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It's a jungle out there: International trade when bargaining power matters

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Anti-globalisation protesters often claim that the gains from trade accrue primarily to large countries. This contradicts conventional trade models, which predict that small countries gain more from trade than do large countries. We first present evidence which shows that the terms of trade do indeed move in favour of countries which become larger. We then develop a model of international trade based on Ricardian comparative advantage, in which the terms of trade are derived based on the bargaining power of the two trading partners. If bargaining power depends on country size, the terms of trade will be in the larger country's favour. However, general equilibrium adjustments mean that the larger country may not be better off under Nash bargaining than under free trade. The smaller country is unambiguously worse off compared to free trade.

Keywords: Nash bargaining; gains from trade; Ricardian model.
JEL Classification: F11, F13.

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Abstract

Anti-globalisation protesters often claim that the gains from trade accrue primarily to large countries. This contradicts conventional trade models, which predict that small countries gain more from trade than do large countries. We first present evidence which shows that the terms of trade do indeed move in favour of countries which become larger. We then develop a model of international trade based on Ricardian comparative advantage, in which the terms of trade are derived based on the bargaining power of the two trading partners. If bargaining power depends on country size, the terms of trade will be in the larger country's favour. However, general equilibrium adjustments mean that the larger country may not be better off under Nash bargaining than under free trade. The smaller country is unambiguously worse off compared to free trade.

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1 Introduction

> "Small countries have long feared economic dominance by their larger neighbours."
>
> Donald R. Davis (1998), p. 1264.

Although there is almost universal support for free trade by economists, the average non-economist is less convinced (see Poole (2004)) for a comparison of attitudes towards trade by economists and non-economists). One of the views of the anti-globalisation protesters at the WTO conference in Seattle in 1999 and elsewhere is that smaller countries tend to get "exploited" by larger countries, who are able to impose "unfair" terms of trade. Such views are also echoed by some such as Chang (2008). However, this is exactly the opposite of standard models of international trade, in which a small country gains more from trade than does a large country. This is because a large country is more willing to trade than a small country; this willingness to trade pushes the terms of trade against a large country, leading to smaller gains from trade.

Underlying the anti-globalisation ideas is the notion that larger countries have more power than small countries, whereas in standard models of trade, large countries have less power than small countries. In the next section, we show empirically that the anti-globalisation idea has bite: there is indeed a positive association between country size and the terms of trade, in a large panel of countries from 1980 to 2014. Motivated by this finding, we proceed to develop a model in which this empirical finding holds true. In the model, when two countries trade with each other, the equilibrium price emerges as a result of Nash bargaining between the two countries. When bargaining power depends on the size of the economy, the equilibrium price (henceforth, the Nash bargaining price) is indeed one in which the terms of trade are in favour of the country with the larger economy. This is in contrast with the results of standard models, and is consistent with the empirical evidence presented in Section 2.

However, the presence of this positive association between country size and the terms of trade does not necessarily mean that the larger economy will gain more from trade than the smaller economy. The larger economy may also gain less than the smaller

economy, and may even experience a welfare loss relative to autarky[1][2]. This potential loss arises because incomplete specialisation of the larger country is the norm under Nash bargaining[3]. As the terms of trade move in favour of the larger country, those who are employed in the country's comparative disadvantage sector will lose, and they will represent an increasing fraction of the country's employment, the larger is the larger economy relative to its trading partner. Regardless of the welfare effect on the larger economy, the smaller economy is always worse off under Nash bargaining than under free trade, but better off when compared to autarky. Hence in general the Nash bargaining outcome leads to lower world welfare compared to free trade, with most of the loss being imposed on the smaller economy.

In the standard Ricardian model, incomplete specialisation of the larger country results in all the gains from trade accruing to the smaller country, with free trade prices being equal to the larger country's opportunity cost of production (as in autarky). The second main theoretical result of this paper is that the Nash bargaining prices will be different from the larger country's opportunity cost, despite incomplete specialisation. If wages are equalised between sectors due to free inter-sectoral movement of labour, this leads to profits being generated in the larger country's comparative advantage sector. If these profits are distributed to workers in the same sector, then those employed in the comparative advantage sector will gain from trade, while those employed in the comparative disadvantage sector will lose. Thus, the model is able to generate within-country distributional effects of trade, despite there being only one factor of production and no heterogeneity across firms.

This paper is related to several strands of literature. First, we follow the lead of Piccione and Rubinstein (2007) who introduce the concept of a jungle economy in which economic transactions are governed by coercion. Using a different definition of

[1] Note that this result is stronger than that of Samuelson (2004), who develops a Ricardian model of trade in which, when one country experiences a technological improvement in its comparative *dis*advantage sector, its trading partner will experience a terms of trade loss, and therefore be worse off than in the initial free trade equilibrium. However, in Samuelson's model, autarky is never welfare superior to trade.

[2] Why would a country engage in trade if it is worse off than in autarky? As will be argued below, it is possible that some agents in the economy (workers in the comparative advantage sector) will gain from trade. If those who gain from trade are better able to influence government policy than those who lose from trade, a country may engage in international trade even if it loses from trade overall.

[3] That the larger country is more diversified than the smaller country finds empirical support in Hanson (2012).

power to the one we use, they show, amongst other results, that a jungle equilibrium exists and is Pareto efficient. The paper is also related to Baldwin (1948), in which one country sets prices while the other country makes its best response to these prices. It is also related to the literature on strategic trade policy, in the sense that a policy which seems like a good idea for the larger country actually yields an inferior outcome due to general equilibrium adjustments (see Krugman (1987)). Ruffin (1988) develops a model with different types of labour in which the size of the country is irrelevant to the distribution of the gains from trade.

This paper is also related to the literature on trade policy and trade agreements (see especially Bagwell and Staiger (2002) and Grossman and Helpman (2002)). In that literature, governments bargain over tariffs and other forms of trade policies; in the present paper, governments bargain directly over the terms of trade. Broda et al (2008) find evidence in support of the idea that countries with market power in international markets set higher import tariffs. There is also a literature on the home market effect (the idea that large countries have an advantage in sectors produced under increasing returns to scale; see Krugman (1980, 1991), Helpman and Krugman (1985), but also Davis (1998) for a contrary view). Finally, in its focus on the role of country size in international trade, the paper is also related to the literature on the gravity model of trade (Anderson and van Wincoop (2003)); in that literature the focus is on the relationship between country size and the volume of trade, whereas we investigate the relationship between country size and the terms of trade.

Section 2 presents the empirical evidence in support of the idea that larger countries have more favourable terms of trade. Section 3 develops the Ricardian model with prices being determined by Nash bargaining in free trade. Section 4 presents some simulations, and Section 5 provides some concluding comments.

2 Terms of trade and the size of the economy

Our objective in this section is to show empirically that there is a positive association between the size of an economy and its terms of trade. Data for this section has been obtained from the World Bank's World Development Indicators. The main variable of interest is the Net Barter Terms of Trade, which is calculated as the percentage ratio of the export unit value index to the import unit value index, measured relative to the base year 2000. Data is available for an unbalanced panel of 194 countries from 1980 to 2014, for a total of 4,394 observations. Figure 1 shows the correlation between the Net Barter Terms of Trade and GDP at market prices in current US dollars, in

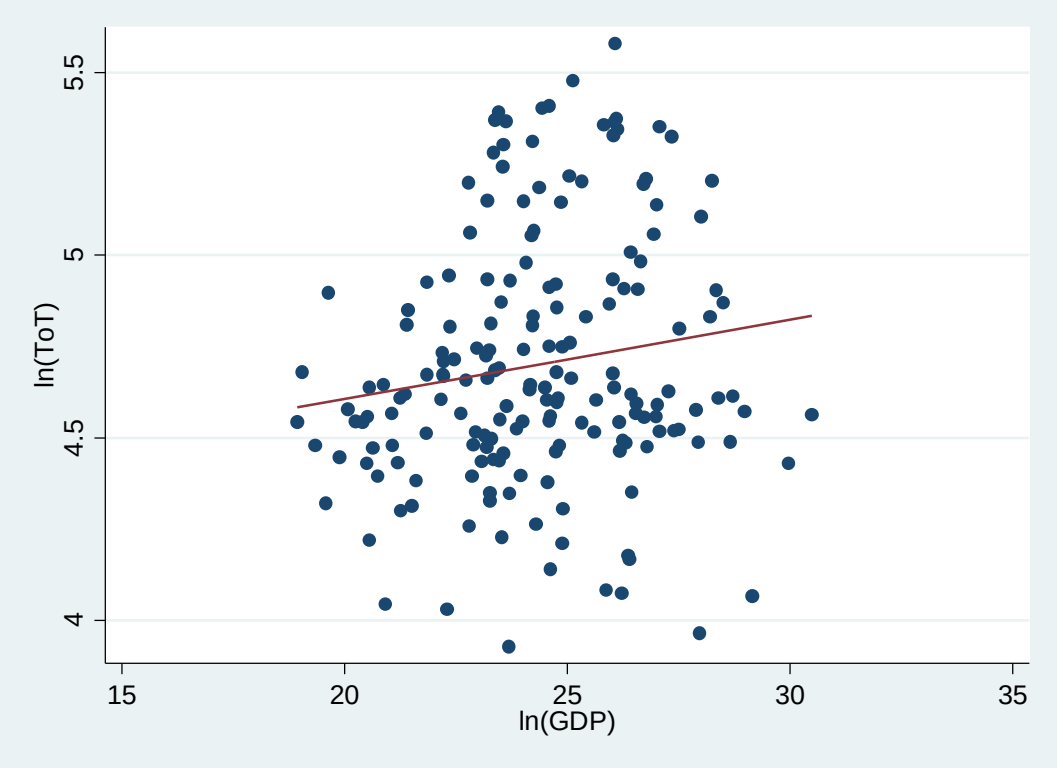
logarithms, in 2014, along with a linear best-fit line. There is a clearly positive relationship between the Net Barter Terms of Trade and GDP. The slope of the line is 0.0217, with a p-value of 0.045, and the correlation between the two variables is 0.1498.

Turning to more formal econometric evidence, we estimate the following equation, for country i in year t:

$$\ln TOT_{it} = \alpha_i + \beta_t + \gamma \ln GDP_{it} + \epsilon_{it} \quad (1)$$

In this specification, we include both country and year fixed effects, to control for unobserved time-invariant heterogeneity across countries (for example, differences in industrial structure across countries), and country-invariant heterogeneity across time (for instance, shocks which are common across countries). By controlling for both these effects, the coefficient on $\ln GDP_{it}$, γ, is identified through across-time variation within country. That is, γ shows how the terms of trade changes as a country's GDP changes.

Figure 1: Scatter of the Net Barter Terms of Trade against GDP, 2014.



Of course, the terms of trade may also change for other reasons, for example changes in the structure of the economy. To control for this, we estimate the following equation:

$$\ln TOT_{it} = \alpha_i + (\alpha_i \times time) + \beta_t + \gamma \ln GDP_{it} + \epsilon_{it} \quad (2)$$

Where we also include a country-specific time trend[4].

Table 1: Estimating the relationship between the terms of trade and the size of the economy.

	(1)	(2)
Dependent variable	$\ln TOT_{it}$	$\ln TOT_{it}$
Estimation Method	FE	FE
$\ln GDP_{it}$	0.270	0.317
	(0.057)***	(0.046)***
$\ln Debt\ Service$		
$\ln Electricity\ output$		
R-squared	0.48	0.75
Observations	4,394	4,394
Countries	194	194
Years	1980-2014	1980-2014
Country FE	Yes	Yes
Year FE	Yes	Yes
Country time trend		Yes

Notes: * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$. Standard errors clustered by country in parentheses. Estimation is via OLS with country and year fixed effects in column (1), and country and year fixed effects and country time trends in column (2).

Table 1 presents the results of these regressions, with standard errors clustered by country to control for within-country correlation in the residuals. The first column reports fixed effects results without country time trends, while the second column includes country time trends. In both columns, the coefficient on GDP is positive and highly significant. Adding a country time trend increases the size of the coefficient on GDP. The magnitude of the coefficients suggest that a 1 percent increase in the size of a country's GDP would improve its terms of trade by about 0.3 percent.

[4] Additional sensitivity analysis including different model specifications are reported in Appendix A. In addition, GDP and the terms of trade are likely to be simultaneously determined. This would bias the estimated value of γ. Since we are interested in establishing the presence of a relationship between the two variables, rather than on the direction of causation, we do not attempt to overcome the simultaneity bias through the use of instrumental variables.

3 Nash Bargaining

In this section we develop a Ricardian-type model of international trade which generates the result documented above, that larger countries have more favourable terms of trade, and derive the implications of the model. There are two countries, Home and Foreign, and two goods, 1 and 2. Labour is the only factor of production. Consumer preferences are identical across countries, and are given by:

$$U = C_1^{\alpha} C_2^{1-\alpha} \qquad 0 < \alpha < 1 \tag{3}$$

Labour is the only factor of production. Endowments of labour in the two countries are $\bar{L}$ and $\bar{L}^*$ (Foreign variables are indicated with an asterisk). Without loss of generality, let Home be larger than Foreign, $\bar{L} \geq \bar{L}^*$. Production technologies are given by:

$$\text{Home:} \qquad Q_1 = AL_1 \qquad Q_2 = L_2 \tag{4a}$$

$$\text{Foreign:} \qquad Q_1^* = L_1^* \qquad Q_2^* = AL_2^* \tag{4b}$$

Where $A > 1$ indicates that Home has a comparative (and absolute) advantage in good 1, and Foreign in good 2. All markets are perfectly competitive.

Note first that the relative prices under autarky are determined by the opportunity cost of production in each country, and are equal to the marginal rate of substitution between the two goods:

$$\frac{p_1}{p_2} = \frac{1}{A} = \frac{\alpha}{1-\alpha}\frac{C_2}{C_1} \qquad \frac{p_1^*}{p_2^*} = A = \frac{\alpha}{1-\alpha}\frac{C_2^*}{C_1^*} \tag{5}$$

Suppose that the two countries engage in trade. In the Nash bargaining framework, the difference in opportunity cost between the two countries can be divided between them, depending on their relative bargaining power. Suppose that the bargaining power depends only on the size of each country's economy pre-trade (i.e. in autarky)[5]. If the two countries reach an agreement, the resulting prices are the Nash bargaining prices $(p_1/p_2)_{NB}$, and international trade occurs. If the two countries do not reach an agreement, then there is no trade, and the two countries revert to their autarkic relative prices as given in equation (5). Bargaining is assumed to be costless.

Implicit in the foregoing discussion is the assumption that there is collective decision-making. Even though there are many, perfectly competitive firms, they delegate the

[5] It is also possible to solve the model under the assumption that bargaining power depends on the size of the economy after bargaining, but the results do not differ much.

price-setting decision to the national government. The Nash bargaining problem is to choose the Nash bargaining prices to maximise the Nash product[6]:

$$\max\left[\left(\frac{p_1}{p_2}\right)_{NB}-\left(\frac{p_1}{p_2}\right)\right]^{w_A\bar{L}}\left[\left(\frac{p_1}{p_2}\right)_{NB}-\left(\frac{p_1^*}{p_2^*}\right)\right]^{w_A^*\bar{L}^*} \tag{6}$$

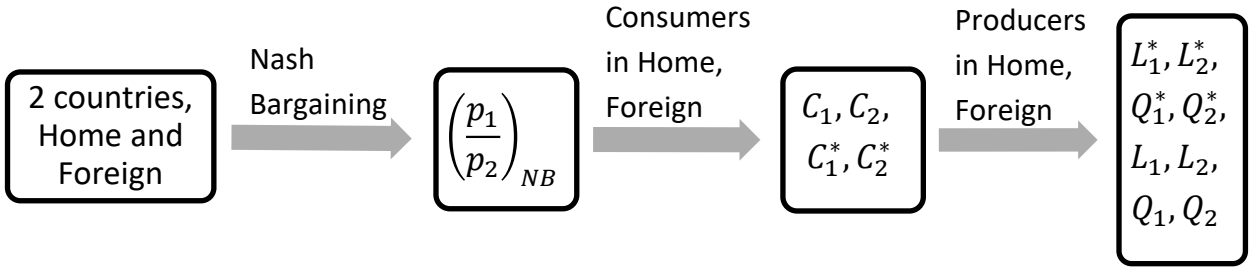
Where $w_A\bar{L}$ is Home GDP in autarky, and $w_A^*\bar{L}^*$ is Foreign GDP in autarky. Differentiating with respect to $(p_1/p_2)_{NB}$, setting equal to zero, and solving for $(p_1/p_2)_{NB}$ gives:

$$\left(\frac{p_1}{p_2}\right)_{NB}=\left(\frac{w_A^*\bar{L}^*}{w_A\bar{L}+w_A^*\bar{L}^*}\right)\left(\frac{p_1}{p_2}\right)+\left(\frac{w_A\bar{L}}{w_A\bar{L}+w_A^*\bar{L}^*}\right)\left(\frac{p_1^*}{p_2^*}\right) \tag{7a}$$

$$=\frac{S_A^*}{A}+AS_A=\frac{A^2S_A+S_A^*}{A} \tag{7b}$$

Where $S_A=w_A\bar{L}/(w_A\bar{L}+w_A^*\bar{L}^*)$ and $S_A^*=w_A^*\bar{L}^*/(w_A\bar{L}+w_A^*\bar{L}^*)$ are the shares of the two countries in world GDP, in autarky. That is, the relative price under Nash bargaining lies somewhere between the autarkic prices of the two countries, with the weights given by the relative sizes of the two countries' economies. If the Home economy is larger than Foreign economy, the free trade price will be closer to the autarkic price of Foreign.

Figure 1: Timeline of activities in the Nash Bargaining model.



3.1 The sectoral allocation of labour

In the conventional analysis (as laid out in Appendix B), free trade prices are determined by the simultaneous determination of demand and supply. As a result, all markets clear, and each country chooses a production bundle which maximises the

[6] Instead of bargaining over prices, it may be tempting to set up the bargaining game so that countries bargain over national welfare, so that the larger country would end up with higher welfare than the small country. We defer this discussion to Section 4, where our simulations will help explain why it is not possible to bargain over welfare.

value of its output at free trade prices. This is no longer the case under Nash bargaining. With prices no longer being determined by market forces, if consumers choose their consumption bundle to maximise their utility given the Nash bargaining prices, then producers may have to change the quantities produced in order to clear the market. We make this assumption in what follows. We also make the further assumption that producers in both countries make their production decisions simultaneously. Figure 1 shows the timing of events in the model.

Since the Nash bargaining prices are not equal to either country's autarkic prices, producers in both countries would seek to specialise in their comparative advantage product. However, they will not be able to do so, since the Nash bargaining relative price of good 1 is higher than the market clearing price. The optimal production bundle will involve the smaller country Foreign being completely specialised in its comparative advantage good 2, while the larger country Home will be incompletely specialised. That is, Nash bargaining moves the world economy away from the first-best allocation, and the second-best allocation may involve further deviations from the first-best (Lipsey and Lancaster (1956))[7].

To formalise the remark above, from the production functions, total world output of goods 1 and 2 are given by:

$$Q_1^W = AL_1 \qquad\qquad Q_2^W = L_2 + AL_2^* = \overline{L} - L_1 + A\overline{L}^* \tag{8}$$

Since output equals consumption for the world and relative prices are equal to Home's autarkic prices, substituting into the consumer equilibrium condition (5) gives the labour allocation in Home between the two goods:

$$AL_1 = \left(\frac{\alpha}{1-\alpha}\right)\left(\frac{p_2}{p_1}\right)_{NB}\left[\overline{L} - L_1 + A\overline{L}^*\right] \tag{9a}$$

$$L_1 = \left(\frac{\alpha}{1-\alpha}\right)\left(\frac{p_2}{p_1}\right)_{NB}\left(\overline{L} + A\overline{L}^*\right)\left[A + \left(\frac{\alpha}{1-\alpha}\right)\left(\frac{p_2}{p_1}\right)_{NB}\right]^{-1} \tag{9b}$$

$$L_2 = \overline{L} - L_1 \tag{9c}$$

Equation (9b) shows that the division of labour into the two sectors depends on the Nash bargaining price, and the endowments of the two countries. Comparing equation

[7] To show that this must be the equilibrium allocation of production, consider a small deviation for the smaller country Foreign. This reduces Foreign's output of good 2, and increases its output of good 1. However, this must be met by an equal and opposite adjustment in Home's output (since prices and consumption are fixed). But such an adjustment must reduce the total value of world output, since each country is being asked to increase its output of its comparative disadvantage good, at the expense of its comparative advantage good.

(9a) with the equivalent equation under free trade ($AL_1 = \left(\frac{\alpha}{1-\alpha}\right) A\left[\overline{L} - L_1 + A\bar{L}^*\right]$)[8], we can establish that $L_1^{NB} < L_1^{FT}$ (hence $L_2^{NB} > L_2^{FT} \geq 0$) since $(p_2/p_1)_{NB} < A$. That is, Home allocates more labour to good 2 under Nash bargaining than under free trade. In addition, the larger country Home is *always* incompletely specialised; the higher relative price of good 1 reduces relative consumption of good 1, which in turn requires a larger world output of good 2 than can be produced by the smaller country Foreign alone. The implications of this incomplete specialisation will be discussed further when we present simulations of the model in Section 4.

3.2 Consumption, utility and trade

Here, we solve for consumption and hence trade volume between the two countries. The Foreign country's GDP is equal to the value of its output:

$$GDP_{NB}^* = A(p_2)_{NB}\bar{L}^* \tag{10}$$

Per capita consumption of the two goods in Foreign is therefore:

$$C_1^* = \frac{\alpha GDP^*}{(p_1)_{NB}\bar{L}^*} = \alpha A\left(\frac{p_2}{p_1}\right)_{NB} \qquad C_2^* = \frac{(1-\alpha)GDP^*}{(p_2)_{NB}\bar{L}^*} = (1-\alpha)A \tag{11}$$

Note that, comparing Nash bargaining consumption with free trade consumption ($C_1^* = \alpha A^2$ and $C_2^* = (1-\alpha)A$), consumption of good 2 is the same, whereas Nash bargaining consumption of good 1 is always less than free trade consumption since $(p_2/p_1)_{NB} < A$. The smaller, completely specialised Foreign country is worse off under Nash bargaining than under free trade. Conversely, Foreign is better off under Nash bargaining than under autarky, since autarkic consumption is $C_1^* = \alpha$ and $C_2^* = (1-\alpha)A$.

World market clearing allows us to back out Home per capita consumption as the difference between world output and total Foreign consumption, divided by the number of Home consumers:

$$C_1 = \left(\frac{1}{\bar{L}}\right)(AL_1 - C_1^*\bar{L}^*) \tag{12a}$$

$$C_2 = \left(\frac{1}{\bar{L}}\right)[A\bar{L}^* + L_2 - (1-\alpha)A\bar{L}^*] = \left(\frac{1}{\bar{L}}\right)[L_2 + \alpha A\bar{L}^*] \tag{12b}$$

Since $L_2^{NB} > L_2^{FT}$, we have $C_2^{NB} > C_2^{FT}$, and since $(p_2/p_1)_{NB} < A$, we have $C_1^{NB} < C_2^{FT}$. That is, Home consumers consume more of good 2 and less of good 1 under Nash bargaining than under free trade, because the relative price of good 1 is higher under

[8] All derivations of the expressions from the standard model are collected in Appendix B.

Nash bargaining than under free trade. Solving explicitly for C_1 and C_2 and substituting into the utility function (3) gives:

$$U_{NB} = \left\{\frac{(A^2S_A+S_A^*)(\bar{L}+\alpha A\bar{L}^*)-\alpha A\bar{L}^*}{\bar{L}[(1-\alpha)(A^2S_A+S_A^*)+\alpha]}\right\}\left[\left(\frac{\alpha A}{A^2S_A+S_A^*}\right)^{\alpha}(1-\alpha)^{1-\alpha}\right] \quad (13)$$

Compared with utility under autarky (and free trade, assuming Home is incompletely specialised) $U_A = U_{FT} = (\alpha A)^{\alpha}(1-\alpha)^{1-\alpha}$, welfare under Nash bargaining is ambiguous; on the one hand, the first term on the right hand side of equation (13) is always greater than 1. On the other hand, the second term is less than U_A, since $A^2S_A + S_A^* > 1$. Thus it is possible that international trade with prices determined by Nash bargaining, leads to a welfare loss for the larger Home country, relative to both free trade and autarky.

The volume of trade is the sum of the difference between Foreign production and consumption of the two goods:

$$VT_{NB} = \alpha A\bar{L}^*\left[1+\left(\frac{p_2}{p_1}\right)_{NB}\right] \quad (14)$$

The volume of trade is lower under Nash bargaining than under free trade, since $VT_{FT} = \alpha A\bar{L}^*(1+A)$.

3.3 Winners and losers from trade

In the Nash bargaining equilibrium the smaller country Foreign is completely specialised in good 2, whereas the larger country Home is incompletely specialised. Given free movement of labour between sectors, workers in the two sectors in Home will be paid identical wage rates. Hence the zero profit condition in sector 2 implies:

$$w_1 = w_2 = (p_2)_{NB} \quad (15)$$

It will be convenient to normalise this to unity. However, there exist supernormal profits in sector 1, since:

$$\pi_1 = (p_1)_{NB}Q_1 - w_1L_1 = ((p_1)_{NB}A - (p_2)_{NB})L_1 > 0 \quad (16)$$

Where the second equality comes from substituting from the production function (4a) and equation (15), and the inequality comes from $(p_1/p_2)_{NB} > (p_1/p_2) = 1/A$. There are at least three possible ways in which these supernormal profits may be distributed. The first possibility is that the profits are distributed equally to all workers in Home. In this case, all workers have the same total income, and the outcomes are as in the previous subsection.

A second possible way in which the profits may be distributed, is to workers in sector 1 only. In this case, from equations (15) and (16), total income per worker (wages plus profits) in sector 1 is, making use of the normalisation above,

$$\omega_1 = A(p_1/p_2)_{NB} > 1 = w_2 \tag{17}$$

Would this not encourage workers in sector 2 to move to sector 1? No, because as shown in Figure 1, labour is allocated to the two sectors *after* consumption has been decided, so any additional workers in sector 1 would produce output which is not sold (and hence has zero value). They would be better off remaining in sector 2.

Given homothetic preferences, equation (17) implies that each worker in sector 1 also consumes ω_1/w_2 times as much of each good as each worker in sector 2. Total consumption in Home can be divided into consumption by the workers in the two sectors:

$$C_1\overline{L} = L_1C_{1L_1} + L_2C_{1L_2} = L_1\left(\frac{\omega_1}{w_2}\right)C_{1L_2} + L_2C_{1L_2} = C_{1L_2}\left[L_1\left(\frac{\omega_1}{w_2}\right) + L_2\right] \tag{18}$$

Hence we can obtain consumption of the two goods by workers in each sector:

$$C_{1L_2} = C_1\overline{L}\left[L_1\left(\frac{\omega_1}{w_2}\right) + L_2\right]^{-1} = \frac{C_1w_2\overline{L}}{\omega_1L_1+w_2L_2} < C_1 \tag{19a}$$

$$C_{2L_2} = C_2\overline{L}\left[L_1\left(\frac{\omega_1}{w_2}\right) + L_2\right]^{-1} = \frac{C_2w_2\overline{L}}{\omega_1L_1+w_2L_2} < C_2 \tag{19b}$$

$$C_{1L_1} = C_1\overline{L}\left(\frac{\omega_1}{w_2}\right)\left[L_1\left(\frac{\omega_1}{w_2}\right) + L_2\right]^{-1} = \frac{C_1\omega_1\overline{L}}{\omega_1L_1+w_2L_2} > C_1 \tag{19c}$$

$$C_{2L_1} = C_2\overline{L}\left(\frac{\omega_1}{w_2}\right)\left[L_1\left(\frac{\omega_1}{w_2}\right) + L_2\right]^{-1} = \frac{C_2\omega_1\overline{L}}{\omega_1L_1+w_2L_2} > C_2 \tag{19d}$$

Where the inequalities reflect the fact that $\omega_1 > w_2$. Thus workers in sector 1 earn and consume more than workers in sector 2; our simulations in Section 4 will shed more light on how these consumption levels compare with autarkic consumption.

A final possible way in which to distribute the supernormal profits in sector 1, is that it is wasted in rent-seeking or lobbying activities, as is sometimes assumed in the trade policy literature (see Bagwell and Staiger (2002), Grossman and Helpman (2002)). If this is the case, then the remaining wage income implies low consumption levels by workers in both sectors, as given by equations (19a) and (19b).

Given free trade in goods, the relative wage rate in the Foreign country is:

$$\frac{w^*}{w_2} = A \gtrless \frac{\omega_1}{w_2} \qquad \text{if} \qquad \left(\frac{p_1}{p_2}\right)_{NB} \lesseqgtr 1 \tag{20}$$

That is, Foreign wages are always higher than Home wages in sector 2, and may also be higher than Home income in sector 1, ω_1 (under scenario 2 above), if the Nash bargaining prices are sufficiently low.

4 Simulations

To make the results clearer, we turn to simulations. We simulated the model with the following parameter values: $A = 2, \alpha = 0.5, \bar{L} + \bar{L}^* = 24$. Wages in Home in sector 2 are normalised to unity. Fixing the total labour endowment in the world enables us to focus on the impact of relative sizes on world welfare. The results are summarised in Figures 2 and 3. Figure 2(a) shows that, as Home becomes larger relative to Foreign, the relative price of good 1 (in which Home has a comparative advantage) falls under free trade, until the Home country is so large that it is incompletely specialised under free trade, and the relative price is equal to Home's autarkic relative price. However, under Nash bargaining, the relative price of good 1 *rises* as Home becomes larger. This figure shows the key effect of introducing Nash bargaining: it shifts the terms of trade in favour of the larger country, relative to free trade.

Note another interesting feature of Figure 2(a). When $\bar{L} = 12$, this implies that $\bar{L}^* = 12$ as well. However, this does not mean that $(p_1/p_2)_{NB} = 1$. To see why, note that the formula for the Nash bargaining price (equation (7a)) is a weighted average of the two countries' autarkic prices. Suppose that the two economies are the same size in autarky, so the weights are the same; then given $A = 2$, the Nash bargaining price will be $(p_1/p_2)_{NB} = (0.5)(0.5) + (0.5)(2) = 1.25$.[9] But this implies that, after trade, if both countries are completely specialised, Home would have a larger economy than Foreign: $(p_1)_{NB}A\bar{L} > (p_2)_{NB}A\bar{L}^*$. As shown in the discussion around equation (10), this implies that Home would be incompletely specialised, even when the two countries have the same labour endowment.

Figure 2(b) shows the welfare effect of this shift in the terms of trade. When Home is only slightly bigger than Foreign, Home gains more from trade than does Foreign; this is the opposite of the standard result. As Home becomes larger relative to Foreign, both countries' welfare decreases, with Home's welfare decreasing faster than Foreign's. The reason for this is that, as Home becomes larger relative to Foreign, it uses an increasing share of its labour in producing good 2, so the improvement in Home's terms of trade actually harms the Home workers who produce good 2. When Home becomes

[9] More formally, the free trade prices are based on the (weighted) *geometric mean* of the autarkic prices in the two countries, whereas the Nash bargaining prices are based on the (weighted) *arithmetic mean* of the autarkic prices.

incompletely specialised in free trade ($\overline{L} = 16$), Foreign gains more from trade under Nash bargaining than Home. Indeed, when Home becomes very large relative to Foreign, Home is worse off under Nash bargaining than under free trade (and autarky). Figures 2(c) and 2(d) show that both the volume of trade and world welfare are lower under Nash bargaining than under free trade.

Figure 2: Comparing Nash bargaining and free trade.

Figure 2(a): Relative prices.

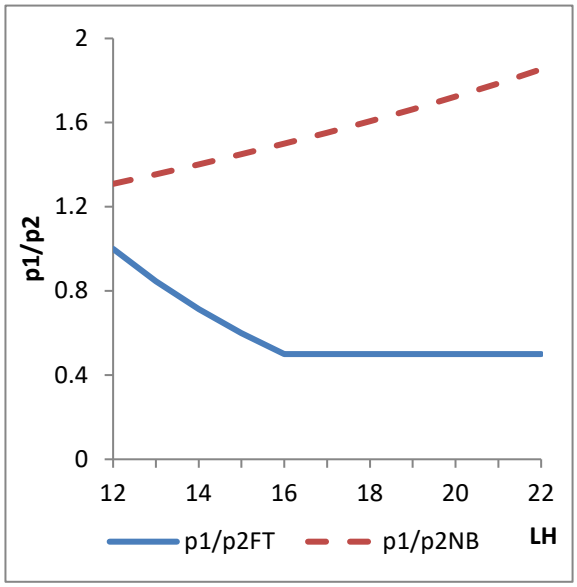


Figure 2(b): Gains from trade.

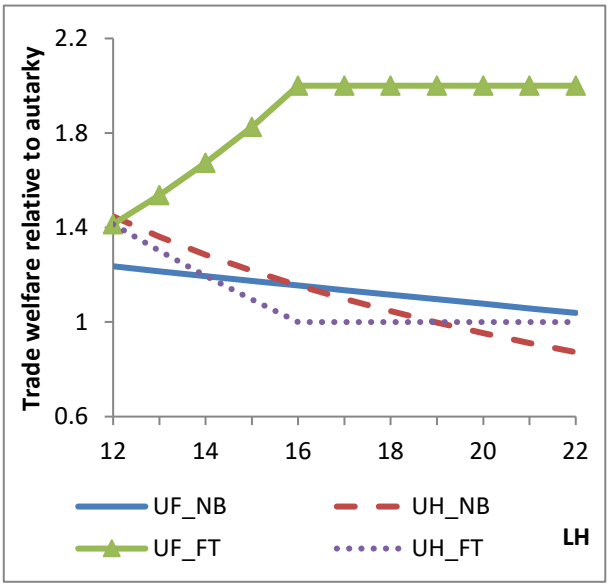


Figure 2(c): Volume of trade.

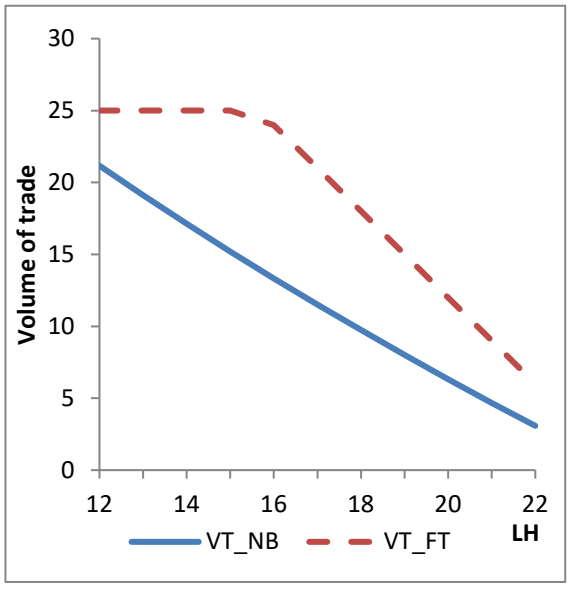
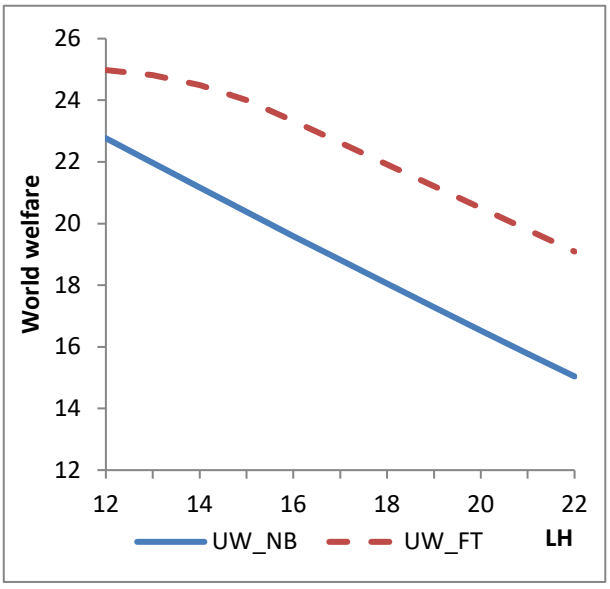


Figure 2(d): World welfare.



Notes: Parameter values assumed: $A = 2, \alpha = 0.5, \overline{L} + \overline{L}^* = 24$.

Figure 3: Details of the Nash bargaining equilibrium.

Figure 3(a): w_1/w_2 and GDP per capita in Home

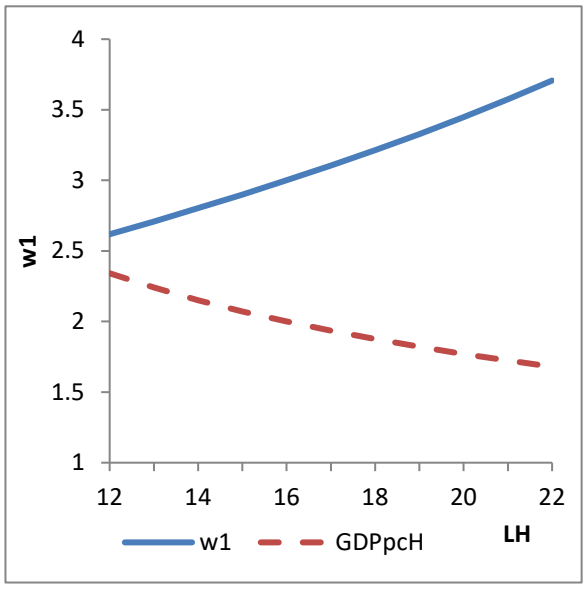


Figure 3(b): $L_1/\overline{L}$

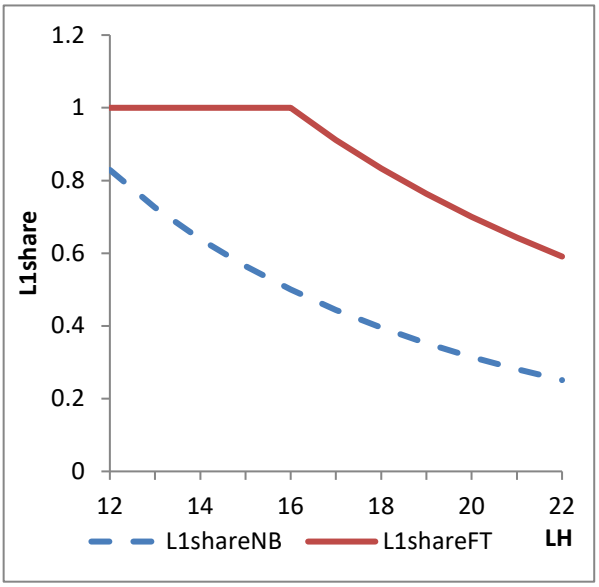


Figure 3(c): Consumption of good 1.

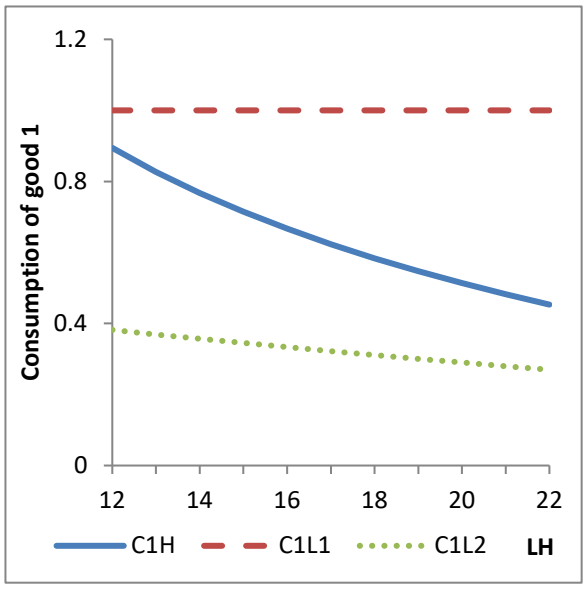
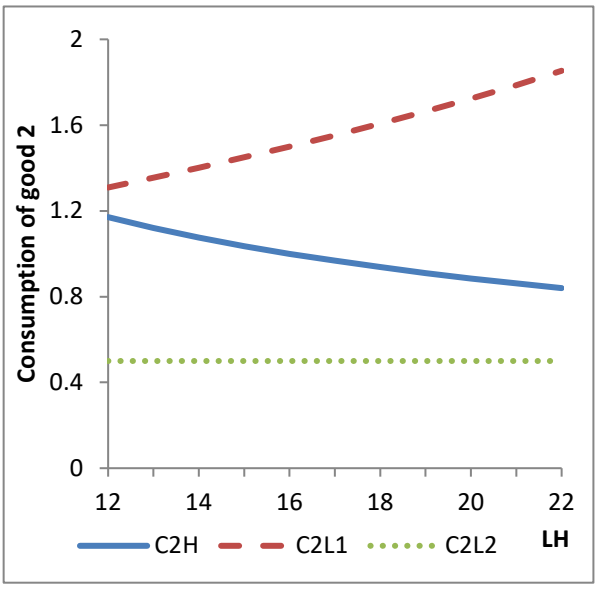


Figure 3(d): Consumption of good 2.



Notes: Parameter values assumed: $A = 2, \alpha = 0.5, \overline{L} + \overline{L}^* = 24$.

An additional feature of Figure 2(b) is that, as the larger country Home becomes larger relative to Foreign, its welfare falls, regardless of whether relative prices are rising or falling[10]. This seems puzzling at first, but the reason for this is intuitive. Welfare is a

[10] This explains why we have not attempted to set up the Nash bargaining model with countries bargaining over national welfare: there does not appear to be a price mechanism that would allow the larger country to gain welfare when it becomes larger. This is in addition to the fact that prices are

function of real income, that is, prices and output. Under free trade, as a country grows larger, its terms of trade move against it, and this more than offsets the increase in output from increased size. Under Nash bargaining, although the terms of trade move in favour of the larger country, it is forced to produce more of its comparative disadvantage good (as shown in the labour allocations in Figure 3(b)), hence reducing the value of its output.

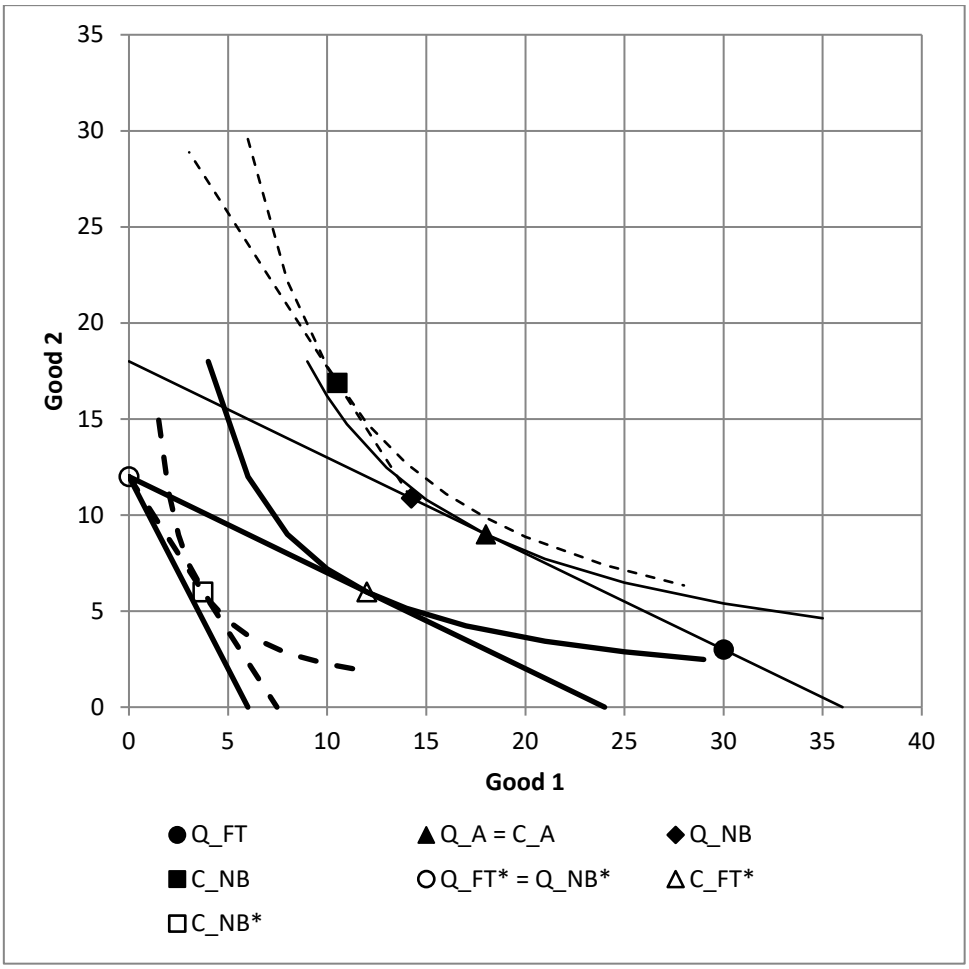
Figure 3 provides additional detail on the outcomes under Nash bargaining, under the assumption (as in section 3.3) that the profits in sector 1 are distributed only to workers in sector 1. Figure 3(a) shows that the larger is Home, the higher is the relative wage in sector 1 as compared to sector 2. However, at the same time GDP per capita is decreasing; this is because an increasing fraction of Home labour is allocated to sector 2. This is shown in Figure 3(b). If Home is not too large relative to Foreign, Home will be completely specialised in good 1 under free trade, whereas under Nash bargaining, Home is always incompletely specialised, and always allocates a lower share of labour to sector 1 than under free trade. Indeed, by the time Home starts to allocate labour to good 2 under free trade, under Nash bargaining it already allocates half of its labour in good 2.

Figures 3(c) and 3(d) show consumption of both goods by workers in the two sectors in Home (note that the autarkic consumption levels for Home are $C_{1A} = 1.0$ and $C_{2A} = 0.5$). Since $\omega_1 > w_2$, workers in sector 1 always consume more of both goods than workers in sector 2. As Home becomes larger relative to Foreign, the relative price of good 1 rises, so consumption shifts towards good 2, and workers in sector 1 are better off. However, because an increasing fraction of Home labour is allocated to sector 2, overall consumption of both goods falls as Home becomes larger relative to Foreign. Workers in sector 1 are better off than under autarky; they consume the same amount of good 1, but more of good 2. On the other hand, workers in sector 2 are worse off than under autarky; they consume the same amount of good 2, but less of good 1. Hence our simulations make it clear that those who remain in the comparative advantage sector of the larger Home country will gain from Nash bargaining relative to free trade (and autarky), while those in the comparative disadvantage sector are worse off. This may be what creates an incentive for the Home government to engage in Nash bargaining, if the Home government is controlled by those in sector 1, even though the country as a whole may experience a welfare loss. Workers in Foreign are

observable, whereas utility is not, so in practice bargaining over prices would be much easier than bargaining over utilities.

always worse off under Nash bargaining than under free trade, but better off than under autarky (Figure 2(b)).

Figure 4: Production, consumption and welfare under free trade and Nash bargaining.



Notes: The fainter lines are for Home, the bold lines for Foreign. The solid lines and curves are for autarky and free trade, while the dashed lines and curves are for the Nash bargaining outcomes. Parameter values assumed: $A = 2, \alpha = 0.5, \overline{L} = 18,\ \overline{L}^* = 6$.

Figure 4 shows, in a conventional diagram of the production possibilities frontier and indifference curves, the production, consumption and welfare of the model when $\overline{L} = 18$ and $\overline{L}^* = 6$. The fainter lines are for Home, the bold lines for Foreign. The solid lines and curves are for the free trade equilibrium while the dashed lines and curves are for the Nash bargaining outcomes. The circles indicate free trade production points, the triangles free trade consumption points, the diamonds Nash bargaining production points, and the squares, Nash bargaining consumption points. Figure 4 illustrates all the results we have seen previously: the smaller country Foreign is much worse off as a result of Nash bargaining compared to free trade, while the larger country Home is slightly better off. Both countries still gain relative to autarky, although as noted above

this is not a general result. Relative to the free trade outcome, under Nash bargaining the larger country Home allocates much more of its labour towards good 2. To improve Home welfare under Nash bargaining, the Home government may consider introducing a subsidy on the consumption of good 1 and a tax on the consumption of good 2; this would have the effect of shifting some Home labour into good 1, and likely lead to increased welfare.

5 Conclusions

This paper develops a model of international trade based on Ricardian comparative advantage, in which free trade prices are determined, not by market forces, but by governments bargaining. The bargaining power of a country depends on the size of its economy. As a result, and unlike in standard trade models, free trade prices are biased in favour of the larger country. We find empirical support for the prediction that larger countries have more favourable terms of trade. Despite this, the larger country need not necessarily gain from trade, because the equilibrium implies that the larger country will be incompletely specialised, and hence allocate some of its labour to its less productive (and now disadvantaged) sector. Hence our results demonstrate once again how general equilibrium adjustment may influence our evaluation of a policy which appears to be beneficial for a country in partial equilibrium. The real cost of the Nash bargaining approach falls on the smaller country, which is unambiguously worse off than under free trade (albeit still better off than under autarky).

In this paper we have made use of the one-factor, perfect competition model of trade based on Ricardian comparative advantage. Even with such a simple setup, the model yields some interesting additional results. For example, the volume of trade is lower than would be predicted by the standard model, and so may go some way towards addressing Trefler's (1995) case of the missing trade. It also yields lower gains from trade than in the standard model, and hence may speak to the recent literature on the gains from trade (e.g. Costinot and Rodriguez-Clare (2014), Melitz and Redding (2014)).

However, it is possible to argue that the results of the model hold more generally for models in which the gains from trade at least partly arise from differences in relative prices between autarky and free trade. For instance, this would be true for the Heckscher-Ohlin model. It would also be true for the model of international trade under monopolistic competition with non-CES utility (as in Krugman 1979, but not Krugman 1980, where CES utility implies that firms charge the same prices both before and after

trade). In these models, as with the present model, the standard result is that the terms of trade are more favourable to the small country than to the large one. This result would be overturned under Nash bargaining, and may lead to other interesting results.

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Appendix A: Additional regression results

In this Appendix we report the results of two additional sensitivity analyses which are not reported in the text. First, Figure 1 suggests a nonlinear relationship between (the natural log of) GDP and the terms of trade. We therefore include a quadratic term for GDP in the regression equation:

$$\ln TOT_{it} = \alpha_i + \beta_t + \gamma_1 \ln GDP_{it} + \gamma_2 (\ln GDP_{it})^2 + \epsilon_{it} \quad \text{(A1)}$$

A significant estimate of γ_2 would indicate the presence of a nonlinear relationship. The second sensitivity analysis we report here, is to include a lagged dependent variable in the model, giving:

$$\ln TOT_{it} = \alpha_i + \beta_t + \gamma_1 \ln GDP_{it} + \gamma_3 \ln TOT_{it-1} + \epsilon_{it} \quad \text{(A2)}$$

The idea behind including the lagged dependent variable is that the best predictor of the current terms of trade, is the previous terms of trade. The lagged dependent variable would also capture the effects of other variables which may have been omitted from the analysis. It is well-known (see Baltagi (2013)) that including a lagged dependent variable leads to biased fixed effects estimates (the "Nickell" bias, Nickell (1981)). However, as Judson and Owen (1999) note, the bias decreases in size the larger the time dimension of the dataset. Since our dataset has a relatively large time dimension, we make use of the same estimation methods as in the text.

Table A1: Additional regression results

	(1)	(2)	(3)	(4)
Dependent variable	$\ln TOT_{it}$	$\ln TOT_{it}$	$\ln TOT_{it}$	$\ln TOT_{it}$
	FE	FE	FE	FE
$\ln GDP_{it}$	0.276	-0.061	0.036	0.097
	(0.295)	(0.410)	(0.012)***	(0.017)***
$(\ln GDP_{it})^2$	-0.000	0.008		
	(0.006)	(0.009)		
$\ln TOT_{it-1}$			0.865	0.709
			(0.014)***	(0.020)***
R-squared	0.48	0.75	0.87	0.88
NxT	4,394	4,394	4,203	4,203
N	194	194	192	192
T	35	35	35	35
Country FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Country time trend		Yes		Yes

Notes: * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$. Standard errors clustered by country in parentheses. Estimation is via OLS with country and year fixed effects and country time trends.

The results are reported in Table A1. In columns (1) and (2), there is no evidence of any nonlinear relationship between the terms of trade and GDP. The apparent nonlinearity in Figure 4 has been absorbed by the country and year fixed effects in Table A1. In columns (3) and (4), lagged terms of trade, as expected, have a large and highly significant effect on current terms of trade. That the coefficient is close to but less than 1 indicates evidence of mean-reversion. Including lagged terms of trade in the regression reduces the magnitude of the coefficient on GDP, but does not change the sign or significance of the coefficient; GDP remains positively and significantly associated with the terms of trade.

Appendix B: The model in autarky and free trade

In this Appendix we show the results of the standard Ricardian model under both autarky and free trade.

B.1 Autarky

With perfectly competitive markets and free movement of labour between sectors in a country, there is a single equilibrium wage rate in each country. From the firm's zero profit condition, we have the relationship between prices and wages:

$$w = p_1 A = p_2 \qquad w^* = p_1^* = p_2^* A \tag{B1}$$

Substituting this into the consumer's first order condition gives the relationship between relative prices, productivity, and relative consumption:

$$\frac{p_1}{p_2} = \frac{1}{A} = \frac{\alpha}{1-\alpha}\frac{C_2}{C_1} \qquad \frac{p_1^*}{p_2^*} = A = \frac{\alpha}{1-\alpha}\frac{C_2^*}{C_1^*} \tag{B2}$$

Since consumption equals output in autarky, substituting from the production functions and labour market clearing gives the labour used in each sector:

$$L_2 = \bar{L} - L_1 = \frac{1-\alpha}{\alpha}L_1 \quad \leftrightarrow \quad L_1 = \alpha\bar{L} \qquad L_2 = (1-\alpha)\bar{L} \tag{B3a}$$

$$L_1^* = \alpha\bar{L}^* \qquad L_2^* = (1-\alpha)\bar{L}^* \tag{B3b}$$

The share of good 1 in consumer expenditure is α. Hence the per capita quantity of good 1 consumed is:

$$C_1 = \frac{\alpha w}{p_1} = \alpha A \qquad C_1^* = \frac{\alpha w^*}{p_1^*} = \alpha \tag{B4}$$

and the per capita quantity of good 2 consumed is:

$$C_2 = \frac{(1-\alpha)w}{p_2} = 1-\alpha \qquad C_2^* = \frac{(1-\alpha)w^*}{p_2^*} = (1-\alpha)A \tag{B5}$$

Substituting these into the utility function gives:

$$U_A = (\alpha A)^\alpha (1-\alpha)^{1-\alpha} \qquad U_A^* = \alpha^\alpha [(1-\alpha)A]^{1-\alpha} \tag{B6}$$

B.2 Free trade under complete specialisation

Suppose that each country is specialised in its comparative advantage good: Home in good 1, and Foreign in good 2. Then the free trade relative price will be:

$$\left(\frac{p_1}{p_2}\right)_{FT} = \frac{\alpha}{1-\alpha}\frac{\bar{L}^*}{\bar{L}} \tag{B7}$$

Notice that, all else being equal, the larger is a country, the lower will be the relative price of the good which it exports. Note also that, from equation (B1) relating prices to wages, the relative wage between the two countries is also equal to the relative price in equation (B7).

Since Home is specialised in good 1, the quantity of good 1 consumed is the same as in autarky, while the rest is exported to Foreign:

$$C_1 = \frac{\alpha w}{p_1} = \alpha A \qquad\qquad C_1^* = \frac{\alpha w^*}{p_1} = \alpha A\left(\frac{p_2}{p_1}\right)_{FT} \tag{B8}$$

Now, however, Home does not produce good 2, and has to import it from Foreign at the free trade price. Hence, the quantity of good 2 consumed in the two countries is:

$$C_2 = (1-\alpha)\left(\frac{w}{p_2}\right) = (1-\alpha)A\left(\frac{p_1}{p_2}\right)_{FT} \tag{B9a}$$

$$C_2^* = (1-\alpha)\left(\frac{w^*}{p_2}\right) = (1-\alpha)A \tag{B9b}$$

Hence utility under free trade is:

$$U_{FT} = (\alpha A)^{\alpha}\left[(1-\alpha)A\left(\frac{p_1}{p_2}\right)_{FT}\right]^{1-\alpha} \tag{B10a}$$

$$U_{FT}^* = \left[\alpha A\left(\frac{p_2}{p_1}\right)_{FT}\right]^{\alpha}[(1-\alpha)A]^{1-\alpha} \tag{B10b}$$

Comparing utility under autarky with utility under free trade, we have:

$$G_{FT} = \frac{U_{FT}}{U_A} = \left[A\left(\frac{p_1}{p_2}\right)_{FT}\right]^{1-\alpha} = \left[A\frac{\alpha}{1-\alpha}\frac{\bar{L}^*}{\bar{L}}\right]^{1-\alpha} \tag{B11a}$$

$$G_{FT}^* = \frac{U_{FT}^*}{U_A^*} = \left[A\left(\frac{p_2}{p_1}\right)_{FT}\right]^{\alpha} = \left[A\frac{1-\alpha}{\alpha}\frac{\bar{L}}{\bar{L}^*}\right]^{\alpha} \tag{B11b}$$

The gains from trade are larger, the smaller is the country, and the greater the technological difference between the two countries.

With both countries completely specialised, Home produces $A\bar{L}$ units of good 1, and consumes $\alpha A\bar{L}$ units, hence exports $(1-\alpha)A\bar{L}$ units of good 1. It does not produce good 2, but consumes (hence imports) $\alpha A\bar{L}^*$ units of good 2. Therefore the volume of trade is:

$$VT_{FT} = (1-\alpha)A\bar{L} + \alpha A\bar{L}^* \tag{B12}$$

B.3 Free trade under incomplete specialisation

If one country is much larger than the other, then in free trade the larger country will be incompletely specialised, while the smaller country will be specialised in its comparative advantage good. Without loss of generality, let Home be the larger country. Then, Home will be incompletely specialised if

$$\frac{\alpha}{1-\alpha}\frac{\bar{L}^*}{\bar{L}} < \frac{1}{A} \qquad \leftrightarrow \qquad \bar{L} > A\left(\frac{\alpha}{1-\alpha}\right)\bar{L}^* \tag{B13}$$

The smaller country Foreign is specialised in good 2, while the larger country Home produces both goods 1 and 2. Therefore, free trade prices are equal to Home's autarkic prices given in equation (B2). And, since goods prices are equalised across countries, we have $w_1 = w_2 = w^*/A$; that is, if $A > 1$, (nominal and real) wages are higher in Foreign than in Home.

From the production functions, total world output of goods 1 and 2 are given by:

$$Q_1^W = AL_1 \qquad Q_2^W = L_2 + AL_2^* = \bar{L} - L_1 + A\bar{L}^* \tag{B14}$$

Since output equals consumption for the world and relative prices are equal to Home's autarkic prices, substituting into the consumer equilibrium condition (B2) gives:

$$AL_1 = \left(\frac{\alpha}{1-\alpha}\right)A\left[\bar{L} - L_1 + A\bar{L}^*\right] \tag{B15}$$

Which gives the labour allocation in Home between the two goods:

$$L_1 = \alpha\left[\bar{L} + A\bar{L}^*\right] \qquad L_2 = \bar{L} - L_1 = \bar{L} - \alpha\left[\bar{L} + A\bar{L}^*\right] \tag{B16}$$

Substituting these into the production functions gives the quantity of the two goods produced. Next, we solve for consumption and hence trade volume between the two countries. The Foreign country's GDP is equal to the value of its output:

$$GDP^* = Ap_2\bar{L}^* \tag{B17}$$

Per capita consumption of the two goods in Foreign is therefore:

$$C_1^* = \frac{\alpha GDP^*}{p_1\bar{L}^*} = \alpha A^2 \qquad C_2^* = \frac{(1-\alpha)GDP^*}{p_2\bar{L}^*} = (1-\alpha)A \tag{B18}$$

Hence, making use of world market clearing, we have:

$$C_1 = \left(\frac{1}{\bar{L}}\right)(AL_1 - C_1^*\bar{L}^*) = \alpha A \tag{B19a}$$

$$C_2 = \left(\frac{1}{\bar{L}}\right)[A\bar{L}^* + L_2 - C_2^*\bar{L}^*] = \left(\frac{1}{\bar{L}}\right)[L_2 + \alpha A\bar{L}^*] = (1-\alpha) \tag{B19b}$$

Substituting consumption into the utility function (3) gives:

$$U_{FT} = (\alpha A)^\alpha(1-\alpha)^{1-\alpha} \qquad U_{FT}^* = (\alpha A^2)^\alpha[(1-\alpha)A]^{1-\alpha} \tag{B20}$$

Comparing these with the autarkic utility in equations (B6) shows the standard result that the large, incompletely specialised Home does not gain from trade, while the small, completely specialised Foreign gains from trade. The volume of trade is the sum of the difference between Foreign production and consumption of the two goods:

$$VT_{FT} = \alpha A\bar{L}^*(1 + A) \tag{B21}$$

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