrium is given by

$$V(1,\phi^F(f^A,g^B,R^F),f^A) = V(R^F,1,g^B)$$

$$= U((\phi^F(f^A,g^B,R^F)\alpha-1)s, (R^F-\alpha)s) , \qquad (52)$$

where ϕ^F is the new world price of x and R^F the new world price of y. Note we are assuming agents in A specialize in x and servicing, agents in B specialize in y and servicing, and $L_x^A < n^a$, $L_y^B < n^B$. This is possible given our assumptions.

Now for agents in country A, moving to free trade is equivalent to doing three things. The first is a move that doubles the population of A. From equation (15) we see that the labour allocations are multiplicative in n when everything is symmetric. As I show in Ryan (1987) this will continue to hold when the symmetric assumption is relaxed as long as each industry faces constant returns to scale for the industry. Thus allocations are not affected by this movement.

The second change is to a production environment where the world is now more symmetrical, for g has improved from A's point of view. Thus R rises, $\phi(f,g,R)$ falls and the welfare of all agents in A improves.[5]

The third change is related to the effective productivity of the service sector. Recall that, when the world faces asymmetric production possibilities in x and y, traders may be trading on their own behalf and there may be excess capacity in one direction. Now, since $(f^A-g^B) = 0 < (f^A-1) = (g^B-1)$, the world is more symmetric. Given symmetry in tastes, at worst the servicer trading will be eliminated and in addition excess service capacity may be eliminated (if such excess capacity in either direction cannot be reallocated, such as is the case for transport). Thus servicers in A and B have capacity that they can allocate to servicing producer/consumers. Consequently the move to free trade not only captures the benefit of comparative advantage in final good production, but also there is an added gain due to this "as if" improvement in service technology.

CONCLUSION

In this paper I endogenously derive intermediation services in the context of a two-good, one-factor n-agent model.

The paper derives several important results, some of which differ significantly from previous work. The first result is that output of goods can fall as a result of an improvement in service technology. This is in contrast with Falvey's (1976) conclusions. At the same time, however, all agents' welfare rises as a result of the technical change. These two results can be compared to the work of Bacon and Eltis (1978), who suggest that a nation's wealth is based upon its capacity to produce final goods, and that the growth of the service sector represents a backward step in economic development.

The nature of equilibrium in this model also provides some new insights into the trading process. Because services are demanded indirectly, the equilibrium price and quantity demanded depend more upon demand considerations than on the service technology itself. In particular, any asymmetry either in demand, production or in service technology, may lead to excess capacity in equilibrium in the service sector, and an inefficient trading pattern relative to free trade. As a consequence, if free trade makes the world more symmetrical, service capacity is released and thus an "as if" technical improvement occurs, yielding gains from trade in addition to those normally associated with the Ricardian gains from trade. Further, the model shows that a country exporting services would normally be expected to have a deficit on the merchandise account. This is a result that Canadians should take into account when considering the American concerns about the U.S. merchandise trade deficit with Canada.

FOOTNOTES

1. From Bank of Canada Review (1987), National Income Accounts, Table H5, G.N.P. at factor cost by industry.

2. Simple casual empiricism tends to suggest that agents specialize in production processes, thus this assumption has some empirical validity.

3. Note that the trading constraint

$$L_s s = \text{Max}\ \{L_x\ y(1,R,1),\ L_y\ x(R,1,1)\}$$

is being ignored here. This is permissable because the definition of the servicers income and the market clearing conditions imply that the trading constraint is always met, at least when everything is symmetric. For a more detailed analysis readers should consult the section on differential service technologies in section III.

4. Although I expect that this result holds for a wide class of utility functions, to date it has only been possible to show it for a limited class of C.E.S. utility functions, including both Leontief and Cobb-Douglas functions.

5. This analysis can also be conducted from the point of view of country B and the results are equivalent.

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