Explaining International Trade Among China, India and the US*

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Abstract

This paper first presents four key features of international trade among China, India and the US. We outline a simple three-country model based on a combination of imperfect competition, comparative advantage, and identical but non-homothetic preferences that is consistent with these stylised facts. The model is then used to shed light on the recent debates over the impact of economic growth in China and India on the US. The US may suffer a terms of trade loss from growth in its major trading partners, but the magnitude of the loss is dampened by the increase in the number of varieties available for consumption.

JEL codes: F12, F14.

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1 Introduction

The objective of this paper is threefold: to present some evidence on trade patterns between China, India and the US, to present a model that can explain the evidence, and finally, to use the model to shed light on the recent debate over the impact of economic growth in China and India, on US welfare.

We present four key stylised facts. First, Table 1 shows that, at the 3-digit level, the correlation between China and India’s imports from the US, is always higher than the correlation between China and India’s exports to the US. That is, China and India import similar goods from the US, while exporting different goods to the US. Second, Table 2 shows that the value of trade between China, India and the US, are roughly proportional to the size of the respective economies. Both China and India trade much more with the US than they do with each other.

The third stylised fact is shown in Table 3. The correlation between exports from China to India, and China to the US, is very low. This means that China exports different goods to India than it does to the US. The same conclusion can be drawn from correlations between India’s exports to China and to the US. Finally, Table 4 shows the fourth stylised fact, which is the presence of a significant amount of bilateral trade within the same 3-digit industries, between all three countries.

To summarise:

Stylised fact 1: China and India import similar goods from the US, but export different goods to the US.

Stylised fact 2: Both China and India trade much more with the US than they do with each other.

Stylised fact 3: China (India) exports different goods to India (China) than it does to the US.

Stylised fact 4: There is significant bilateral trade within the same 3-digit industries, between all three countries.

The model we develop to explain these four stylised facts makes use of increas-
ing returns to scale and monopolistic competition, combined with differences in relative factor endowments and technology across countries, and non-homothetic preferences. In the interest of keeping the model as simple as possible, we impose strong assumptions on the technology side along the lines of Krugman (1981), and we adopt the simplest possible, quasi-linear utility function. The underlying monopolistic competition model is that of Krugman (1980), based on the Dixit-Stiglitz (1977) framework.

This is not the only possible way to model these stylised facts. For example, it is possible to model intra-industry trade within a constant-returns framework, as has been done by for example Falvey (1981), Falvey and Kierzkowski (1987), and Davis (1995). It is also possible to model the other stylised facts using appropriate modifications to such a constant-returns model. That we have chosen the particular modelling approach adopted in this paper, reflects the simplicity of the setup and the naturalness of the assumptions of the model.

After showing how the model can explain our four stylised facts above, we extend the model to address the recent debate over the impact of economic growth in China and India, on US welfare. Samuelson (2004) has argued that the US may lose from economic growth in China, if China becomes more similar to the US in terms of its comparative advantage. Jones and Ruffin (2005), on the other hand, using a similar framework to Samuelson (2004), argue that technological transfer from the US to less developed countries in its comparative advantage industries, may lead to gains to the US. We find using our model, that the US may lose from growth in China and India. The US can suffer a terms of trade loss if China and India experience rapid skill or capital accumulation. This loss is at least partially offset by gains from the increase in the number of varieties available for consumers.

The model we present in this paper relates to several strands of literature. As it uses a monopolistic competition model, it builds on the insights from Helpman

\footnote{See Bhagwati and Davis (1999) for a survey of the literature, and Soo (2005b) for further results on Davis’s (1995) model.}

\footnote{For example, Soo (2005a) shows that, contrary to the claim in Helpman and Krugman (1985), relative country sizes do matter for the volume of trade in a perfectly competitive, factor-endowments model.}
and Krugman (1985). In generating a gravity-type prediction on the volume of trade, it follows work by Anderson (1979) and Krugman (1979, 1980). And finally, in discussing international trade between developed and less developed countries, it is related to the work by Markusen (1986) and Flam and Helpman (1987). Where the present paper extends on the analysis of the latter two papers, is in taking into explicit account the fact that countries trade with more than one trading partner, and considering the simultaneous impact of changing conditions on all trading partners. In addition, this paper focuses on trade between two developing countries, whereas previous work has concentrated more on trade between developed and less developed countries. Finally, by using simple functional forms, we are able to derive precise expressions for trade flows between countries.

The structure of the rest of this paper is as follows. In the next section, we present the structure of the model, starting with the autarkic equilibrium, then allowing for free trade between the three countries. Section 3 considers the implications for welfare in all three countries when China and India grow. Section 4 concludes.

2 The model

In this section we first describe the autarkic equilibrium of the model, then consider its implications for free trade in goods but not in labour.

2.1 Autarkic equilibrium

The basic setup of the model is that of a monopolistic competition model developed from Krugman (1981), with the main point of departure being the use of non-homothetic preferences. There are three countries, \( x = 1, 2, 3 \), and three industries, \( h = 1, 2, 3 \). Each industry consists of a large number of products which enter symmetrically into demand. The representative consumer has the following quasi-

\footnote{Other papers in this area include Stokey (1991), Ramezzana (2000) and Matsuyama (2000).}
linear utility function:

\[ U = \ln C_1 + \ln C_2 + C_3 \]  

(1)

where each of \( C_h \) is a composite index of products comprising a constant-elasticity-of-substitution (CES) function:

\[ C_1 = \sum_i c_{1i}^\theta \quad \quad C_2 = \sum_j c_{2j}^\theta \quad \quad C_3 = \sum_k c_{3k}^\theta \quad \quad 0 < \theta < 1 \]  

(2)

where \( c_{1i} \) is consumption of the \( i \)th product of industry 1, and so on. The value of \( \theta \) measures the degree of substitutability among products within an industry. The lower is \( \theta \), the more differentiated are products in the industry. Quasi-linear utility implies that consumption of goods in all three industries initially increases with income, then goods in industries 1 and 2 have zero income elasticity of demand above a certain income threshold, beyond which all additional income is spent on goods in industry 3. We assume that consumer income always lies beyond this threshold.

Each industry is produced using a specific type of labour, so that there are three types of labour, \( y = 1, 2, 3 \). Type 1 labour is used in industry 1, type 2 labour in industry 2, and type 3 labour in industry 3. Making the labour industry-specific prevents us from considering the redistribution of labour across industries as parameter values change; however it does make the model much easier to solve, and in any case sectoral reallocation of labour is not the main focus of the present paper. Labour is not specific to products within each industry. The cost function for any product in each industry exhibits increasing returns to scale:

\[ l_{1i} = \alpha + \beta x_{1i} \quad i = 1, \ldots, n_1 \]
\[ l_{2j} = \alpha + \beta x_{2j} \quad j = 1, \ldots, n_2 \]
\[ l_{3k} = \alpha + \beta x_{3k} \quad k = 1, \ldots, n_3 \]  

(3)

where \( l_{1i} \) is labour used in producing the \( i \)th product of industry 1, \( x_{1i} \) is the output of that product, and so on. Because of increasing returns to scale, consumers’ preference for variety, and the large number of potential products of each industry, each firm will produce its own unique product.
Total employment in each industry is equal to the sum of employment in each product in that industry. Full employment is assumed. In country 1, the labour force is exogenously split between the three types of labour as follows:

\[
\begin{align*}
\sum_i l_{1i} &= L_1^1 = 3 - 2z \\
\sum_j l_{2j} &= L_2^1 = z \\
\sum_k l_{3k} &= L_3^1 = z
\end{align*}
\] (4)

where \( L_y^x \) is the total endowment of labour type \( y \) in country \( x \). The parameter \( z \) measures the quantity of the different types of labour.

Given these conditions, equilibrium in the model is solved in the standard way. Since all products in an industry enter symmetrically into demand and all firms have identical cost functions, all products in each industry have the same price. From the firm’s profit maximisation problem, and noting that the elasticity of demand is \( \frac{1}{\theta} \), the firm’s profit-maximising price is a constant markup over marginal cost:

\[
\begin{align*}
p_{1i} &= \frac{\beta w_1}{\theta} \\
p_{2j} &= \frac{\beta w_2}{\theta} \\
p_{3k} &= \frac{\beta w_3}{\theta}
\end{align*}
\] (5)

where \( p_{1i} \) is the price of product \( i \) in industry 1, and so on.

Free entry and exit of firms ensures that profits are zero in equilibrium. Combining this zero profit condition and the firms’ pricing decision allows us to solve for the output (and hence size) of each firm:

\[
x_{1i} = x_{2j} = x_{3k} = \frac{\alpha \theta}{\beta} \frac{\theta}{1 - \theta} = x
\] (6)

Notice that firm sizes are independent of market size. Then, the number of firms in each industry can be obtained by combining the full employment condition with the labour endowment and the size of firms:

\[
n_1 = \frac{3 - 2z}{\alpha + \beta x} \\
n_2 = n_3 = \frac{z}{\alpha + \beta x}
\] (7)

The number of firms is proportional to the labour endowment. Relative prices
and wages are determined from the first order conditions of the consumer’s maximisation problem:

\[
\begin{align*}
\left(\sum_i c_{1i}^\theta \right)^{-1} \left(\sum_j c_{2j}^\theta \right)^{-1} &= \lambda p_{1i} \\
\left(\sum_j c_{2j}^\theta \right)^{-1} &= \lambda p_{2j} \\
\theta c_{3k}^\theta &= \lambda p_{3k}
\end{align*}
\]

where \( \lambda \) is the Lagrange multiplier on the budget constraint or the marginal utility of income. Given our symmetry assumptions, the relative prices are:

\[
\begin{align*}
\frac{p_{1i}}{p_{2j}} &= \frac{n_2}{n_1} = \frac{L_2}{L_1} \\
\frac{p_{3k}}{p_{1i}} &= n_1 c_{1i}^\theta \\
\frac{p_{3k}}{p_{2j}} &= n_2 c_{2j}^\theta
\end{align*}
\]

Equilibrium wages are determined by these prices and the pricing equation (5).

### 2.2 Free trade equilibrium

In this section we consider what happens when we allow three countries to engage in free international trade in goods but not in labour. Assume that preferences are identical across countries, and free trade in goods but not in labour between countries. To determine the pattern of trade between the three countries, we must first determine the endowment of the three types of labour in each country. Country 1’s endowment is given in the previous subsection. Assume that countries 2 and 3 have the following endowments:

\[
\begin{align*}
\sum_i l_{1i}^2 &= L_1^2 = z \\
\sum_j l_{2j}^2 &= L_2^2 = 3 - 2z \\
\sum_k l_{3k}^2 &= L_3^2 = z
\end{align*}
\]

where as above \( L_y^x \) is the total endowment of labour type \( y \) in country \( x \). The parameter \( z \) is a measure of the similarity of relative endowments across the countries. If \( z = 0 \), each country has only one type of labour, and hence can only produce varieties of a single industry. If \( z = 1 \), all countries have the same relative endowment ratio.
Since $0 < z < 1$, Country 1 is relatively well-endowed with type 1 labour compared to countries 2 and 3, while Country 2 is relatively well-endowed with type 2 labour compared to countries 1 and 3, and Country 3 is relatively well-endowed with type 3 labour compared to countries 1 and 2. Therefore, Country 1 has a comparative advantage in industry 1, Country 2 in industry 2, and Country 3 in industry 3. Total world endowment of type 1 and 2 labour is each equal to $3 + z$, while the total world endowment of type 3 labour is equal to $6 - 2z$.

Assume that countries 1 and 2 are equally productive in all industries, but country 3 is twice as productive as countries 1 and 2 in all industries. Therefore, although country 3 has twice as much labour as countries 1 and 2, this reflects the fact that country 3 is twice as efficient as countries 1 and 2 in all industries, so that the labour endowments defined above are in fact efficiency units of labour. In this case, all countries have the same number of consumers, and hence with identical prices across countries, will consume equal amounts of type 1 and type 2 goods. Identical numbers of consumers simplifies the analysis in the presence of quasi-linear utility.

To put this endowment specification into the China-India-US context, China and India would be countries 1 and 2. Each of these countries would have a comparative advantage in a good that has a zero income elasticity of demand beyond some threshold consumption level. Examples of such goods may include food, clothing, writing instruments. We abstract from other differences between the two countries, while remaining aware that there are major differences between them. The US would be represented by country 3: superior technology to both China and India, and having a comparative advantage in producing a good that is income-elastic, for instance, computer software.

Since preferences and technology are identical across countries up to the Hicks-neutral productivity difference discussed above, the profit maximising price is the same as in equation (5) above. From the first order conditions for the consumer’s problem above, since world endowment of type 1 and 2 labour are identical, equi-

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4If we abstract from the quality of these goods.
librium price ratios are:

\[ \frac{p_{1i}}{p_{2j}} = \frac{L_2^W}{L_1^W} = 1 \quad \frac{p_{3k}}{p_{1i}} = n_1^W c_{1i} \quad \frac{p_{3k}}{p_{2j}} = n_2^W c_{2j} \]  

(11)

where \( L_1^W \) and \( L_2^W \) are the world endowment of type 1 and type 2 labour, and \( n_1^W \) and \( n_2^W \) are the total number of type 1 and type 2 firms in the world. Next, we normalise \( p_1 = p_2 = w_1 = w_2 = 1 \) which implies \( \beta = \theta \). Prices and wages in industry 3 are pinned down by equation (11). Free trade in goods implies factor price equalisation across countries, measured in efficiency units of labour.

From equations (7) and (6), and making use of the assumption that \( \beta = \theta \), the total world output of each industry is:

\[ n_1^W x = n_2^W x = 3 + z \quad n_3^W x = 6 - 2z \]

National incomes \( Y^x \) are equal to:

\[ Y^1 = Y^2 = 3 - z + w_3 z \quad Y^3 = 4z + w_3 (6 - 4z) \]

Because of the quasi-linear utility function and identical numbers of consumers in each country, each country consumes one-third of the world output of each product of industries 1 and 2; that is, \( \frac{3+z}{3} \). Therefore, we can back out the total expenditure by each country on industry 3 by subtracting expenditure on industries 1 and 2 from national income. For countries 1 and 2, expenditure on good 3 becomes:

\[ 3 - z + w_3 z - 2 \left( \frac{3 + z}{3} \right) = 1 - \frac{5z}{3} + w_3 z \]  

(12)

and country 3’s expenditure on good 3 becomes:

\[ 4z + w_3 (6 - 4z) - 2 \left( \frac{3 + z}{3} \right) = \frac{10z}{3} + w_3 (6 - 4z) - 2 \]  

(13)

Now, defining \( X_{xy}^h \) as the exports of industry \( h \) from country \( x \) to country \( y \), we can compute the exports of each country to the other two countries. Because all varieties of a good are symmetric, a country’s exports of an industry to another
country depends on the output of the country in that industry, multiplied by the
fraction of world output that is consumed in the importing country. For country
1, exports of the three industries to countries 2 and 3 are:

\[
X_{12}^1 = X_{13}^1 = \frac{3-2z}{3} \\
X_{22}^1 = X_{23}^1 = \frac{z}{3} \\
X_{32}^1 = \frac{z}{2(3-z)} \left(1 - \frac{5z}{3} + w_3z\right) \\
X_{13}^3 = \frac{z}{2(3-z)} \left(\frac{10z}{3} + w_3(6-4z) - 2\right)
\]

Therefore, country 1 exports the same quantity of industries 1 and 2 to both
countries, but exports of industry 3 to the two countries are different. Country 2’s
exports to countries 1 and 3 can be obtained analogously. Country 3’s exports to
countries 1 and 2 are:

\[
X_{31}^1 = X_{32}^1 = X_{31}^2 = X_{32}^2 = 2z \\
X_{33}^3 = X_{32}^3 = \frac{3-2z}{(3-z)} \left(1 - \frac{5z}{3} + w_3z\right)
\]

Figure 1 presents the key results of the model as functions of the relative en-
dowment parameter \(z\).\(^5\) Figure 1(a) shows that the wage rate of type 3 labour
increases as countries become more similar to one another (\(z\) increases). This is
because world relative supply of type 3 labour decreases as \(z\) increases. Notice
also that the wage rate of type 3 labour is significantly greater than that of type
1 and type 2 labour (which were both normalised to 1).

Figure 1(b) shows the impact that this has on national incomes. As \(z\) increases,
countries 1 and 2 experience a gain in both nominal and real income because they
get more of the high-wage type 3 labour, whereas country 3 suffers a loss of nominal
and real income, because it loses some of the high-wage type 3 labour, and acquires

\(^5\)Figure 1 is drawn for the following parameter values: \(\theta = 0.8, x = 0.5\). \(\theta = 0.8\) is a
commonly-used value; it corresponds to an elasticity of substitution between varieties of 5.
Changing the parameter values does not qualitatively change the figures, although smaller values
of firm size \(x\) place a greater weight on type 3 goods.
more of the low-wage type 1 and 2 labour. Figure 1(c) shows that national welfare decreases in country 3 and increases in countries 1 and 2 as \( z \) increases.

Figure 1(d) shows the exports of the three goods by country 1. As \( z \) increases, country 1 loses sector 1 and gains sectors 2 and 3, and this is reflected in the changes in its exports. Exports of good 3 to country 3 are much larger than to country 2; this is due to the higher fraction of country 3 income devoted to consumption of type 3 goods.

Figure 1(e) reports the exports of the three goods by country 3. As \( z \) increases, country 3 starts exporting more of goods 1 and 2. However, it initially increases the value of its exports of good 3, for two reasons. First, countries 1 and 2 are increasing their expenditures on good 3 as a result of income growth in these two countries, and second, the relative price of good 3 is increasing. These two factors initially outweigh the decline in country 3 endowments of type 3 labour. At higher values of \( z \), the opposite is true; the value of country 3 exports of good 3 starts declining as its endowment of type 3 labour continues to fall.

Figure 1(f) shows that, largely as a result of the increase in exports of good 3 to country 3, total exports to country 3 takes up an increasing fraction of country 1 income as \( z \) increases. This result is overturned only for large values of \( z \), as country 3’s share of world income continues to decrease.

### 2.3 Discussion: Basic model

What are the predictions of the model relative to the four stylised facts above? While the assumptions of the model make it too stark to calibrate precisely to the data, several patterns emerge from trade between the three countries.

First, both countries 1 and 2 import the same goods in the same quantities from country 3, but due to differences in relative endowments between the two countries, their export mix to country 3 differs between the two countries (stylised

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*6Here, as in case 1 in section 3 below, countries 1 and 2 are symmetric to one another and share the same income and utility levels.*
fact 1). Second, trade volumes depend on each country’s income; if country 3 has a higher level of income than country 2, then country 1 will trade more with country 3 than with country 2, in general (stylised fact 2).

Third, country 1 does not export an identical bundle of goods to countries 2 and 3, because different per capita income levels in the two countries lead to different demand patterns and hence different imports from country 1 (stylised fact 3). And finally, each country exports positive amounts of each of the three goods to the other two countries; there is thus a significant amount of intra-industry trade (stylised fact 4). Note however that because export and import volumes of each of the three goods do not coincide (although trade is balanced), the Grubel-Lloyd index is not equal to 1.

3 Economic growth in China and India

One of the main economic trends in the world today is the rapid economic growth of China and India. This rapid growth has prompted fears, especially in the US, that these countries will come to compete with the US, and that as a result the US will be worse off as these countries develop. This is essentially the argument in Samuelson (2004). In this section we explore the predictions of our model for the impact growth in China and India on national welfare in our three country framework. We consider two alternative cases: symmetric growth in total factor productivity (TFP) or endowment convergence of both China and India with the US, and asymmetric growth (e.g. growth in only China).

3.1 Framework

There are two possible ways to think about economic growth in this model: as proportional increases in the efficiency of labour, implying an increase in the endowment without changing relative supplies, or as changing relative supplies of labour. We consider both these changes in a unified framework. Assume for simplicity that the total number of workers/consumers is unchanged, and that all
adjustment occurs either through workers changing type, or changes in labour productivity.

Now let endowments of the three countries be equal to:

\[
\begin{align*}
L_1^1 &= \gamma_1 (3 - \eta_1 - \mu_1) \\
L_1^2 &= \gamma_2 \eta_2 \\
L_1^3 &= 2\gamma_3 \mu_3 \\
L_2^1 &= \gamma_1 \eta_1 \\
L_2^2 &= \gamma_2 (3 - \eta_2 - \mu_2) \\
L_2^3 &= 2\gamma_3 \mu_3 \\
L_3^1 &= \gamma_1 \mu_1 \\
L_3^2 &= \gamma_2 \mu_2 \\
L_3^3 &= \gamma_3 (6 - 4\mu_3)
\end{align*}
\]

The inequalities ensure that each country has strictly positive endowments of each type of labour. The \(\gamma\)’s indicate TFP differences across countries that are uniform across industries, while the \(\eta\)’s and \(\mu\)’s represent differences in factor endowments. If all the \(\eta\)’s and \(\mu\)’s are identical to one another, and all the \(\gamma\)’s equal to 1, then we revert to the structure in section 2, where a single parameter, \(z\), governed relative factor endowments across countries. Using this notation allows us to consider flexibly changes in endowments or productivity either simultaneously or individually, and consider changes in countries either symmetrically or asymmetrically.

Appendix A gives the details of the analytical solution to the model. Here, we focus on the graphical representations of the two cases noted above.

### 3.2 Case 1: Symmetric growth in China and India

There are two sub-cases to consider: simultaneous TFP growth in China and India, and simultaneous endowment convergence with the US.

First, consider simultaneous TFP growth. In terms of the framework in the previous subsection, this involves fixing all the \(\eta\)’s and \(\mu\)’s to be identical to one another, only allowing for variation in the \(\gamma\)’s. We further fix \(\gamma_3 = 1\) and \(\gamma_1 = \gamma_2 \geq 1\), so that country 3’s TFP does not increase, while that of countries 1 and 2 increase proportionally to one another.

Figure 2(a) graphs welfare levels in the three countries, and is drawn with the
values of $\gamma_1 = \gamma_2$ on the horizontal axis\textsuperscript{7}. National welfare in all three countries increases as productivity increases in countries 1 and 2. This occurs because the increase in productivity lowers prices and hence increases real wages, and in addition increases the number of varieties available for consumption, leading to gains for consumers in all three countries.

It is also possible to consider simultaneous endowment convergence of China and India with the US. To do so, we fix all the $\gamma$’s equal to 1, so that there is no TFP growth in any country, and we fix $\eta_1 = \eta_2 = \mu_3$ equal to some constant value. Allow $\mu_1 = \mu_2 \neq \mu_3$; that is, we allow countries 1 and 2 to move their endowment structures in the direction of country 3. Once again we assume symmetric changes in the endowments of countries 1 and 2.

Figure 2(b) graphs welfare levels in the three countries. As countries 1 and 2 converge in relative endowments with country 3, world relative supply of type 3 labour increases, thus reducing the relative wage of type 3 labour. This harms country 3, as it is relatively abundant in type 3 labour. This loss is partially offset by the welfare gain from the increase in the number of varieties of type 3 goods which are mainly consumed by consumers in country 3. The net effect is that country 3 welfare decreases marginally as countries 1 and 2 converge in endowments with it, whilst welfare in countries 1 and 2 increase substantially, as they experience a shift towards the high-wage type 3 labour. Note however that this result that country 3 loses, is somewhat sensitive to the parameter values chosen. For example, a lower value of the degree of substitutability between varieties $\theta = 0.6$ (corresponding to an elasticity of substitution between varieties of 2.5) would lead to net gains for country 3, and even larger gains to countries 1 and 2.

In comparing the welfare effects of TFP growth versus endowment convergence of China and India to the US, it seems clear from Figure 2 that TFP growth in these countries leads to higher welfare for each country and hence for the world as well. This is an intuitively appealing result: TFP improvements shift the production possibilities frontier outwards, enlarging the size of the world economy, whereas

\textsuperscript{7}Figure 2(a) is drawn for the following parameter values: $\theta = 0.8$, $x = 0.5$, $\mu_i = \eta_j = 0.5$, $\forall i, j$.

Figure 2(b) is drawn for the following parameter values: $\theta = 0.8$, $x = 0.5$, $\mu_3 = \eta_1 = \eta_2 = 0.5$. See the previous footnote for a discussion of these parameter values.
endowment convergence with the US, while it increases world relative supply of the good with high income elasticity of demand, leads to much smaller welfare gains. The world as a whole, however, gains from both types of growth in China and India.

### 3.3 Case 2: Asymmetric growth

In the previous subsection, we considered the impact of symmetric growth in countries 1 and 2. The symmetric case is the easiest to solve, as it preserves relative world endowments of type 1 and type 2 labour, hence relative supplies of goods 1 and 2 and relative prices of goods 1 and 2. Dropping the assumption of symmetry would imply changes in the relative prices of the two goods.

In this subsection we consider the implications of relaxing the symmetry assumption. This can be done by allowing for unilateral changes in the TFP term $\gamma$, unilateral changes in the relative endowment parameter $\mu$, or some combination of both. Since the last case is simply a combination of the first two cases, it is the first two cases which we focus on. The question we address here is whether growth in one country harms or helps its trading partners in terms of national welfare. We consider changes in country 1 only; changes in country 2 are symmetric.

In the first case, we consider the implications when country 1 converges in TFP with country 3; that is, $\gamma_1$ increases, holding all other parameters constant. The second case we consider is when country 1 converges in endowments with country 3; $\mu_1$ increases, holding all other parameters constant. Parameter values are as in the previous subsection. The starting point at the left of each panel of Figure 3 is the initial symmetric position, while the final point at the right of each panel, is the position when country 1 has fully converged with country 3 in either TFP or relative endowments.

Figure 3 shows that all three countries prefer case 1, where country 1 experiences TFP growth, rather than case 2, where country 1 converges in endowments with country 3. For country 1, increasing TFP makes its workers more productive, hence increasing output and national income, which more than offsets the
increases in the prices of the goods which it imports. This gain is greater than what country 1 would gain, if it were to experience endowment convergence with country 3.

For countries 2 and 3, the increase in country 1’s TFP would increase world relative supply of good 1, hence driving down its relative price, and leading to terms of trade gains for countries 2 and 3. This is in addition to the gain in welfare from the increased number of varieties available. Countries 2 and 3 will suffer a welfare loss if country 1 converges in endowments with country 3. Country 3 would suffer a terms of trade loss as world relative supply of good 3 increases, and this loss is greater than the gain from the increased number of varieties available to country 3 consumers, who are the major consumers of good 3. Country 2 also suffers a terms of trade loss as a result of this change, as world relative supply of its export good 2 rises, whilst it is unable to gain sufficiently from the lower prices and greater variety of good 3, because it does not spend enough of its income on consumption of this good. For this reason, country 2’s loss from country 1 endowment convergence with country 3, is greater than the loss to country 3. As in the previous subsection, lower values of the degree of substitutability between varieties $\theta$ would lead to net gains for country 3, and if $\theta$ is sufficiently low ($\theta \leq 0.5$), to net gains for country 2 as well. Country 1 never loses regardless of the value of $\theta$.

The key implication of this result is that TFP growth in countries such as China and India, be they in the form of technological progress, or improved infrastructure or institutions, leads to gains for the countries themselves, and for their trading partners as well. On the other hand, rapid skill or capital accumulation, whilst still beneficial to the countries themselves, may well harm their trading partners, in particular the less developed countries such as those in Africa which are unable to grow as quickly as China and India.\textsuperscript{8} This result is also partly driven by the fact that factors of production are industry-specific; allowing for inter-industry mobility of factors may lead to different results, as in Jones and Ruffin (2005).

\textsuperscript{8}Empirically, what has happened as China and India have rapidly accumulated skill, is that many skilled workers have migrated to the developed world. This may lead to gains to the developed countries sufficient to overturn the result that these countries will experience losses from this type of growth.
4 Conclusions

This paper develops a model of international trade between three countries that takes into account elements of factor endowment differences across countries, intra-industry trade of the Dixit-Stiglitz type, and non-homothetic preferences. Although the model is very simple, it is able to generate predictions of the pattern of trade between the three countries, that is consistent with trade patterns between China, India and the US.

The crucial simplicity of the model allows us to extend it to consider the implications for each of the countries, when two of the countries (China and India) grow relative to the third country. There are many possible ways in which the countries can grow, and we consider several of these. The key result that emerges is that TFP growth is more beneficial to both the countries that experience this growth, and for their trading partners, than rapid skill or capital accumulation. Whilst the simplicity of the model prevents us from making this a strong policy recommendation, it is nonetheless suggestive, and emphasises the importance of technological progress, and improvements in infrastructure and institutions.

The use of an explicit three-country framework is also a new development in a field that has been largely driven by two-country frameworks\(^9\). In this case, a three-country approach enables us to explore the interdependencies between countries when their trading partners grow. It is found that TFP growth in a single country benefits all countries, whereas endowment convergence of a poor country with a rich country, harms the converging country’s trading partners. There is thus again a suggestion that larger improvements in world welfare can be obtained through increasing specialisation of national economies in their initial comparative advantage industries. Nonetheless, there exists the possibility of conflict between countries, as changes in one country may impact on other countries in different ways depending on the structure of each country’s economy. This again appears to be consistent with the conflicts in international trade that have been observed between different countries.

References


5 Appendix A: Solutions for Section 3

This Appendix solves out the analytical solution to the model allowing for differences in TFP and relative endowments in section 3. Working through the same steps as in section 2, world output in each industry is now:

\[
\begin{align*}
    n_1 x &= \gamma_1 (3 - \eta_1 - \mu_1) + \gamma_2 \eta_2 + 2\gamma_3 \mu_3 \\
    n_2 x &= \gamma_2 (3 - \eta_2 - \mu_2) + \gamma_1 \eta_1 + 2\gamma_3 \mu_3 \\
    n_3 x &= \gamma_3 (6 - 4\mu_3) + \gamma_1 \mu_1 + \gamma_2 \mu_2 
\end{align*}
\]

National incomes are now equal to:

\[
\begin{align*}
    Y^1 &= \gamma_1 [3 + \mu_1 (w_3 - 1)] \\
    Y^2 &= \gamma_2 [3 + \mu_2 (w_3 - 1)] \\
    Y^3 &= 2\gamma_3 [3w_3 - 2\mu_3 (w_3 - 1)] 
\end{align*}
\]

so world income is:

\[
Y^W = 3 (\gamma_1 + \gamma_2 + 2\gamma_3 w_3) + (w_3 - 1) (\gamma_1 \mu_1 + \gamma_2 \mu_2 - 4\gamma_3 \mu_3)
\]

As in section 2, national expenditures on goods 1 and 2 are $\gamma_1(3-\eta_1-\mu_1) + \gamma_2 \eta_2 + 2\gamma_3 \mu_3$ and $\gamma_2(3-\eta_2-\mu_2) + \gamma_1 \eta_1 + 2\gamma_3 \mu_3$ respectively, so again we can back out national expenditures on good 3:

\[
\begin{align*}
    E^1_3 &= \gamma_1 [3 + \mu_1 (w_3 - 1)] - \frac{1}{3} \left\{ \begin{array}{c} [\gamma_1 (3 - \eta_1 - \mu_1) + \gamma_2 \eta_2 + 2\gamma_3 \mu_3] \\
        + [\gamma_2 (3 - \eta_2 - \mu_2) + \gamma_1 \eta_1 + 2\gamma_3 \mu_3] \end{array} \right\} \\
    &= (2 + \mu_1 w_3) \gamma_1 - \gamma_2 + \frac{1}{3} [\gamma_2 \mu_2 - 2\gamma_1 \mu_1 - 4\gamma_3 \mu_3] \\

    E^2_3 &= \gamma_2 [3 + \mu_2 (w_3 - 1)] - \frac{1}{3} \left\{ \begin{array}{c} [\gamma_1 (3 - \eta_1 - \mu_1) + \gamma_2 \eta_2 + 2\gamma_3 \mu_3] \\
        + [\gamma_2 (3 - \eta_2 - \mu_2) + \gamma_1 \eta_1 + 2\gamma_3 \mu_3] \end{array} \right\} \\
    &= (2 + \mu_2 w_3) \gamma_2 - \gamma_1 + \frac{1}{3} [\gamma_1 \mu_1 - 2\gamma_2 \mu_2 - 4\gamma_3 \mu_3]
\end{align*}
\]
For country 1, exports of the three industries to countries 2 and 3 are:

\[
X_{12}^1 = X_{13}^1 = \frac{\gamma_1 (3 - \eta_1 - \mu_1)}{3}
\]

\[
X_{22}^1 = X_{23}^1 = \frac{\gamma_1 \eta_1}{3}
\]  \hspace{1cm} (19)

Country 2’s exports to countries 1 and 3 can be obtained analogously:

\[
X_{12}^2 = X_{13}^2 = \frac{\gamma_2 \eta_2}{3}
\]

\[
X_{22}^2 = X_{23}^2 = \frac{\gamma_2 (3 - \eta_2 - \mu_2)}{3}
\]  \hspace{1cm} (20)

Country 3’s exports to countries 1 and 2 are:

\[
X_{12}^3 = X_{13}^3 = X_{23}^3 = \frac{2\gamma_3 \mu_3}{3}
\]

\[
X_{22}^3 = \frac{\gamma_3 (6 - 4\mu_3)}{\gamma_3 (6 - 4\mu_3) + \gamma_1 \mu_1 + \gamma_2 \mu_2}
\]

\[
X_{23}^3 = \frac{\gamma_2 \mu_2}{\gamma_3 (6 - 4\mu_3) + \gamma_1 \mu_1 + \gamma_2 \mu_2}
\]  \hspace{1cm} (21)
5.1 Additional results for asymmetric case

When considering the case of asymmetric changes in the two countries, we cannot employ the normalisation used in section 2, which sets the prices and wages in industries 1 and 2 equal to 1. Therefore, writing out the expressions for national income in full gives:

\[
Y_1 = \gamma_1 (3 - \eta_1 - \mu_1) + w_2 \gamma_1 \eta_1 + w_3 \gamma_1 \eta_1 \\
= \gamma_1 [3 + \eta_1 (w_2 - 1) + \mu_1 (w_3 - 1)]
\]

\[
Y_2 = \gamma_2 \eta_2 + \gamma_2 (3 - \eta_2 - \mu_2) w_2 + w_3 \gamma_2 \eta_2 \\
= \gamma_2 [3w_2 + \eta_2 (1 - w_2) + \mu_2 (w_3 - w_2)]
\]

\[
Y_3 = 2\gamma_3 \mu_3 + 2\gamma_3 \mu_3 w_2 + \gamma_3 (6 - 4\mu_3) w_3 \\
= 2\gamma_3 [\mu_3 (1 + w_2 - 2w_3) + 3w_3]
\]

The expression for the world output of each good is identical to that for the case when prices and wages in industries 1 and 2 are identical.
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<th>Obs</th>
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Table 1: Correlations between China and India’s exports to the US, and between China and India’s imports from the US, 3-digit level.

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Table 2: Imports of China and India as a share of total imports.
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Table 3: Correlations between China’s (India’s) trade with India (China) and with the US.
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</table>

Notes: WGL: Weighted Grubel-Lloyd index, calculated as $WGL_i = \sum_g GL_{ig} \frac{(X_{ig} + M_{ig})}{\sum_g (X_{ig} + M_{ig})}$

UGL: Unweighted Grubel-Lloyd index, calculated as $UGL_i = \sum_g GL_{ig} / G$

where $GL_{ig} = 100 \left(1 - \frac{X_{ig} - M_{ig}}{X_{ig} + M_{ig}}\right)$

and X, M represent exports and imports, i is a country indicator, g is an industry indicator, G is the number of groups.

Table 4: Bilateral Grubel-Lloyd indices of intra-industry trade between China, India and the US.
Figure 1: Key variables as functions of the endowment similarity parameter $z$
Figure 2: National welfare as countries 1 and 2 experience productivity improvement or converge in endowments with country 3

Figure 3: National welfare as only country 1 grows in TFP (case 1) or converges in endowments with country 3 (case 2)