1. The Application of Toy Economic Models to the Analysis of Globalization

by Christopher Bliss[1]

ABSTRACT

A Toy Model is a simple economic model, with no claims to generality. These models are usually constructed for some specific purpose. That was the origin of the famous trade model, the Heckscher-Ohlin-Samuelson (HOS) Model, originally constructed to model Nineteenth Century transatlantic trade. Despite its simplicity, the HOS model is often invoked in discussions of globalization. This paper reviews such applications, including the version of the HOS model promoted by Wood (1994). It is argued that a three-factor two-good toy model with a specific factor in one sector represents a significant improvement on existing toy models for the analysis of globalization.

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[1]Christopher Bliss is at the Department of Economics, Oxford, and Nuffield College, Oxford (christopher.bliss@nuf.ox.ac.uk)

> "With three or more factors of production it is certainly not necessary that the result of trade is to make the ratios of factor prices in the respective countries more closely approach unity. Some may do so, but others may diverge depending upon complicated patterns of complementarity and competitiveness." (Stolper and Samuelson 1941-2, p. 72)

1.1. Introduction

What are the effects of globalization? What is globalization anyway? Most commentators have in mind the consequences of two trends which do describe important aspects of the modern world. These are:

- A growing tendency for poor countries to export into the markets of developed countries.
- An increased mobility of capital, particularly that effected by foreign direct investment (FDI), seeking attractive conditions for production for international markets. Here attractiveness includes, but is not confined to, low wages.

The above bullet items present a highly stylized picture, which needs to be qualified. Thus, while globalization may have increased over the last 40 years, and the pace of its increase may have accelerated recently, the world is arguably less globalized now than it was in 1900. Trade flows from the poorer to the richer countries are large relative to the domestic products of many of the exporters, but never huge as a proportion of rich country imports. The pattern of trade between rich and poor is massively influenced and distorted by rich country protection. Overt protection is large with agriculture and fibres, in particular; but covert (anti-dumping type) protection is important and pervasive.

Similarly, FDI is seen as important when it is viewed from the point of view of specially small poor recipient countries. However viewed from the perspective of rich importing countries it is somewhat marginal, at least so far as poor country exports are concerned. There would certainly be more FDI driven exports from the poor countries if rich-country protection did not resist it.

So what we see in the world is a messy and incomplete globalization. This has not deterred numerous commentators from discussing a world in which globalization has gone all the way. This is either because they can only think in grossly simplified terms (Ross Perot or James Goldsmith), or because they find it convenient to treat simple stylized examples (Adrian Wood and many other economic theorists).

This paper is motivated by the observation that the models frequently employed by international trade theorists are extremely simple, and by the speculation that models not much more complicated might give better and more interesting insights into globalization.

1.2. Why are Trade Models so Simple?

The Heckscher-Ohlin-Samuelson (HOS) 2X2 trade model is the most commonly used model of international trade. Its popularity is explained by the ease with which it may be applied to answer many different questions, and by its great intuitive accessibility. A model which was forged to explain the pattern of trade between the old and new worlds in the nineteenth centuries; and can be readily developed to treat the question of why unions favour protection, the effect of migration on production patterns, and many other questions, is surely a well-made model.

The model yields the following conclusions, all of which figure in at least some discussions of globalization:

- Factor-Price Equalization. If any two countries with access to the same technology and selling at the same prices, produce both goods, their factor prices must be equal[2]. (see Figure 1).

- Magnification. When relative goods prices inside a country alter (perhaps due to a freeing-up of international trade), factor prices will reflect and magnify those changes. If labour intensive imports become cheaper, wages will fall more than proportionately to the change in prices, so that labour will lose even if it only consumes the labour intensive good. (see Figure 2).

- Rybczynski's result. When capital moves into a country which faces fixed world output prices, and produces both goods, and which remains diversified after the capital inflow, there is no fall in the return to capital and no rise in the real wage rate. Rather the capital intensive sector expands, and the labour-intensive sector contracts, accommodating the altered factor supplies at unchanged goods and factor prices.

These are impressive results. Some of them capture visions (or nightmares) of globalization quite effectively. Others surprise and tease the intuition. Thus fears of something like factor-price equalization seem to mirror aspects of labour's protectionist leanings (those which made themselves felt in the Clinton administration's appalling stance at Seattle). On the other hand, Rybczynski's result is not what most people without a training in trade theory would expect. The result makes a connection between factor migration and external trade; obvious once pointed out, but easy to overlook.

All this granted, can such baby models be taken seriously? The truth is that for the most part there are two kinds of economic theory. They are the pure, complicated and general; call that general equilibrium. And there is the silly, little and useful; call that

[2]This result requires the assumption that one sector uses a particular factor more intensely than the other sector at all factor prices. Figure 1 embodies that assumption.

the baby model. General equilibrium models describe the economy in fine mathematical detail, and prove rigorously using powerful topological theorems that an equilibrium exists. The trouble is that from the very general almost nothing follows[3]. As we have seen, baby models, can give strong and definite results. Also they formalize intuitive ideas that people have, and by doing that may throw up problems with what previously seemed obvious.

Some of you may think that the above discussion shows what a poor imitation of a science is economics. To some extent, yes. Yet similar disjunctions are to be seen in physics. Newtonian general gravitation is like general equilibrium theory. It is mathematically precise and complete. Yet by itself it does not tell one very much. If you want to see what the theory can do, you turn to the physics equivalent of baby models. An isolated Earth orbiting the sun on a elliptical path is an approximate observation modelled perfectly by the theory. The trouble is it is only a rough observation, because the Earth does not share the Solar system with the Sun alone. It is part of a hugely complicated many-body system (a general equilibrium system). Using Newtonian mechanics one can write down the equations of this system, but they are beyond solution.

1.3. How Big should the Baby be?

It is reassuring to know that trade models must be small and simple. Yet surely a model can be so oversimplified that it gets the answer badly wrong. Isaac Newton built such a model when he tried to compute the velocity of sound in air, neglecting to take into account that the periodic local contractions of the air, which is a sound wave, cause local heating of the air (Boyle's Law).

Nearly everyone who has been exposed to HOS trade theory has felt worry and dissatisfaction. Which precisely are the two goods? Which are the two factors? What difference do non-tradeable goods make? Are these essentially 2X2 results; or are there higher dimension versions of the same theorems?

Usually HOS results do not carry over into higher-dimension models. An interesting exception is Rybczynski's result, which has exact analogues in very general general equilibrium models. In any case, going beyond 2X2 forces the issue of squareness versus non-squareness. Should the number of factors and goods be expanded in parallel, so that the two values remain equal? A 3X2 model differs from a 2X2 model in a different way from that which separates a 2X2 model from a 3X3 model. Ethier (1984) provides an excellent survey of this eclectic field. For the most part Ethier neglects toy models, that is a simple low dimension model built for a particular purpose, without any pretensions to mathematical generality.

[3] Another approach is provided by computable general equilibrium models (CGE models). These are more complicated than baby models, but their authors eschew the proof of general theorems. Rather the models simulate particular solutions for given numerical values. The major difficulty with the CGE approach is that it is more or less impossible for the outsider to see where an outcome "comes from" or to critically assess a study.

One might say that the HOS model started as a toy model in that sense, but so much has it become the reference model of trade theorizing that it is hard to see it today as the toy model which it was originally.

1.4. Adrian Wood's North-South Trade Model

In a fascinating and influential book, Wood (1994) proposes a model of North-South trade which reduces the analysis to an application of the 2X2 HOS model. He argues that capital is so perfectly mobile in the modern world that it can be neglected for the purpose of explaining comparative advantage differences between nations. That reduces the analysis to the examination of an HOS model with unit cost functions dependent on three factor prices; but one, the cost of capital, is the same in all countries.

Wood's two immobile factors are skilled and unskilled labour. For these factors free(er) trade gives factor-price equalization, or a movement in that direction. Even with the same technology everywhere, there will not be factor-price equalization if trade is not completely free. Also richer countries may have higher productivity of all factors in equal proportion, when relative factor prices can be equalized without absolute equality.

The consequence of opening up more North-South trade is a fall in the wage level of unskilled workers in the North and a rise in the wage of the same type of worker in the South. That would typically mean more inequality in the North, and less inequality in the South.

One problem with Wood's intriguing argument is that the evidence does not provide strong support for the view that capital is perfectly mobile internationally. Therefore it would be distinctly preferable to use a model with three factors: capital, skilled labour and unskilled labour. The problem with following that line straightforwardly is that with a general 2X3 model one loses the nice definite results of a toy model. A fine review of the eclectic results obtainable in higher dimensions is provided by Ethier (1984). Technically interested readers are referred there. Here we adopt a completely different approach. As with Jones (1971), but a bit less special, we build a toy model in which factors enter into goods production in a particular pattern.

1.5. A Special Two-Good Three Factor Model

The model is called the General Three Factor Model (GTFM). In fact it is special, and the term general only appears in its title to distinguish it from an even more special separable version of the model, which permits more definite results. The key feature of the model is the following:

DEFINITION 1. *In the GTFM one factor, called without loss of generality skilled labour, is only used in one of the two production sectors. The other two factors are used in both sectors.*

A particular version of the GTFM was created by the author to analyse the economic consequences of the abolition of the Corn Laws, see Bliss (1998). In that application labour and capital are employed in both agriculture and manufacturing, while land is used only in agriculture. Here it is better to keep in the front of the mind the case in which capital and unskilled labour are used in both a high-tech and a low-tech sector; while skilled labour is only employed in the high-tech sector.

It is most straightforward to work with a particular version of the GTFM, called the STFM. The distinctive feature this case is that the cost of the third factor (the one used in only one sector) enters *separably* into total costs for that sector. That means that the price of this factor has no effect on the relative use of the other two factors.

For the STFM, the following list of results may be derived, and compared directly with the parallel list of results for the HOS model given above. These results are proved in the Mathematical Appendix below:

- Factor-price equalization. Can only come about by chance. Only if two countries have the same price of skilled labour will an argument the same as shown by Figure 1 work. With different prices of skilled labour, two countries can support different rates of profit and different unskilled wages, even if they produce both goods and share the same technology.
  In Jones' model the prices of the two "general factors" move together. Therefore if one country has a higher rate of profit than another, it will also have a higher unskilled wage rate, In the present case that can happen, but it does not have to.

- Magnification. Is observed in the GTFM, at least in the separable case, but now its force is weakened.

- Rybczynski's result. When capital moves into a country which faces fixed world output prices, and produces both goods, and which remains diversified after the capital inflow, there can be a fall in the return to capital. Suppose that the capital inflow tends to expand the high-tech sector. This will push up the wage rate of skilled labour, and that may depress the return to capital.

I feel that the results above are more satisfactory, for the intuition at least, than those derived from the HOS model. For example, any model which predicts factor-price equalization causes some embarrassment, as it is plainly at odds with reality. Similarly, the Rybczynski result goes somewhat against reasonable intuition, and to have it softened can only be welcome. On the other hand, while recognizing that other changes apart from trade liberalization have influenced inequality in developed and underdeveloped countries, I find the Wood account of trade liberalization and inequality to be attractive. For that reason I am pleased that my new toy model preserves the essentials of Wood's account.

1.6. A New Model of North-South Trade

The application of the Toy trade model takes the following specific form. It is the STFM, but now capital and unskilled labour are the factors employed in both sectors; while skilled labour is employed in only one sector - called naturally the high-tech sector (or the H-sector for short). The other sector is the low-tech or L-sector. Relative to the L-sector, the H-sector is assumed to use capital more intensely than unskilled labour.

Even with free trade there will be no factor price equalization, not unless North and South happen to have just the right relative levels of skilled labour to bring about what here can only be a fluke result. Now suppose that the opening up of North-South trade causes the relative price of the L-sector good to fall in the North and to rise in the South. We have seen above that magnification features in the STFM. So because the L-sector uses unskilled labour more intensely than capital, the real return to capital will rise in the North (in terms of either product) and the real wage of unskilled labour will fall (in terms of either product). In the South mirror image movements of factor earnings (in the opposite direction) will be observed.

Because skilled labour is employed in the H-sector, it functions like land in the original discussion of the STFM, and in its application to the Corn Laws. For this reason:

- Magnification is moderated. So the fall in the real wage of unskilled labour is less than it would be in the simple HOS model with just simple labour and capital.

- The wage of skilled labour will rise in the North and will fall in the South. Thus wages of skilled labour in the North will rise relative to wages of unskilled labour (more inequality); and in the South wages of skilled labour will fall relative to wages of unskilled labour (more equality). In terms of qualitative changes, all this is as in Wood's analysis.

It is difficult to compare changes quantitatively between the two models, our own and Wood's. In terms of the two kinds of labour they have different structures. However when we consider a version of Wood's model similar to our own in that skilled labour is used only in the H-sector, useful comparisons may be made.

Concentrate on the North. The relative price of the L-good falls. This raises the real return to capital. In the STFM capital is immobile. In Wood's model the change considered will cause a capital inflow, presumably from countries like the South, where the return to capital has fallen. In HOS theory a capital inflow into a small country has no effect on factor prices (the Rybcyznski effect). In the STFM model such an inflow expands the H-sector, which further raises the real wage of skilled labour and depresses the real wage of unskilled workers in so far as these workers consume the H-good.

Already the results of the STFM are different from those which emerge from an HOS type of model. All the countries of the North together cannot be small. The price changes

considered so far result simply from trade liberalization (say a cut in tariffs). These price changes induce output changes which will normally cause the terms of trade to move in the opposite direction from the price changes induced by freer trade. The more capital mobility there is, the stronger will be the terms of trade buffering of trade liberalization. Therefore the STFM model predicts stronger relative wage changes than would the equivalent Wood model, on account of capital immobility.

1.7. Conclusions

Our simple extension of the HOS trade model has provided a structure which lends itself to useful intuitive analysis, and to relevant applications. The presence of a third factor in one sector undermines the factor-price equalization result and also the simple Rybcyznski property. However Stolper-Samuelson magnification does apply, although its power is moderated.

The model may be used to enrich the treatment of North-South trade pioneered by Wood. Allowing capital to be immobile may make the model more realistic. However Wood's major conclusions concerning the effect of easier trade on wage inequality survive the extension to a three-factor framework.

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1.8. Mathematical Appendix

The HOS model is specified by the equations:

$$c_a\left[r,w\right]=1 \tag{1}$$

$$c_m\left[r,w\right]=p \tag{2}$$

$$y_a\cdot\frac{\partial c_a\left[r,w,q\right]}{\partial r}+y_m\cdot\frac{\partial c_m\left[r,w,q\right]}{\partial r}=K_0 \tag{3}$$

$$y_a\cdot\frac{\partial c_a\left[r,w,q\right]}{\partial w}+y_m\cdot\frac{\partial c_m\left[r,w,q\right]}{\partial w}=L_0 \tag{4}$$

where $c_j\left[r,w\right]$ is the unit cost function for sector j (j=a or m), that is agriculture or manufacturing; r and w are the factor prices in terms of agricultural output of respectively capital and labour; y_j is output in sector j; and K_0 and L_0 are given factor supplies of respectively capital and labour.

Equations (5)-(9) define a model mentioned above which may be called the *General Three-Factor Model* (GTFM). The term general distinguishes this model from a special separable version presented below. The model is not general as such,as the structure of factor inputs is quite particular.

$$c_h\left[r,w,s\right]=1 \tag{5}$$

$$c_l\left[r,w\right]=p \tag{6}$$

$$y_h\cdot\frac{\partial c_h\left[r,w,s\right]}{\partial r}+y_l\cdot\frac{\partial c_l\left[r,w,s\right]}{\partial r}=K_0 \tag{7}$$

$$y_h\cdot\frac{\partial c_h\left[r,w,s\right]}{\partial w}+y_l\cdot\frac{\partial c_l\left[r,w,s\right]}{\partial w}=L_0 \tag{8}$$

$$y_h\cdot\frac{\partial c_h\left[r,w,s\right]}{\partial q}=T_0 \tag{9}$$

where $c_j\left[r,w,s\right]$ is the unit cost function for sector j (j=h or l), that is high-tech or low-tech production; r , w and s are the factor prices in terms of high-tech output of respectively capital, unskilled labour and skilled labour; y_j is output in sector j; and K_0, L_0, and T_0, are given factor supplies of respectively capital, unskilled labour and skilled labour.

The GTFM can behave in a manner easily comparable with an ordinary HOS model. To see this, suppose that the production function for high-tech output is a constant returns function of the form:

$$y_h = \phi^h(l^{sh}) \cdot f^h\left[k^h, \ell^{uh}\right] \tag{10}$$

where l^{sh} and l^{uh} are the inputs of respectively skilled and unskilled labour into high-tech production, and k^h is the input of capital. The function (10) is separable in the sense that the choice of the optimal amount of skilled labour to use is independent of the other two inputs and their prices.

With the production function (10) we have a unit cost function:

$$c_h\left[r, w, s\right] = c_h\left[r, w\right] \cdot d\left(s\right) \tag{11}$$

When (11) replaces (5) in the GTFM, we have case which will be called the *Separable Three Factor Model* (STFM).

THEOREM 1. *In the STFM factor-price equalization does not necessarily result. If there is any substitutability between labour and capital, magnification is a feature of the model, but its impact is moderate relative to the two-factor HOS model.*
Proof: Given relative product prices p, unit-cost price equality requires:

$$c_h\left[r, w\right] \cdot d\left(s\right) \tag{12}$$

$$c_l\left[r, w\right] = p \tag{13}$$

Given the standard factor intensity property for capital and labour, if two countries produce both products and share the same value of $d(s)$, factor-price equalization follows from (12) and (13). It is as if the low-tech good the high-tech good were $p \cdot d(s)$ in a completely standard HOS model. It is equally plain that if the two countries do not share the same value of $d(s)$, it is as if they faced different output prices, and factor-price equalization is not to be expected.
With magnification suppose a rise in p, and imagine that the changes which result do not include any alteration in the value of $d(s)$. Then the usual conclusions of the HOS model apply, and the real wage of unskilled labour in terms of either product will fall. However if there is any substitutability between the capital and unskilled labour inputs, the high-tech sector will shrink in size; the marginal product of skilled labour will fall; and the high-tech sector will experience a fall of its unit cost function in terms of r and w. The net effect is as if the rise in p were more moderate than its true arithmetic value. However magnification does not depend upon the size of the rise in p, so magnification will still result.

The proof of the theorem makes clear why separability is required, and also, looking just beyond the argument, how greater complications will be encountered is separability is

not assumed. If one tries to push through a similar argument to the theorem, but using the cost-price-equality equations (5) and (6), rather than (11) and (6), what happens? So long as s is not altered, everything is as standard HOS reasoning. And when the high-tech sector shrinks, s will again fall. Without separability the change in s has a differential effect on the marginal attractiveness of the other two inputs. Then Stolper and Samuelson's "complicated patterns of complementarity and competitiveness" make themselves felt.

Figure 1
Factor-Price Equalization

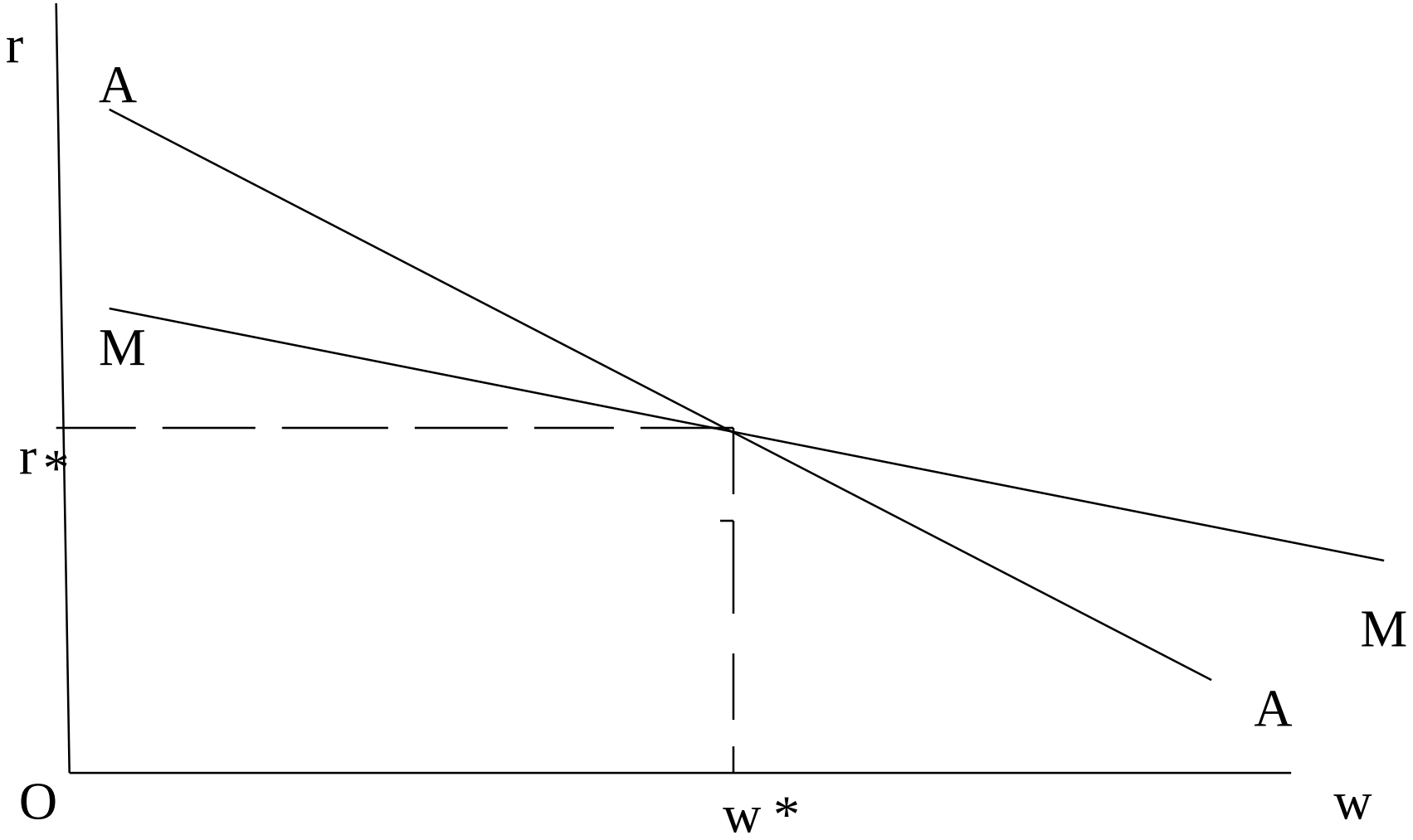

Figure 2
Magnification