Offshoring and globalisation: What is new about the new paradigm?

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1. INTRODUCTION

Globalisation is a new and important phenomenon – and has been at least since the age of steamships, railroads and the telegraph. While there is much to be said for this nothing-new-under-the-sun scepticism, three Princeton economists have recently argued that today's globalisation demands a radical re-think. Gene Grossman and Esteban Rossi-Hansberg argue that international trade theory needs a "new paradigm" to understand recent globalisation (Grossman and Rossi-Hansberg 2006a, b; GRH hereafter). As they put it: "Revolutionary progress in communication and information technologies has enabled an historic (and ongoing) break-up of the production process. Countries like England and Portugal still produce some goods from start to finish, but increasingly they participate in global supply chains in which the many tasks required to manufacture complex industrial goods (or, increasingly, to provide knowledge-intensive services) are performed in several, disparate locations. To better understand the implications of these trends, we need a new paradigm for studying international trade that emphasizes not only the exchange of complete goods, but also trade in specific tasks, or, what we shall refer to as 'offshoring.'" (Grossman and Rossi-Hansberg 2006a, p.1).

Alan Blinder goes further; the title of his recent paper in Foreign Affairs is "Offshoring: The Next Industrial Revolution?" (Blinder 2006). Focusing more on service sector offshoring, he writes: "We are now in the early stages of a third Industrial Revolution—the information age. The cheap and easy flow of information around the globe has vastly expanded the scope of tradable services, and there is much more to come. Industrial revolutions are big deals. And just like the previous two, the third Industrial Revolution will require vast and unsettling adjustments in the way Americans and residents of other developed countries work, live, and educate their children." The Blinder contribution follows an early easy to read, but somewhat tongue-in-check contribution by another Princeton economist, Krugman (1996). Both pieces are thought provoking but the arguments are informal so it is difficult to discern specifics about exactly what is new.

The first goal of this paper is to identify what is new in the 'new paradigm' (or perhaps we should call it the Princeton Paradigm to avoid the eventual emergence of a new, new paradigm). The second goal is to investigate formally how 'trade in tasks' alters the main findings of the Heckscher-Ohlin (HO) model; we focus on the four standard HO theorems. Using a simplified version of the GRH model, we show that the Princeton paradigm does indeed significantly alter the main HO findings. For example, trade in goods appears even when the Heckscher-Ohlin theorem says there is no basis for trade and it involves both inter-industry and intra-industry trade in a competitive setting without invoking the Ricardian motives for trade emphasised by Davis (1995). If an econometrician investigated the trade thus generated from the perspective of trade in goods rather than trade in tasks, she might conclude that there was a 'missing trade' puzzle as in Trefler (1995). If one ignores trade in tasks and focus only on trade in goods, the model appears to generate a Leontief-like paradox, and appears to violate the factor price equalisation and Heckscher-Ohlin theorems. We also show that the GRH 'productivity effect' does not hold in general and we characterise the necessary and sufficient condition in a simple model. Finally, we extend the model in various directions. One extension allows offshored tasks to involve both low- and high-skill tasks. Another introduces a small modification of the basic model that

allows for intra-industry offshoring between technologically advanced nations (a common phenomenon according to the empirical literature on offshoring, Amiti and Wei, 2005)

1.1. What's really new?

The new- and old-globalisation paradigms fit together most naturally when thinking of globalisation as two great unbundlings. Since the dawn of human civilisation, the cost of moving goods, people and ideas has fostered the geographic clustering of production and people. Rapidly falling international transportation costs caused the first unbundling – it allowed goods to be made far from the point of consumption. The result was rapidly growing international trade in goods and this could be understood in terms of the 'old paradigm' (i.e. trade theory). More recently, rapidly falling international communication and coordination costs have fostered a second unbundling – the end of the need to undertake manufacturing stages near each other. The result was offshoring and a rapid growth of trade in intermediate goods since about 1985 in North America and East Asia (Dallas Fed 2002, Urata 2001, Yi 2003, Ando and Kimura 2005). Even more recently, the second unbundling has spread from factories to offices with the result being the offshoring of service-sector jobs (Amiti and Wei 2005). Understanding the second unbundling (which has variously been called fragmentation, offshoring, vertical specialisation, slicing up the value-added chain, and service sector offshoring) is the subject of the Princeton paradigm.

Figure 1 helps illustrate some basic distinctions between the new and old paradigms. Under the old paradigm, domestic productive factors compete with foreign factors via the goods market. Domestic factors are bundled together in a black-box process that yields goods; these then face international competition. Primary factors of production – call them high-skilled labour H and low-skilled labour L, to be concrete – go in one end of the factory and goods come out the other end. This is modelled with a production function, say $X=F[L_X,H_X]$, which is a shortcut to describing hugely complex production processes.

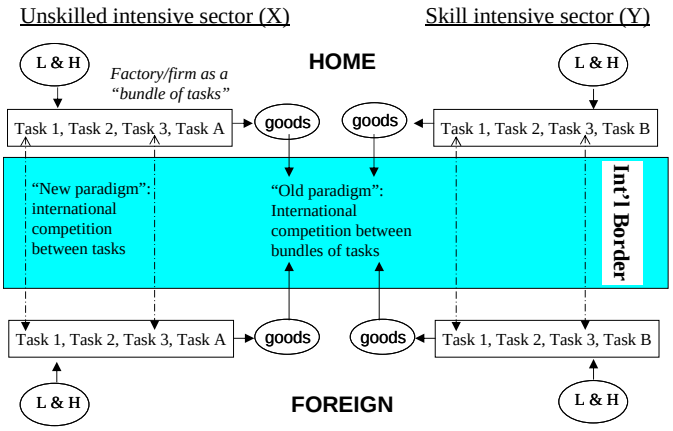

Figure 1: Trade in tasks versus trade in goods

GRH suggest that it is useful to think of the production process as bundles of tasks. Figure 1 illustrates a bit of the complexity by showing various 'tasks' that must be undertaken to produce final goods from primary factors. For the low-skill-intensive sector, X, on the left side, final-good production requires task 1, task 2, task 3 and sector-specific task A. In the high-skill-intensive sector, Y, final-good production also requires tasks 1 to 3 as well as the sector-specific task B. For example, task 1 could be data-entry services, task 2 could be inventory management and task 3 could be information technology

(IT) services, while the sector-specific tasks A and B would be related to unique features of the sectors' manufacturing processes.

As long as all the tasks remain bundled together in a given firm, there is no harm in submerging the details with a production like $F[L_X,H_X]$. However, as the second unbundling occurs, some of the individual tasks become tradable and the package of tasks comes undone. $F[L_X,H_X]$ is no longer a useful shortcut since international competition reaches into the factory. Domestic and foreign productive factors compete via "tasks" as well as the particular packages of tasks called final goods. The new-ness of this trade in tasks is considered more extensively below, but it is already worth pointing out that it means that the standard aggregates for the analysis of globalisation's impact – firms, sectors and skill groups – are less relevant when it comes to Princeton-paradigm globalisation. For example, L-intensive tasks such as task 1 may be offshored by both the low-skilled labour intensive sector X and the skill-intensive sector Y. Moreover, the unbundling could affect both high- and low-skilled tasks within the same sector. In some sense, globalisation's impact on the economy occurs at a much finer level of resolution so sectors and skill groups may be less useful when thinking about the optimal policy response.

Three new aspects of the new paradigm

The trade in tasks versus trade in goods distinction might seem merely semantic at first, but as far as policy making goes there are at least three really new things (Baldwin 2006). The key is the fact that the second unbundling occurs at a much finer level of disaggregation. As international communication and coordination costs have fallen, firms can offshore many tasks that were previously considered non-traded. International competition, which was between firms and sectors in different nations during the first unbundling can, after the second unbundling, occur between individual workers or production teams performing similar tasks in different nations. One important new feature of this is that the impact of deeper globalisation may seem quite unpredictable from the perspective of firms and sectors.

When trade becomes freer in a standard trade-in-goods model with trade costs, it is easy to identify winning and losing sectors. The winning sectors are those that are already the most competitive (i.e. export sectors), while the losers are those that are the least competitive (i.e. import sectors). The type of labour used most intensively in the export sector wins while the labour used most intensively in the import sector loses. Under the Princeton paradigm, the impact of lowering the cost of moving goods, people and ideas may be much more diffuse. There is much less reason for believing that winning and losing sectors will be correlated with initial degrees of competitiveness. There is also much less reason for believing that the labour skill group used intensively in the winning sectors will share the gains. When the cost of coordinating complex processes across distance (trading ideas) falls, it is difficult to predict winning and losing tasks. Knowing the direct cost of telecommunications is not enough since it interacts in complex and poorly understood ways with the nature of the task and the task's interconnectedness with other tasks. Since economists lack an thorough understanding of the 'glue' that resulted in the bundling of various tasks in the first place, the way in which various tasks come unglued may seem unpredictable from the trade-in-goods perspective of sectors and skill groups.

Another novel feature would seem to be the suddenness of the changes, especially when it comes to service sector offshoring. Telecommunication costs have fallen rapidly but the impact has been quite different for different tasks due to way in which the organisation of tasks depends upon complex interactions within factories and offices. Small changes in organisation together with cheap communication costs may mean that a new task or set of tasks can be offshored economically.

A third novel feature is the individuality of the effects of deeper integration. In the first unbundling, one could view firms as black-box bundles of tasks since firm-against-firm competition was globalisation's finest level of resolution. The Princeton paradigm suggests that the forces of globalisation will achieve a far finer resolution, at the level of tasks. This means that particular workers in particular firms in a given sector could suffer from globalisation while others in the same firm and

same educational attainment prosper from globalisation. New paradigm competition is on a much more individual basis and this has some implications for policy. For example, policies design to help ailing firms and declining sectors may fail to assist the losers from deeper new-paradigm globalisation.

1.2. Literature review

Grossman and Rossi-Hansberg (2006a, b) are the first to present a formal model of the 'new paradigm'. There are many theoretical models of the second unbundling in what is sometimes called fragmentation or offshoring theory following Jones and Kierzkowski (1990). It may be useful to distinguish between two types of offshoring that have been modelled in the theoretical literature.

JK-Offshoring

In 2004, Greg Mankiw announced to the US business media that offshoring was just like trade in goods: "More things are tradable than were tradable in the past, and that's a good thing." Mankiw was in good company since trade theorists have long modelled the second unbundling as if it were just like trade in new goods. The various contributions by Ron Jones and coauthors, by Alan Deardorff, by Tony Venables and by Jim Markusen on fragmentation deal with this type of offshoring which we might call 'JK offshoring' since the most commonly cited reference for it is Jones and Kierzkowski (1990).[1]

A central insight in the JK-offshoring literature is that one can think of offshoring as technical progress in final goods. The intuition is dead easy. Unbundling production processes allows trade in intermediate goods and services. This opens new opportunities for gains from trade. The gains from trade mean that the same quantity of primary resources can produce a higher value of final goods, i.e. technological progress in final goods. While the productivity improvement is guaranteed at the global level in a Walrasian setting, national gains are subject to the usual provisos concerning terms of trade, factor intensive reversals, etc. This ancient insight helps place JK-offshoring models in the broader context of trade theory.[2]

A second central insight in the JK-offshoring literature concerns the general equilibrium incident of offshoring on wages. In general the literature concludes that there is nothing that can be said in general. The wage impact depends upon, inter alia, the factor intensity of the offshored intermediate good or service, the factor intensity of offshoring sector, factor-intensity reversals, elasticities of substitution in demand, factor endowments, technology differences between nations and much more. The usefulness of these results is to dispel the common perception that offshoring low-skill labour intensive production to low-wage nations must harm low-skilled workers in the offshoring nation.

One defining feature of all the models of JK-offshoring is that they assume that the offshoring/fragmentation only occurs in one sector. Moreover, they follow the standard trade theory assumption that any good made in a particular nation is made using that nation's technology.

GRH-offshoring

The GRH paper introduces a new view of offshoring. The GRH model is quite general, and therefore difficult to work with, but it uses a series of special cases to illustrate what is really new. As far as results go, two findings seem entirely novel. First, they find that their version of offshoring leads to a 'productivity effect' on wages. Second, they find that the general equilibrium incidence of offshoring

[1] Other contributions include Dixit and Grossman (1982), Ron Jones and co-authors: (Jones and Findlay 2000, 2001, Jones and Kierzkowski 1990, 1998, 2000, Jones and Marjit 1992); Deardorff (1989a, b), Venables (1999), and Markusen (2005). These papers present a bouquet of special cases in which many expected and unexpected things can happen. For an even older tradition in trade in intermediate goods, see Batra and Casas (1973).

[2] Jones and Kierzkowski (1990) point out that it can be gleaned from Adam Smith's work; they also quote the 1928 American Economics Association Presidential address by Allyn Young. The insight is quite explicit in Jones and Kierzkowski (2000 p.13) and implicit in the diagrammatic analysis in Jones and Kierzkowski (1998).

low-skill intensive tasks is unambiguous; it always raises low-skilled wages in the offshoring nation when one controls for the standard HO factors such as terms of trade effects. It seems that these novel results stem from two novel assumptions in GRH. The first assumption is that the offshoring firms from the technologically advanced nation use the advanced technology when undertaking a particular task in the technologically backward nation (although doing so may entail an offshoring cost). The second stems from Princeton-paradigm view of 'trade in tasks' versus trade in goods. This leads them to make assumptions about offshoring costs that ensure that when, for example, low-skill-intensive tasks are offshored then they are offshored by all sectors regardless of the sector's overall factor intensity.

1.3. Organisation of paper

The next section, Section 2, quickly reviews the standard 2x2x2 model to fix ideas and notation. Section 3 introduces a simplified GRH model and then studies its properties and how these deviate from the standard 2x2x2 trade model. Since the only formal results in GRH concern factor prices, this section contains several novel implications of GRH-offshoring especially as concerns the trade and production effects. Section 4 extends the basic model in two directions. First it allows for less extreme assumptions on the factor-intensity of offshored tasks. Second it present a version of the model in which two-way intra-industry offshoring arises between similar nations. The final section presents our concluding remarks.

2. OLD PARADIGM: TRADE IN GOODS

To fix notation we introduce the standard 2x2x2 Heckscher-Ohlin world with two nations, Home and Foreign, two final goods, X and Y, and two primary factors, human capital (K) and labour (L). Tastes are identical across nations and homothetic. We start with what seems the most natural case. Home is the technologically superior nation and also relatively abundant in high-skilled labour. Home's technological superiority allows it to produce both goods with less capital and labour; all the unit input requirements for Foreign production are γ times larger than those of Home (i.e., $a_{ij}^* = \gamma a_{ij}$, where the a's use the standard notation and the "*" indicates the Foreign input coefficient and $\gamma>1$). In other words, Home has a Hicks neutral technological edge over Foreign. To be concrete, X is L-intensive and Foreign is relatively abundantly endowed with unskilled labour, i.e.:

$$(1) \qquad \frac{a_{LX}}{a_{KX}} > \frac{a_{LY}}{a_{KY}}, \qquad \frac{L^*}{K^*} > \frac{L}{K}$$

Since the international technology differences are Hicks neutral, the first inequality holds for both nations. Although there are technological differences between nations, there is no Ricardian motive for trade due to the Hicksian assumption.

2.1. Autarkic equilibrium

When trade in goods and tasks is impossible the autarkic equilibrium in Home or Foreign is characterised by two pricing equations, two employment equations and a market clearing condition. The pricing equations are:[3]

$$\textbf{(2)} \qquad \begin{aligned} 1 = p_X &= a_{LX} w + a_{KX} r\,; & p_Y &= a_{LY} w + a_{KY} r \\ 1 = p_X^* &= \gamma\, a_{LX} w^* + \gamma\, a_{KX} r^*\,; & p_Y^* &= \gamma\, a_{LY} w^* + \gamma\, a_{KY} r^* \end{aligned}$$

where we have taken X as numeraire, w and r are the rewards for unskilled labour (L) and skilled labour (K), respectively, and "*" indicates a Foreign variable; γ is Home's technological advantage,

[3] In general, these should be inequalities. We can use equalities since we assume that parameters are such that both nations' production structures are diversified at the sectoral level with free trade, i.e. they share a diversification cone. This requires them to have sufficiently similar endowment ratios.

and we have made the substitutions for all $a_{ij}^* = \gamma a_{ij}$. Solving the price equations, we find the Home wage for unskilled and skilled labour to be:

(3)

$$w = \frac{p_X a_{KY} - p_Y a_{KX}}{a_{LX} a_{KY} - a_{LY} a_{KX}}, \qquad r = \frac{p_Y a_{LX} - p_X a_{LY}}{a_{LX} a_{KY} - a_{LY} a_{KX}}$$

$$w^* = \frac{p_X^* a_{KY} - p_Y^* a_{KX}}{a_{LX} a_{KY} - a_{LY} a_{KX}} \left(\frac{1}{\gamma}\right), \qquad r^* = \frac{p_Y^* a_{LX} - p_X^* a_{LY}}{a_{LX} a_{KY} - a_{LY} a_{KX}} \left(\frac{1}{\gamma}\right)$$

The employment equations are:

(4)

$$L = a_{LX} X + a_{LY} Y; \qquad K = a_{KX} X + a_{KY} Y$$

$$L^* = \gamma a_{LX} X^* + \gamma a_{LY} Y^*; \qquad K^* = \gamma a_{KX} X^* + \gamma a_{KY} Y^*$$

Where X and Y are the equilibrium outputs of the X and Y sectors in Home; the corresponding variables with "*" indicate Foreign sector outputs. Solving (4) for outputs, we get for Home and Foreign, respectively:

(5)

$$X = \frac{a_{KY} L - a_{LY} K}{a_{LX} a_{KY} - a_{LY} a_{KX}}, \qquad Y = \frac{a_{LX} K - a_{KX} L}{a_{LX} a_{KY} - a_{LY} a_{KX}}$$

$$X^* = \frac{a_{KY} L^* - a_{LY} K^*}{a_{LX} a_{KY} - a_{LY} a_{KX}} \left(\frac{1}{\gamma}\right), \qquad Y^* = \frac{a_{LX} K^* - a_{KX} L^*}{a_{LX} a_{KY} - a_{LY} a_{KX}} \left(\frac{1}{\gamma}\right)$$

Finally, the market clearing conditions will be:

(6)

$$\frac{p_Y^* Y^*}{p_X^* X^*} = \frac{\alpha E^*}{(1-\alpha) E^*}, \qquad \frac{p_Y Y}{p_X X} = \frac{\alpha E}{(1-\alpha) E}$$

assuming Cobb-Douglas preferences; the E's are national income and expenditure measured in the numeraire good, X. The E's equal the sum of labour group incomes.[4]

Solving (6) using (5) we see that the autarky relative prices are linked to relative factor endowments:

(7)

$$\frac{p_Y}{p_X} = \left(\frac{\alpha}{1-\alpha}\right)\left(\frac{a_{KY}}{a_{KX}}\right) \frac{\frac{L}{K} - \frac{a_{LY}}{a_{KY}}}{\frac{a_{LX}}{a_{KX}} - \frac{L}{K}}$$

The expression for Foreign relative autarky prices is isomorphic. As is well known, a condition for both economies to have diversified production is that their endowment ratios lay between the factor intensity ratios, so the difference of ratios in both the numerator and denominator will be positive.[5] With some reflection, it should be clear that the relative price of the K-intensive good Y falls as the K becomes more abundant. Algebraically, this result turns on the fact that $a_{LY}/a_{KY} < a_{LX}/a_{KX}$ so that L/K is more proportionally important in the numerator than it is in the denominator.

[4] Specifically, $U = X^{1-\alpha} Y^{\alpha}$ and $E = X + p_Y Y = wL + rK$.

[5] To see this, note that the denominators in (5) are positive as a consequence of (1), so a necessary and sufficient condition for X,Y>0 is $\frac{a_{LX}}{a_{KX}} > \frac{L}{K} > \frac{a_{LY}}{a_{KY}}$.

2.2. Free trade in goods and the 4 theorems[6]

When free trade is allowed, there is no change in national production (the sectoral outputs are determined independently of the relative price with fixed input coefficients), but trade in goods equalises relative prices in Home and Foreign. The free trade relative price is:

(8)
$$\frac{p_Y}{p_X} = \left(\frac{\alpha}{1-\alpha}\right)\left(\frac{a_{KY}}{a_{KX}}\right)\frac{\left(\frac{L^*}{K^*} - \frac{a_{LY}}{a_{KY}}\right)K^* + \left(\frac{L}{K} - \frac{a_{LY}}{a_{KY}}\right)\gamma K}{\left(\frac{a_{LX}}{a_{KX}} - \frac{L^*}{K^*}\right)K^* + \left(\frac{a_{LX}}{a_{KX}} - \frac{L}{K}\right)\gamma K}$$

As is well known, the free trade relative price lays between the two autarky prices (indeed, it is a sort of weighted average of the two autarky prices). This means that the relative price of Y rises in the K-abundant nation (Home) and falls in the L-abundant nation (Foreign). The Factor Price Equalisation theorem is slightly modified in our model: Free trade in goods equalises the rewards to productive factors measured in 'effective' units. By inspection of (3), the equality of prices in free trade implies $w=w^*\gamma$ in free trade, so taking an effective unit of L* to be L^*/γ (i.e. it is as if each hour of Foreign labour were worth $1/\gamma$ hours of Home labour) this tells us that the effective wage rates are equalised.

The Heckscher-Ohlin theorem here is that the nation that is relatively well endowed with L exports the L-intensive good and imports the K-intensive good. Using the free trade equilibrium values, Home's imports of X – the value of its consumption of X (which will be $(1-\alpha)$ times its income wL+rK) minus the value of its production of X – will be:

(9)
$$M_X^{HO} \frac{\left(\frac{L^*}{K^*} - \frac{L}{K}\right)\alpha K^* K / a_{KX}}{\left(\frac{a_{LX}}{a_{KX}} - \frac{L}{K}\right)\gamma K + \left(\frac{a_{LX}}{a_{KX}} - \frac{L^*}{K^*}\right)K^*}$$

Since the numerator is positive (the endowment ratios are within the diversification cone), the sign of the value of Home of imports of X depend upon the relative factor endowments. Since Home is relatively K-abundant, the numerator is positive. Given trade balance, Home's imports of X must be matched by its exports of Y, so we have the Heckscher-Ohlin theorem (in value terms), namely, K-abundant nation is a net importer of the L-intensive good and net export of the K-intensive good.

Here the Stolper-Samuelson theorem is that a rise in the price of the K-intensive good will raise r more than proportionally and w will fall. This can be seen from log differentiation of (3). This yields:

$$\frac{dr}{r} = \frac{p_Y a_{LX}}{p_Y a_{LX} - p_X a_{LY}}\left(\frac{dp_Y}{p_Y}\right)$$

Since the term in brackets is positive and greater than unity, we see that r must rise with p_Y and more than proportionally. Of course, if r is to rise and p_X is to stay equal to unity, then we know that w must fall. The Rybczynski theorem is that a rise in a nation's endowment of K will raise its production of the K-intensive good more than proportionally and will lower its production of the other good. This can be seen from log differentiation of (5) following an analogous procedure as in the previous theorem.

[6] See the Maple file 4Theorems.ms for calculations.

2.3. Some normalisations

The preceding equations use the classic notation. To reduce the notational clutter in the expressions that follow, we choose – without loss of generality – units for X and Y such that $a_{KX}=a_{KY}=1$ and then we introduce the lambda notation for the L/K ratio in each sector, i.e.:

$$a_{KX} \equiv a_{KY} \equiv 1, \qquad \frac{a_{LX}}{a_{KX}} \equiv \lambda_X > \lambda_Y \equiv \frac{a_{LY}}{a_{KY}}$$

and we choose units of low-skilled labour L and high-skilled labour K such that the world supply of each is unity. Home's endowment of L and K are s_L and s_K, while that of Foreign are $1\text{-}s_L$ and $1\text{-}s_K$. Thus the endowment ratios are:

$$\frac{L}{K} \equiv \frac{s_L}{s_K} > \frac{1-s_L}{1-s_K} \equiv \frac{L^*}{K^*}$$

With this notation, expressions (3) and (5) become:

(10)

$$w = \frac{1-p_Y}{D}, \quad r = \frac{p_Y\lambda_X - \lambda_Y}{D}, \quad w^* = \frac{1-p_Y}{D\gamma}, \quad r^* = \frac{p_Y\lambda_X - \lambda_Y}{D\gamma}$$

$$X = \frac{s_L - \lambda_Y s_K}{D}, Y = \frac{\lambda_X s_K - s_L}{D}, X^* = \frac{(1-s_L) - \lambda_Y(1-s_K)}{D\gamma}, Y^* = \frac{\lambda_X(1-s_K) - (1-s_L)}{D\gamma}$$

where D, a mnemonic for denominator, is positive since X is L-intensive, i.e.:

$$D \equiv \lambda_X - \lambda_Y > 0$$

Note that this notation, these normalisations and the assumptions regarding factor intensities and factor abundances together imply:

$$\frac{\lambda_Y}{\lambda_X} < p_Y < 1$$

3. NEW PARADIGM: TRADE IN TASKS

We modify the model to introduce the possibility of trade in tasks à la GRH as well as trade in goods. We presume that production of X and Y involves a set of 'tasks'. Thus far, we have assumed that the tasks are bundled into the X and Y sector production functions due to prohibitive coordination costs of separating them spatially; thus they must all be undertaken in the same 'factory'. Since all tasks are always undertaken in the same factory, there was nothing to be gained from being explicit about the tasks. One only has to look at how much L and K are necessary to make a good. This is what is done in traditional trade theory. Once the coordination costs fall enough, however, firms may find it economical to separate tasks spatially and undertaking some tasks in the other nation. GRH define this 'trade in tasks' as offshoring.

To determine which tasks are offshored, it is necessary to be explicit about the coordination costs and the nature of tasks. GRH work with a continuum of tasks that involve only L, and another continuum of tasks that involve only K. Here we relax the extreme factor intensive assumptions somewhat by abandoning the continuum of task. Specifically, we assume that the production of X involves three tasks, X1, X2 and X3. Each of these uses some K and some L. The individual tasks are not equally easy to separate spatially from the other two tasks. We assume that it costs 'χ' per unit (a mnemonic for 'coordination cost') to spatially separate an individual task from the other two and we assume that χ varies according to the task. It costs $\chi(X1)$ per unit to undertake task X1 in a different nation when tasks X2 and X3 remain in the other. Likewise, the cost of offshoring tasks X2 individually and X3 individually are $\chi(X2)$ and $\chi(X3)$. The form of these offshoring costs is chosen to reduce the general

equilibrium complexities. Specifically, we assume that it takes more K and L to perform each task when it is offshored with the increased factor requirements rising proportionally for the K and L inputs. Thus it is as if the offshoring causes a general deterioration in the production technology.

Formally we decompose the unit input coefficients from the previous section into task-specific requirements. Taking a_{LX} and a_{KX} as examples:

(11) $$a_{LX} \equiv a_{LX}(1) + a_{LX}(2) + a_{LX}(3), \qquad a_{KX} \equiv a_{KX}(1) + a_{KX}(2) + a_{KX}(3)$$

The coefficients for Y production are decomposed into task requirements in an isomorphic manner. The three Y-sector tasks, Y1, Y2, Y3 are also associated with coordination costs χ(Y1), χ(Y2) and χ(Y3). Without loss of generality we order the tasks such that task X1 is the cheapest to offshore, X2 the next cheapest and X3 the most expensive. We impose an isomorphic ordering on Y-sector tasks. Note that we could have included sector specific tasks here, but it would change none of the subsequent analysis so we omit it for clarity's sake.

We have assumed that the offshoring costs reflect the cost of coordinating task X1 with X2 and X3. Presumably, it is much easier to do the coordination when all the tasks are done inside the same firm. While it is possible to model this decision more precisely, doing so would make it difficult to compare trade-in-tasks with traditional trade in goods, so we introduce an extra set of coordination-cost parameters that simplify the problem. We assume that the cost of coordinating the three tasks is much higher when the tasks are performed in separate firms. Thus, it costs χ(X1) to offshore task X1 to Foreign when tasks X2 and X3 are undertaken by the same firm in Home, but is costs ζ(X1) to coordinate the three tasks when task X1 is done in a separate firm from task X2 and X3 – and this regardless of whether they are undertaken in the same nation. For the time being, we assume that the ζ's are sufficiently high to make inter-firm trade in tasks uneconomical (we relax this assumption later on). Thus even if Home firms offshore task X1 to Foreign, they will not supply task X1 to Foreign X producers.[7]

Now consider the issue of whether offshoring a particular task would be economical for a Home firm. Following GRH, we assume that a Home firm gets to use Home technology in the Foreign nation when it offshores a task to Foreign. Thus, the decision to offshore a particular X-sector task will revolve around the inequality:

(12) $$wa_{LX}(i) + ra_{KX}(i) > \frac{wa_{LX}(i) + ra_{KX}(i)}{\gamma}\chi(Xi) \qquad \Leftrightarrow \qquad \gamma > \chi(Xi)$$

Deviation analysis

To find conditions under which GRH-offshoring (i.e. trade in tasks) will occur once we move away from autarky, we examine the problem facing an atomistic Home X producer that is considering offshoring tasks, when no offshoring is yet occurring. Since no offshoring has occurred in this thought-experiment, but trade in goods is free, the analysis from the previous section implies that the low- and high-skill wage gap will be γ (i.e. w=w*γ and r=r*γ). Given this, the task X1 will be offshored only if $\gamma > \chi(X1)$, that is to say, that the wage gap exceeds the offshoring cost.

Many cases can arise since the firm might want to offshore tasks X1 and X2, or X2 and X3, or X1 and X3, or even X1, X2 and X3. To work through all of these, we would have to detail the coordination costs of each proposed bundle. Since the purpose here is to illustrate the fact that trade in tasks leads to some outcomes that are very different than those obtained we only trade in goods occurs, we discipline

[7] GRH simply assume that the offshore production in Foreign can only be sold to Home-based firms (this is implicit in their un-numbered employment condition below their expression 11). This assumption is not necessary for their main results, but it simplifies their analysis.

the range of cases by making restrictive assumptions. Specifically, we assume that when trade in goods and tasks is allowed, all trade in goods and tasks is free but coordination costs imply that offshoring is expensive. In particular, we assume that:

(13) $$\chi(X3) > \chi(X2) > \gamma > \chi(X1)$$

and that the same ordering holds for tasks Y1, Y2 and Y3.

Given this simplifying assumption, the atomistic Home firm would find it profitable to offshore task X1 to Foreign. Moreover, an atomistic Home firm in the Y sector would also find it profitable to offshore tasks Y1 to Foreign. Of course, other firms would follow and the re-organisation of work would change prices, wages, production patterns and trade patterns. We turn to working out the new international equilibrium with free trade in tasks and goods.

Note that Foreign firms would never offshore to Home since this would involve combining inferior technology with expensive factors of production.

3.1. Free trade in goods and tasks

Given this elaboration of coordination costs, the pricing equations for Foreign are unaltered by the offshoring (Foreign firms continue to use Foreign technology and Foreign labour as before). The pricing equation for the Home sectors, however, would be altered since they can now make both X and Y more cheaply. Specifically using the streamlined notation from above:

(14)
$$1 = (\lambda_X - a_{LX}(1))w + r + a_{LX}(1)w^*; \quad p_Y = (\lambda_X - a_{LY}(1))w + r + a_{LY}(1)w^*$$
$$1 = \gamma(\lambda_X w^* + r^*); \qquad p_Y^* = \gamma(\lambda_Y w^* + r^*)$$

Here we have made an assumption that simplifies the expressions, namely that, tasks X1 and Y1 use only low-skilled labour, i.e. $a_{KX}(1)=a_{KY}(1)=0$. For this reason, the a_{Kj}'s are not altered by offshoring. Moreover, we assume that $\chi(X1)=\chi(Y1)=0$ while the coordination costs for offshoring all other tasks are prohibitive. The employment equations are:

(15)
$$s_L = (\lambda_{LX} - a_{LX}(1))X + (\lambda_{LY} - a_{LY}(1))Y; \qquad s_K = X + Y$$
$$1 - s_L = \gamma(\lambda_{LX} X^* + \lambda_{LY} Y^*) + a_{LX}(1)X + a_{LY}(1)Y; \qquad 1 - s_K = \gamma(X^* + Y^*)$$

The solutions to (15) are:

(16)
$$X = \frac{s_L - (\lambda_Y - a_{LY}(1))s_K}{D - A}, \qquad Y = \frac{(\lambda_X - a_{LX}(1))s_K - s_L}{D - A}$$
$$X^* = \frac{(\lambda_Y - 1)A + D(s_K(\lambda_Y - a_{LY}(1)) + 1 - s_L - \lambda_Y(1))}{\gamma D(D - A)}$$
$$Y^* = \frac{(1 - s_K)D(D - A) - ((\lambda_Y - a_{LY}(1))s_K + 1 - s_L - a_{LY}(1))D + (1 - \lambda_Y)A}{\gamma D(D - A)}$$

where

$$A \equiv a_{LX}(1) - a_{LY}(1)$$

In general offshoring could generate a factor-intensity reversal; we assume away the possibility by imposing the regularity conditions D-A>0. We assume this condition holds throughout. The wages are the solution to the pricing equations in (14), namely:

(17)

$$w = \frac{\gamma D - A}{\gamma(D-A)}\left(\frac{1-p_Y}{D}\right), \qquad r = \frac{(p_Y\lambda_X - \lambda_Y)\gamma(D-A) + (\gamma-1)(1-p_Y)(Da_{LX}(1) - A\lambda_X)}{\gamma D(D-A)}$$

$$w^* = \frac{1-p_Y}{D\gamma}, \qquad r^* = \frac{p_Y\lambda_X - \lambda_Y}{D\gamma}$$

where the equilibrium p_Y is the solution to the market clearing condition (this is easily calculated but the expression is too complex to be revealing).

Cross-sector similarities in tasks

One aspects stressed in the Princeton paradigm is the similarity of tasks across sectors. Offshoring, when it occurs, is likely to affect similar tasks in different sectors. This will be reflected in a similarity between the labour requirement in task X1 and Y1. There are two natural assumptions: that task X1 and Y1 use the same amount of L, or that they involve labour inputs that are proportional to their original labour input. In our notation the two assumptions are:

$$A = 0, \qquad A = \delta D; \qquad 0 < \delta \leq 1$$

where $\delta<1$ is the proportion by which the λ's are reduced. Of course, many other assumptions on $a_{LX}(1)$ and $a_{LX}(2)$ are conceivable and we consider them in Section 4.

3.2. Production and trade effects

To focus sharply on the difference that trade in tasks makes, we begin with a special case where there would be no trade in a standard trade-in-goods model. Specifically, we assume for the moment that Home and Foreign have identical endowment ratios, i.e. s_L equals s_K. The Heckscher-Ohlin theorem, expression (9), tells us that there should be no trade in goods. For convenience we re-write (9) with our normalisation and this yields:

(18)

$$M_X^{HO} = \frac{(s_K - s_L)\alpha}{\gamma(\lambda_X - \frac{s_L}{s_K})s_K + (\lambda_X - \frac{1-s_L}{1-s_K})(1-s_K)}$$

Under the standard trade-in-goods paradigm, $s_L=s_K$ implies no trade in X and therefore no trade in Y. When trade in tasks is allowed, it is simple to show that Home imports of X and Y are:[8]

(19)

$$M_X = \frac{a(\gamma-1)s_K(1-s_K)\alpha/\gamma \quad - \quad \alpha(s_K - s_L)}{s_L(\gamma-1)(\frac{s_K}{s_L}(a-\lambda_X)+1) \quad + \quad 1-\lambda_X} - a\frac{s_K}{\gamma D}$$

$$M_{Y1} = aYw^*, \qquad M_{X1} = aXw^*$$

where we have taken the case of A=0 and defined the common labour saving as $a=a_{LX}(1)= a_{LY}(1)$, to reduce the expressions' clutter; the expressions for X, Y and w* in the second row are given in (16) and (17).

Expression (19) shows how the trade-in-tasks alters the pattern of trade. There are four salient points:

1. Trade. By inspection of the top row of (19), we see that the possibility of trade-in-task alters the Heckscher-Ohlin theorem.

Three special cases are useful in illustrating the impact of trade in tasks on the trade pattern. Consider first the case where nations have identical endowment ratios, i.e. $s_L=s_K$. In this case, inspection of (19) shows that M_X need not be zero. To put it differently, if trade in tasks was

[8] See calculations in the Maple file 4Theorems.mw.

happening, but one ignored it, data on this sort of economy would seem to violate the Heckscher-Ohlin theorem. Consider next the case of a=0, i.e. offshoring is not possible (there is no L-saving to be had). In this case, inspection reveals that the expression for M_X in (19) reverts to the standard HO expression in (18). Finally, note that if γ tends to 1, i.e. the technology gap disappears, then inspection reveals that M_X in (19) reverts to the expression in (18).

2. Intra-industry trade. There is intra-industry trade in the X-sector in the sense that Home is a net exporter of X, but it imports some X-sector 'components' from Foreign, namely the output of task X1. If this output were an intermediate good, we would have the technologically backward nation exporting parts and components while the technologically advanced nation exported final goods. The second row of (19) shows this (we have not written out the expressions for w* and X to reduce clutter).
3. Missing trade puzzle. If one ignored the distinction between trade in goods and tasks, testing the Hechscher-Ohlin-Vaneck theorem would involve the net trade in X and Y with the econometrician most likely using the average unit input coefficients for each sector to generate the implicit factor content of trade. This would result in the appearance of a 'missing trade' puzzle since this procedure would systematically underestimate the labour content the Home import vector. Of course, if one uses the correct technology coefficients, the Heckscher-Ohlin-Vaneck theorem holds in this economy.

Intuition

These results might seem strange from a Heckscher-Ohlin perspective when one thinks only of trade in goods. The results, however, are quite obvious viewing trade-in-tasks as 'shadow migration'.[9] Specifically, the employment equations can be re-arranged to show that trade in tasks is identical to moving some Foreign unskilled labour to Home (but paying them w*). Thus, (15) can be written as:

$$\textbf{(20)} \qquad \begin{aligned} & s_L + \Gamma = a_{LX} X + a_{LY} Y\,; \qquad s_K = X + Y \\ & 1 - s_L - \Gamma = \gamma\left(a_{LX} X^* + a_{LY} Y^*\right); \qquad 1 - s_K = \gamma\left(X^* + Y^*\right) \\ & \text{where} \\ & \Gamma \equiv a_{LX}(1) X + a_{LY}(1) Y \end{aligned}$$

where Γ is the 'shadow migration' implied by trade in tasks. These reformulations of the employment conditions provide a pivot for the intuition on how trade in tasks can create trade and an intuitive analysis of the production effects based on the Rybczynski theorem. (If we had allowed the coordination costs χ(X1) and χ(Y1) to be non-zero, the Foreign decrease in L would remain as Γ but Home's rise in L would be less than Γ.)

The shadow migration of Γ units of L from Foreign to Home engenders a Rybczynski effect in both nations. X production rises in Home and falls in Foreign, with the opposite occurring for Y production. Starting from the simple case of identical factor endowment ratios, the shift in production would make Home an exporter of X and an importer of Y, in addition to Home's imports of the task X1 and Y1 outputs.

[9] This insight is clear in Jones (1965 p. 568): "… technological change, through its impact in reducing input coefficients, has precisely the same effects on the system as would a change in factor endowments."

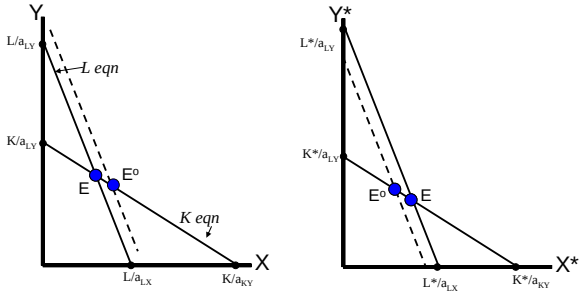

Figure 2: Offshoring's impact on production patterns

The argument is facilitated by Figure 2. The diagrams plot the L and K employment equations for the two nations. The Home's solution is given in the left panel; point E shows the pre-offshoring equilibrium production pattern since it is the combination of X and Y where both Home employment conditions hold. The impact of offshoring on Home is like an increase in Home's unskilled-labour force. In the diagram this shows up as a shift out in the L-employment condition (marked as L eqn) and the new equilibrium, E^o, involves an increase in X production and decrease in Y production. In other words, Home reduces its production of its export good and increases its production of its import good.

In Foreign, offshoring means that some L* is now devoted to task 1 production for the Home country. In the diagram, the production point shifts to E^o. As per the Rybczynski theorem, this involves a decrease in Foreign production of the L-intense good, X, and an increase in the K-intense good, Y. As with the Home, the offshoring expands production in Foreign's import competing sector and shrinks its export-sector production. Since the Rybczynski effects are stronger in the technologically advanced nation, the overall effect is that world X production rises at the expense of Y production.

Turning to the more general case where an HO motive trade exists (i.e. $s_L \neq s_K$), we get an additional result. Supposing that the technologically advanced Home nation is also K abundant (i.e. $s_L < s_K$), the pre trade-in-tasks situation would involve Home exporting Y and importing X. Starting from this case, trade in tasks would dampen trade in final goods since Home shifts its production away from its export good Y and towards its import good X. The opposite occurs in Foreign. That is to say, in this case, trade in tasks is a substitute for trade in goods, much in the way Mundell characterised trade in factors as a substitute for trade in goods. Of course, if it were the K-intensive tasks that were the easiest to offshore, then the opposite would occur since trade in tasks would be like a shift in Foreign high-skilled labour to Home and this would engender the opposite Rybczynski effects. In this case, trade-in-tasks would be a complement to trade in goods.

3.3. Price effects

As it turns out, the factor-price and good-price effects are easier to analyse, so we can conduct the reasoning with general values for $a_{LX}(1)$ and $a_{LY}(1)$. To isolate the price effects of trade in tasks, it proves convenient to re-write the factor price expressions using the pre trade-in-tasks w and r. Re-writing (17):

(21) $$w = w_{HO} + \left(\frac{w_{HO} - w^*_{HO}}{D - A}\right)A, \qquad r = r_{HO} + \left(\frac{w_{HO} - w^*_{HO}}{D - A}\right)\left(\frac{a_{LY}(1)}{a_{LX}(1)} - \frac{\lambda_Y}{\lambda_X}\right)\lambda_X a_{LX}(1)$$

where the subscript 'HO' indicates the pre trade-in-tasks values given in (10). Observe that trade-in-tasks has no direct effect on Foreign wages since the Foreign pricing equations are unaffected, see (14) and (17), although of course the change in p_Y would lead to the standard Stolper-Samuelson effects. To

focus on what is new with trade in tasks, we control for the Stolper-Samuelson effects by taking p_Y as given in this section.

Inspection of (21) provides intuition for the price effects of allowing trade in tasks. There are three key findings to highlight.

- First, expression (21) shows that the use of Home's superior technology with Foreign's cheap labour creates rents that accrue entirely to the Home nation. In the expression these are proportional to the difference between the Home pre-offshoring wage and the Foreign pre-offshoring wage.
- Second, the general equilibrium incidence of the Home gain depends upon the relative L-saving involved in the offshoring of task X1 and Y1. To see this, consider the two polar cases, A=0 (i.e. the amount of L-saving is the same in the two sectors) and A=δD (i.e. the amount of L-saving in the two sectors is proportional to the original labour usage, so the L-intensive sector saves more). When A=0, (21) shows us that all of the gains go to human capital; w equals its pre trade-in-tasks level, but r exceeds its pre trade-in-task level by an amount that is proportional to the pre trade-in-tasks wage gap between Home and Foreign. When A=δD, all the gains go entirely to low-skilled labour; r equals it pre trade-in-task level while w exceeds it by an amount proportional to the efficient gain accruing from the technology transfer (this what GRH call the 'productivity' effect).
- Third, the preceding analysis refines the GRH finding that the general equilibrium incidence of offshoring L-intensive tasks is unambiguously good for L. In particular, it shows that the general equilibrium incidence of the efficiency may not fall on Home high-skilled workers. When the L-saving is equal in the two sectors (i.e. A=0), L does not gain from offshoring L-intensive tasks; rather it is the Home capital owners that win.

Intuition

The intuition for these general equilibrium wage changes is easily illustrated when we view GRH-offshoring as L-saving technological progress. Re-arranging the pricing equations in (14) as:

(22)
$$1 = \Lambda_X w + r\,; \qquad p_Y = \Lambda_Y w + r$$
$$1 = \gamma\,(\lambda_X w^* + r^*); \qquad p_Y^* = \gamma\,(\lambda_Y w^* + r^*)$$

where the Λ's are defined as:

$$\Lambda_X \equiv (\frac{w^*}{w}) a_{LX}(1) + a_{LX}(2) + a_{LX}(3), \quad \Lambda_Y \equiv (\frac{w^*}{w}) a_{LY}(1) + a_{LY}(2) + a_{LY}(3)$$

and

$$\frac{w^*}{w} = \frac{A + D}{\gamma D + A}$$

form the general expression for w*/w; see (17). Using this insight, the general equilibrium effects are simple to derive using Figure 3 which plots the two pricing equations for Home in w-r space. The intersection, E, defines the pre-offshoring equilibrium wage rates, w and r. As shown in (22), offshoring of the L-intensive X1 and Y1 tasks acts like L-saving technological progress in both sectors and this shows up as reductions in the a's in the diagram and thus changes in the Y-axis intercepts. If the L-input requirements shift up proportionally as in the case of A=-δD, then r is unaffected but w rises. If A=0, then the L-input requires shift up by the same amount. These two outcomes correspond to the points E" and E', respectively.

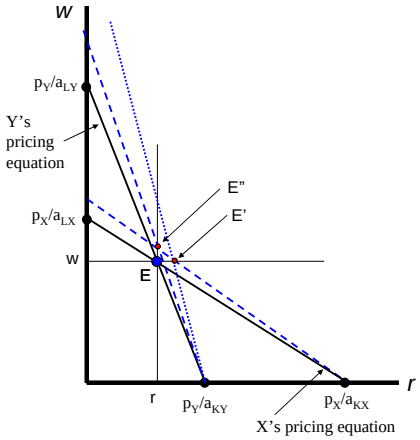

Figure 3: Wage effects of trade in tasks

It is simple to consider more general cases of the relative L-savings implied by offshoring. Differentiating the expression for w in (3) with respect to a_{LX} and a_{LY} yields:

(23) $$dw = \left(\frac{da_{LX}}{a_{KX}} - \frac{da_{LY}}{a_{KY}} \right) \left(\frac{a_{KX} a_{KY}}{a_{KY} a_{LX} - a_{KX} a_{LY}} \right)$$

Since the second term in large brackets is negative given factor intensities, this says that offshoring (which lowers the a_{Lj} in both sectors) raises the low-skill wage, if and only if it lowers the gap between the labour-capital ratios in the L-intensive versus H-intensive sectors (i.e. the gap $a_{LX}/a_{KX} - a_{LY}/a_{KY}$ must fall).

The salient points from this analysis are:

- Missing Factor Price Equalisation puzzle. Trade in tasks leads to a divergence of factor prices between the nations, with the technologically superior nation widening its wage gap with respect to the backward nation. If one ignored the distinction between trade in tasks and trade in goods, data on this sort of economy would seem to violate the Factor Price Equalisation theorem.
- Ambiguity of the general equilibrium incidence. Although offshoring never changes Foreign wages in this setup, its impact on Home wages depends upon the details of the L-saving.
- Wage changes increase with magnitude of offshoring. The size of the wage changes increase with the extent of L-saving from offshoring as measured by the change in the a_{Lj}'s.

It is also worth noting that from the perspective of trade in goods, it would appear that trade was stimulating technology transfer and productivity gains. In fact, it is the other way around. Technology transfers stimulate trade in tasks and produce productivity gains. Again, without detailed knowledge of the trade in tasks, the technologic transfer might appear to be producing productivity gains since the two nations are have identical technology at the level of goods.

4. EXTENDING THE BASIC MODEL

In this section, we extend the basic model in three directions. First, we allow for more general factor intensity assumptions on the offshored tasks. Second, we relax the assumption on inter-firm trade in tasks that prohibited Home firms from selling the offshored task to Foreign firms. Third, we allow for

Ricardian differences among nations and show that this can result in the two-way offshoring that is so commonly observed among OECD nations.

4.1. Local sales of offshored tasks: sharing the rents

The analysis above assumed that the cost of coordinating tasks across firms was prohibitive, so Foreign X and Y producers continued to use the inferior technology despite the presence of efficient task X1 and Y1 producers in the Foreign nation. Here we relax this by assuming the inter-firm coordination costs ζ(X1) and ζ(X1) are zero. In this case, the offshoring Home firms would also supply X1 and Y1 to Foreign producers. This would change the pricing equations to:

(24)
$$1=\Lambda_X w+r\,; \qquad p_Y=\Lambda_Y w+r$$
$$1=\gamma\,(\Lambda_X^* w^*+r^*); \qquad p_Y^*=\gamma\,(\Lambda_Y^* w^*+r^*)$$

where, recalling that the $a_{KX}(1)$'s are zero,

$$\Lambda_X^* \equiv (\frac{1}{\gamma})a_{LX}(1)+a_{LX}(2)+a_{LX}(3), \quad \Lambda_Y^* \equiv (\frac{1}{\gamma})a_{LY}(1)+a_{LY}(2)+a_{LY}(3)$$

and the Λ's are as in (22). The employment equations in this case are:

(25)
$$s_L+\Gamma=a_{LX}X+a_{LY}Y\,; \qquad s_K=X+Y$$
$$1-s_L-\Gamma=\gamma\left(a_{LX}^{'}X^*+a_{LY}^{'}Y^*\right); \qquad 1-s_K=\gamma\left(X^*+Y^*\right)$$

where

$$\gamma a_{LX}^{'} \equiv \gamma\left(a_{LX}-(1-1/\gamma)a_{LX}(1)\right); \quad \gamma a_{LY}^{'} \equiv \gamma\left(a_{LX}-(1-1/\gamma)a_{LY}(1)\right)$$

Γ is defined as in (20).

$$\Lambda_X \equiv (\frac{w^*}{w})a_{LX}(1)+a_{LX}(2)+a_{LX}(3), \quad \Lambda_Y \equiv (\frac{w^*}{w})a_{LY}(1)+a_{LY}(2)+a_{LY}(3)$$

Solving (27) and rewriting the solution in terms of the efficient gain as in (21), we have:[10]

(26)
$$w=w_{HO}+\gamma\left(\frac{(w_{HO}-w_{HO}^*)}{\gamma(D-A)+A}\right)A, \qquad r=r_{HO}+\gamma\left(\frac{(w_{HO}-w_{HO}^*)}{\gamma(D-A)+A}\right)\left(\lambda_X a_{LY}(1)-\lambda_Y a_{LX}(1)\right),$$
$$w^*=w_{HO}^*+\left(\frac{(w_{HO}-w_{HO}^*)}{\gamma(D-A)+A}\right)A, \qquad r^*=r_{HO}^*+\left(\frac{(w_{HO}-w_{HO}^*)}{\gamma(D-A)+A}\right)\left(\lambda_X a_{LY}(1)-\lambda_Y a_{LX}(1)\right)$$

From this is it immediately apparent that the efficiency gain is shared between Home and Foreign factors. Moreover, the determinants of the division of rents between high-skilled and low-skilled labour are quite similar to those when arm's-length sales of X1 and Y1 were uneconomical. Importantly, the international division differs only by γ. For example, if Home L gains, then so does Foreign L, but by less.

The combination of Home's superior technology with cheap Foreign factors creates efficiency gains as in the model above, however here the rents are shared between Home and Foreign factors. The solutions of (25)

[10] See the Maple file 4Theorems.ms

Given the analysis above, it is obvious that this implies that some of the efficiency gains from offshoring will be shared with Foreign low- and high-skilled workers in the sense that all four wage rates could potentially rise from offshoring. The general equilibrium incidence will depend upon the relative shifts in the a_{Lj}'s in a manner isomorphic to the one studied above.

4.2. Offshoring tasks with non-extreme factor intensity

The impact of offshoring was simple to calculate since we assumed that the offshored tasks involved only low-skilled-intensive tasks. Just by re-labelling, we could show that similar trade, production and price effects would occur if by contrast we made the diametrically opposed assumption that all offshoring involves high-skill intensive tasks. Specifically, we would still find that trade in tasks was like 'shadow migration' but the shadow migration from Foreign to Home would involve H rather than L. The Rybczynski effects would therefore be reversed and Home would shift its production into Y and out put X, with the opposite happening in Foreign. If was started from the benchmark case of the technologically advanced nation also being H-abundant, the trade in tasks would magnify trade in goods since it would push each nation towards its export sector. In this case, trade in tasks would seem to be a complement to trade in goods, rather than a substitute.

(27)

$$1 = a_{LX} w + a_{KX} r; \qquad p_Y = a_{LY} w + a_{LY} r$$
$$1 = \gamma\,(a^*_{LX} w^* + a^*_{KX} r^*); \qquad p^*_Y = \gamma\,(a^*_{LY} w^* + a^*_{KY} r^*)$$

where

$$a^*_{LX} \equiv (\frac{1}{\gamma}) a_{LX}(1) + a_{LX}(2) + a_{LX}(3), \quad a^*_{LT} \equiv (\frac{1}{\gamma}) a_{LY}(1) + a_{LY}(2) + a_{LY}(3)$$

On the price side, world production of Y would rise and its price would fall, and the offshoring would look like H-saving technological progress in both Home sectors. This would produce the standard Stolper-Samuelson effects of wages in both nations, but these could be altered by the general equilibrium incidence of the H-saving technology changes. As above, the incidence would depend upon the relative changes in the input coefficients as in Figure 3.

More generally, offshoring tasks X1 and Y1 will involve a combination of L and H savings. Analysis of this general case is simple. Assuming that tasks X1 and Y1 involve some L and H, then offshoring X1 and Y1 will change all of Home's a_{ij}'s. The general equilibrium incidence of this general technological change on w and r flows straight from Jonesian algebra. Totally differentiating the Home's employment and pricing equations from (2) and (4) with respect to the a_{ij}'s, we have:

$$\hat{p}_X + \hat{\pi}_X = \theta_{LX}\hat{w} + \theta_{KX}\hat{r}; \qquad \hat{p}_Y + \hat{\pi}_Y = \theta_{LY}\hat{w} + \theta_{KY}\hat{r}$$

where

$$\hat{\pi}_X = -(\theta_{LX}\hat{a}_{LX} + \theta_{KX}\hat{a}_{KX}); \qquad \hat{\pi}_Y = -(\theta_{LY}\hat{a}_{LY} + \theta_{KY}\hat{a}_{KY})$$

The π's are measures of sector-specific factor saving weighted by cost shares. Solve for the impact on w and r, we have:

$$\hat{w} = \frac{\hat{\pi}_X\theta_{KY} - (\hat{p}_Y + \hat{\pi}_Y)\theta_{KX}}{\theta_{LX}\theta_{KY} - \theta_{LY}\theta_{KX}}, \qquad \hat{r} = \frac{(\hat{p}_Y + \hat{\pi}_Y)\theta_{LX} - \hat{\pi}_X\theta_{LY}}{\theta_{LX}\theta_{KY} - \theta_{LY}\theta_{KX}}$$

Since the denominators are positive (X is L-intensive), the signs of the general equilibrium incidences on w and r depend upon the sign of the numerators. Ignoring terms of trade effects for clarity's sake,

we see that w rises if and only if $(\hat{\pi}_X / \theta_{KX}) > (\hat{\pi}_Y / \theta_{KY})$, in other words if a factor-share weighed measure of factor saving is greater in the X sector than in the Y sector. A similar result applies to the impact on r. Moreover, we have the standard magnification chain $\hat{w} > \hat{\pi}_X > \hat{p}_Y + \hat{\pi}_Y > \hat{r}$ since the weighted technological change enters the Jonesian algebra in a way that is isomorphic to that of price changes.

The production effects are also easily worked out using the Rybczynski theorem and our knowledge of the H-versus-L composition of the labour savings from offshoring. The general equilibrium effects could be traced out using the Figure 3 analysis and our knowledge of the extent to which the offshoring altered the a_{Lj}'s and a_{Kj}'s.

One interesting special case is where all coordination costs are zero so that all tasks are offshored and Home's superior technology completely displaces Foreign's technology. In this case, the outcome would be exactly like a technology transfer from Home to Foreign that brought the Foreign economy to the technology frontier. The wage effects in this case would be extreme. There would be no change in Home wages and a rise in the Foreign wages to Home levels.

4.3. Intra-industry two-way offshoring[11]

To focus on the essential differences between trade in goods and tasks, it proved convenient to eliminate Ricardian motives for trade by assuming that the international technology differences were of the Hicks neutral type. One result of this assumption was that Foreign never offshored tasks to Home. The extensive empirical literature on fragmentation, however, documents the importance of two-way trade in parts and components, which is the goods version of trade in tasks. There is also a much less extensive empirical literature on trade in services task, i.e. service sector offshoring. Again, two-way services trade seems to be an important aspect in the data.

Here we modify the basic model in a way that creates two-way, intra-industry offshoring. We shall do so in a highly specific model. As the analysis above made clear, there are a wealth of cases that could be considered (e.g. various combinations of factor abundance and technology superiority, factor intensity of the offshored tasks, etc.). However it is not really necessary to formally consider all the cases. Most of the cases can be dealt with simply using the two core intuitions: (1) that trade in tasks can be viewed as 'shadow migration' of factors as far as the production effects are concerned so we can use the Rybczynski theorem to work out the production effects, and (2) that trade in tasks can be viewed as technological progress as far as the price effects are concerned so we can use the standard diagram to work out the wage effects.

The model we work with assumes 'mirror image' Ricardian superiority. Home has superior technology in tasks X3 and Y3, while Foreign has superior technology for tasks X1 and Y1. Moreover, we assume that the task-level technological advantages exactly offset each other so that the two nations have the same sector-level unit input coefficients. Formally, we assume:

$$\begin{aligned} & a_{LX} \equiv a_{LX}(1) + a_{LX}(2) + \gamma\, a_{LX}(3), \quad a^*_{LX} \equiv \gamma\, a_{LX}(1) + a_{LX}(2) + a_{LX}(3) \\ \textbf{(28)} \quad & a_{LY} \equiv a_{LY}(1) + a_{LY}(2) + \gamma\, a_{LY}(3), \quad a^*_{LY} \equiv \gamma\, a_{LY}(1) + a_{LY}(2) + a_{LY}(3) \\ & a_{LX} = a^*_{LX}\,, \qquad a^*_{LY} = a_{LY} \end{aligned}$$

As before we measure units of X and Y such that $a_{KX}=a_{KY}=1$ in both nations. Finally, we assume that the nations have the same factor endowment ratios, i.e. $s_L=s_K$.

[11] We would like to thank Toshi Okubo for providing the idea for this section.

Given the analysis above, the outcome allowing trade in goods only is obvious. The two nations will have identical wages and will not trade with each other. Once we allow free trade in tasks – by assuming the coordination costs, the χ's and ζ's, drop to zero, trade occurs.

Specifically, the offshoring will allow Home's superior technology in tasks X1 and Y1 to displace Foreign's technology in these tasks while Foreign's superior technology in tasks X3 and Y3 displace Home's technology.

The production effects are simple to work out. The two-way offshoring is like 'shadow migration' but due to the symmetry we imposed, there is no net shadow migration, so there is no Rybczynski effect in either nation. By contrast, the offshoring (and the fact that tasks can be sold at arm's length among firms, i.e. the ζ's are zero) imply that both nations move to the technology frontier. The technology employed in X and Y production in both nations will be:

$$\textbf{(29)} \qquad \begin{aligned} a'_{LX} &\equiv a_{LX}(1) + a_{LX}(2) + a_{LX}(3) < a_{LX}\ , \qquad \frac{a_{LX}}{a'_{LX}} \equiv \eta > 1 \\ a'_{LY} &\equiv a_{LY}(1) + a_{LY}(2) + a_{LY}(3) < a_{LY}\ , \qquad \frac{a_{LY}}{a'_{LY}} \equiv \eta > 1 \end{aligned}$$

so the two-way offshoring will be isomorphic to an L-saving productivity improvement in both sectors in both nations by the factor η. By inspection of (5), the result will be a rise in X production and fall in Y production in both nations. Given the ex antes symmetry of the nations at the sector level and the ex post symmetry of the nations at the task level, it is clear that there will be no trade in final goods either before or after the freeing up of trade in tasks.

On the price side, the expansion of world X production relative to Y production will raise the relative price of Y and this will have all the standard Stolper-Samuelson effects. The novel effect will be that the two-way offshoring will act like economy wide L-saving technological progress in both nations. By inspection of (3), the general equilibrium incidence of this falls entirely on low-skilled workers. That is, w rises in both nations, but r is unaltered. If one presumed that low-skilled workers earned less than high-skilled workers to begin with, this offshoring would improve the income distribution.

コメント **[RB1]:** ???

As mentioned before, it would be trivial swap the skill and unskilled labels and the result would be the two-way, intra-industry offshoring of skill-intensive tasks would improve the reward to skilled workers without altering that of unskilled workers. If one again presumed that low-skilled workers earned less than high-skilled workers to begin with, this offshoring would improve the income distribution.

Note that the trade in tasks in this model is very much like the trade in goods in Davis (1995) except here the technology is firm-specific, not nation specific, so offshoring firms can bring their superior technology with them.

5. CONCLUDING REMARKS

Globalisation can be thought of as a great unbundling, two in fact. Roughly speaking, the first unbundled happened when it became economical to places factories a long way from consumers. The second one happened when it became economical to unbundled tasks the used to be performed within factories and offices. Trade theory was developed to think about the first unbundling. The second unbundling – variously called fragmentation, offshoring, vertical specialisation and slicing up the value-added chain – is the subject of the new paradigm.

This paper explored what is really new in the new paradigm and how it fits in with standard HO theory. We showed that GRH-offshoring can create trade when there is no HO or Ricardian reason for nations to trade. Moreover, the resulting trade is not just trade in tasks; the offshoring also produces general equilibrium effects that cause nations to trade in goods as well. The magnitude of this trade increases

with the extent of offshoring and the trade is marked by intra-industry trade. Another result is that trade-in-tasks can act either as a substitute or a complement to trade in trades – the result depends upon the factor intensity of the offshored task and the relative factor abundances of the two nations. We argue that one can think of trade in tasks as 'shadow migration' of factors an that this perspective allows one to work out the production effects using the Rybczynski theorem. Finally, the result trade is marked Trefler's famous 'puzzle of missing trade'

On the price side, our findings are less novel but we show that the GRH productivity effect does not hold in general and we identify the necessary and sufficient conditions for it to occur in a model that allows tasks to have non-extreme factor intensities (which includes the GRH model). Since trade in tasks acts like skill-based technological progress when it comes to prices, the standard Jones (1965) results on the general equilibrium incidence of technological progress on factor prices can be used to investigate the GRH productivity effect in a more general setting (as far as factor intensities are concerned).

In short, this paper argues that there is a good deal new in the new paradigm. In 1995, Paul Krugman and Tony Venables published a renowned paper that traced out the first unbundling. The paper was widely known by its working title "History of the world, part I" despite being formally entitled "Globalization and the Inequality of Nations." It seems that the GRH paper may be the first in a line of theory that may eventually come to be called "History of the world, part II."

6. REFERENCES

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7. ERASE FROM FINAL DRAFT

Writing the expressions in this fashion makes it obvious that the Rybczynski and Stolper-Samuelson derivatives are stronger in the technologically advanced nation, Home, since $\gamma>1$.[12]

[12] Note that the elasticities of factor prices with respect to good prices are the same in both countries. Therefore, since Home factor prices are γ times those in Foreign, any change in p_Y triggers a correspondingly magnified response in Home by comparison to Foreign's.