Pandemics, food security and the gains from trade

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30 May 2020

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Abstract

Why has the recent covid-19 pandemic led to the imposition of export quotas in many countries? Why is the agricultural sector highly protected in developed economies? We show how the addition of subsistence constraints to the standard models of international trade together with a potential shock to trade offers a simple explanation of these facts. This simple adaption of the standard trade model also provides a new mechanism for the existence of a 'Transfer Paradox'. A transfer of resources prior to production acts as a kind of ex ante insurance against trade disruption which mitigates the effects of the missing market for trade disruption insurance. The effect of a transfer can be large enough that both the donor and recipient benefit. Although the analysis focuses on agricultural goods it applies to any good or technology regarded as essential for production.

Keywords: International Trade , Income Distribution, Growth and Development,
JEL Classification Numbers: O40, F11, F43.

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1 Introduction

Why has the covid-19 pandemic caused many countries to quickly impose export restrictions on agricultural goods?[1] Why have negotiations over agricultural subsidies in the Doha Development Round at the World Trade Organisation been so protracted?[2] Why is the agricultural sector a highly protected sector in the first place? This paper shows how these facts can be easily explained by the addition of subsistence constraints to standard models of international trade together with a potential shock to trade. The model shows that countries will not wish to expand trade to a level where they are vulnerable in the event of trade disruption and that an increase in the probability of trade disruption will reduce the optimal level of trade. This adapted model also shows the large potential benefits of international cooperation and provides a new mechanism by which a 'Transfer Paradox' may occur. Economies will not want trade to the extent that it leaves them with less than subsistence if trade is disrupted. Economies close to subsistence will therefore not specialize very much regardless of the international price. Transfers that take an economy away from subsistence will give it scope to benefit from trade. This increase in trade may benefit the whole world economy including the transferring economy. This logic is not only applicable to the agricultural sector. The analysis suggests that economies will not wish to completely specialize away from the production of goods and technologies that are essential to production.[3]

Although extremely straightforward this simple amendment to the standard trade model has profound implications. There is currently no shortage of food at the global level, but as Sen (1982) pointed out, famines aren't created by the lack of available food.[4] It is the distribution of food that is crucial. This analysis shows that free international trade can permit the global economy to create large surpluses above subsistence but only if the distribution of these surpluses is such that all countries are guaranteed not to suffer.

This paper may be seen as a blend of several important strands in the international trade and development literature, notably the literatures on the evolution of economies away from subsistence to a state of sustained ecnomic growth, on international trade under uncertainty with incomplete markets, on international trade and non-homothetic preferences, and on international trade and conflict. Galor and Weil (2000) have shown how subsistence constraints can limit investment in fertility and human capital accumulation at low levels of development and how this can lead economies to spend long periods close to subsistence levels of income. Galor and Mountford (2009) showed, in this context, how international trade can magnify differences in development and have large effects on the world distribution of income and population. The

[1] Laborde, David, Abdullah Mamun, and Marie Parent.(2020) document the following countries imposing food export restrictions : Russia,Viet Nam, Kazakhstan, Thailand, Kyrgyzstan, Egypt, Serbia, Cambodia, Honduras, Armenia, Belarus, Ukraine, Moldova, Turkey,South Africa, Romania, North Macedonia, Ghana, and Algeria.

[2] See e.g. Hanrahan and Schnept (2007) and WTO (2017) for descriptions of the intricacies of agricultural subsidy negotiations at the WTO and how issues such as food security and recovering from natural disasters are accepted as legitimate policy objectives

[3] Increased complexity of production processes in developed economies, see e.g. Kremer (1993) implies that economic development won't necessarily cause these concerns to disappear.

[4] Although there may be a shortage of covid-19 vaccine if one is created.

literature on the effects of uncertainty and international trade under complete and incomplete markets is very large.[5] This paper is related to the incomplete markets literature that has shown how the standard theorems of international trade, such as the benefits and pareto optimality of free trade, need not hold in this environment, see for example Newbury and Stiglitz (1984) and Cheng (1987). However this literature has not examined the implications of subsistence constraints for the relationship between trade and growth and therefore the implications of transfer payments and world income inequality for the potential gains from trade. The paper is also closely related to the literature on trade and conflict notably Martin, Mayer and Thoenig (2008) and Rohner,Thoenig and Zilibotti (2013). They show international trade interacts with the prospect of conflict and finds intuitively, and consistently with this paper, that countries with more multilateral trade links are associated with a greater propensity for conflict as this implies a reduced effect of ceasing international trade with any one other country. This paper deals with the different context of pandemics which are quasi exogenous events and which have the potential to reduce trade globally.

The paper is organised as follows. In section 2 we set up the simple model of international trade with subsistence constraints and the possibility of trade disruption. The following section then examines the gains from trade in a two country world economy and demonstrates how a transfer from an economy far away from subsistence to one close to the subsistence constraint can lead to benefits for both economies.

2 International Trade with a Subsistence Constraint and the Possibility of Trade Disruption

We first consider a standard two good Ricardian model of trade with constant returns to scale, with a subsistence constraint and the possibility of trade disruption. We derive the optimal levels of production and consumption for a small economy and show that trade is decreasing in the possibility of trade disruption. We then extend the model to decreasing returns to scale production functions.

Consider the standard Ricardian model of a small open economy with two goods, x and y, which are produced with one factor of production, labor, L. The economy is endowed with a $\bar{L}$ units of labor and a given set of linear constant-returns production technologies for each of the two goods. The amounts of good x and y produced, X^p and Y^P, are

$$X^p = \frac{L^x}{a^x}; Y^p = \frac{L^y}{a^y}$$

where L^i is the amount of labor used in the production of good i, and a^i is the amount of labor required in order to produce one unit of good i for $i = x, y$. Full employment of resources implies that $L^x + L^y = \bar{L}$, and so the production-possibility frontier for the economy is

$$Y^p = \frac{\bar{L}}{a^y} - \frac{a^x}{a^y} X^p$$

[5] See e.g. Pomery (1984) for a survey of literature.

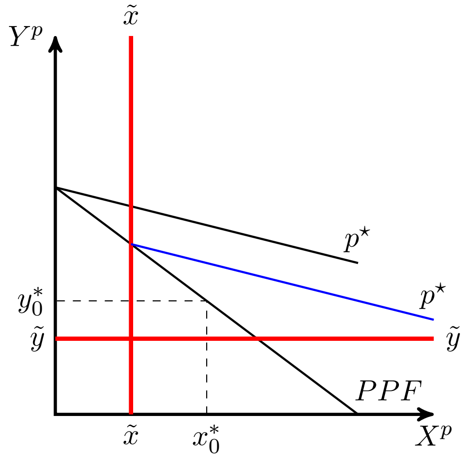


Figure 1: The impact of subsistence constraints on the level of trade

A social planner maximizes the utility of a representative agent who is subject to a subsistence constraint for the consumption of goods x and y that agents need to consume at least $(\widetilde{x}, \widetilde{y})$ to survive. To represent this case we use a Stone Geary utility function $u = \alpha \log(X^c - \widetilde{x}) + (1-\alpha)\log(Y^c - \widetilde{y})$, where X^c and Y^c are the amount of good x and good y consumed respectively. Given, p^*, the international relative price of x the planner chooses X^p, Y^p, X^c and Y^c to maximize utility. We will consider the case where $p^* < a^x/a^y$, the other cases follow directly.

When there is no possibility of trade disruption, the agent's maximization problem is

$$Max_{\{X^p,Y^p,X^c,Y^c\}}\ \alpha \log(X^c - \widetilde{x}) + (1-\alpha)\log(Y^c - \widetilde{y}) + \lambda(Y^p + p^* X^p - Y^c - p^* X^c)$$

which implies the optimal demand functions; $X^c = \widetilde{x} + \alpha(I\ /p^* - \widetilde{x} - \widetilde{y}/p^*)$ and $Y^c = \widetilde{y} + (1-\alpha)(I - p^*\widetilde{x} - \widetilde{y})$. Income is maximized where $X^p = 0$ and $Y^p = \bar{L}/a^y$, since $p^* < a^x/a^y$.

If, however, agents perceive there to be a chance, π, that trade does not take place after production decisions are taken then the planner's maximization problem becomes

$$\begin{aligned} &Max_{\{X^p,Y^p,X^c,Y^c\}}\ \pi\alpha \log(X^p - \widetilde{x}) + \pi(1-\alpha)\log(Y^p - \widetilde{y}) + (1-\pi)\alpha\log(X^c - \widetilde{x}) + \\ &(1-\pi)(1-\alpha)\log(Y^c - \widetilde{y}) + \lambda(Y^p + p^* X^p - Y^c - p^* X^c) \end{aligned}$$

The first order condition for this problem is

$$\begin{aligned} 0 \;\; = \;\; & \pi\alpha\frac{1}{(X^p - \widetilde{x})} + (1-\pi)\alpha\frac{1}{(X^c - \widetilde{x})}\alpha\frac{(p^* - \frac{a^x}{a^y})}{p^*} - \pi(1-\alpha)\frac{1}{(Y^p - \widetilde{y})}\frac{a^x}{a^y} + \\ & (1-\pi)(1-\alpha)\frac{1}{(1-\alpha)(Y^c - \widetilde{y})}(1-\alpha)\frac{(p^* - \frac{a^x}{a^y})}{p^*} \end{aligned}$$

which implies $X^p > \widetilde{x}$ in equilibrium. It also follows from total differentation that X^p will be higher the possibility of conflict i.e. $\frac{\partial X^p}{\partial \pi} > 0$.

This economy is described in Figure 1 which shows how the limitation that $X^p > \widetilde{x}$ limits the gains from trade.

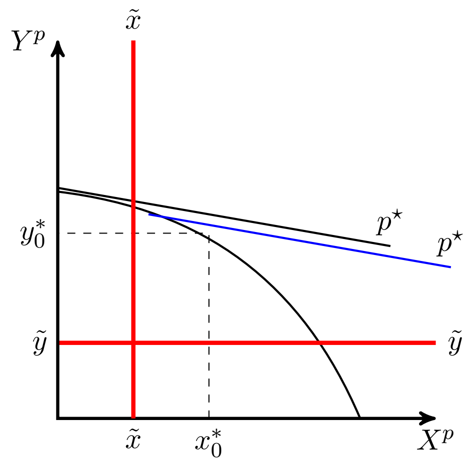


Figure 2: The impact of subsistence constraints on the level of trade with Decreasing Returns to Scale

2.1 Decreasing Return to Scale Production Function

The same logic continues to hold with decreasing returns to scale production functions. Suppose the amount of good x and y produced, X^p and Y^p, are now given by the following production functions,

$$X^p = a^x (L^x)^\beta; \quad Y^p = a^y (L^y)^\gamma$$

where as before $L^y = \bar{L} - L^x$ and where β and γ are parameters such that $0 < \beta, \gamma < 1$. The planner's maximization problem becomes,

$$\begin{aligned} Max_{\{X^p, Y^p, X^c, Y^c\}} \quad : \quad & \pi\alpha \log(a^x (L^x)^\beta - \widetilde{x}) + \pi(1-\alpha)\log(a^y (L^y)^\gamma - \widetilde{y}) + (1-\pi)\alpha \log(X^c - \widetilde{x}) \\ & + (1-\pi)(1-\alpha)\log(Y^c - \widetilde{y}) + \lambda(a^y (L^y)^\gamma + p^* a^x (L^x)^\beta - Y^c - p^* X^c) \end{aligned}$$

If we assume as above that in the absence of a subsistence constraint the optimal point of production, X^{p*}, is less than subsistence, $X^{p*} < \widetilde{x}$, then $I_t = Y^p + p^* X^p$, will be decreasing in X^p and so as before the first order conditions implies $X^p > \widetilde{x}$ in equilibrium.[6] This case is depicted in Figure 2. This Figure depicts the case where the impact of the subsistence constraints is small. However clearly the greater the proportion of potential production is the subsistence constraint, the greater its impact on trade will be. When the proportion is close to one the economy will be very close to its autarkic equilibrium position under free trade regardless of the terms of trade. This case is depicted in Figure 3a below.

2.2 Parametric Examples

Parametric examples of the cases depicted in Figures 1 and 2 are as follows:

For the constant returns to scale economy $\bar{L} = 40$, $a^x = 4$, $a^y = 1$ $p^* = 1$,$\alpha = \frac{1}{2}$, $\widetilde{x} = 4$, and $\widetilde{y} = 4$. The autarkic equilibrium has $X^c = X^p = 6.5$ and $Y^c = Y^p = 14$. Under international

[6] We are only considering economies where subsistence levels of both goods can be produced in autarky, which is evolutionarily intuitive .

trade with no prospect of trade disruption, (i.e. $\pi = 0$), then $X^c = Y^c = 20$ and $X^p = 0$ and $Y^p = 40$. However if $\pi = \frac{1}{10}$ then $X^c \approx Y^c \approx 13.5$ and $X^p \approx 4.3$ and $Y^p \approx 22.7$.

For the decreasing returns to scale economy we keep the scale of the axis by choosing $\bar{L} = 40$, $\gamma = \frac{1}{2}, \beta = \frac{1}{2}, a^x = \frac{10}{\sqrt{40}}$, $a^y = \sqrt{40}$ $p^* = 1, \alpha = \frac{1}{2}, \widetilde{x} = 4$, and $\widetilde{y} = 4$. In this case the autarkic equilibrium has $X^c = X^p = 7.9$ and $Y^c = Y^p = 24.4$ and the trade equilibrium with $p^* = 1$ and no prospect of trade disruption, has $X^c = Y^c \approx 20.61$ and $X^p \approx 2.43$ and $Y^p \approx 38.81$. However if $\pi = \frac{1}{10}$ then $X^c \approx Y^c \approx 19.72$ and $X^p \approx 5.13$ and $Y^p \approx 34.31$.

3 Resource Transfers and the Gains from Trade in a Two Country Two Period Model of the World Economy

In this section we demonstrate the implications of the model described above for the role of the world income distribution in the gains from trade. We do this via an example of a mutually beneficial transfer, a 'Transfer Paradox', from an economy far away from its subsistence constraint to one that is close to its subsistence constraint. In order to model the effects of a transfer which occurs before production decisions are made one needs a model with at least two periods. Production can then take place in the first period and resources be transferred after the first period's production and before the second period's production decisions are made. This implies that the goods transferred must also be storable. Thus the two period problem must allow the agent to transfer resources from one period to the other. This complicates the decision problem. We abstract away from the growth process by assuming that in autarky the two periods are identical so that it is not optimal to transfer resources between periods.[7]

3.1 Autarky

Suppose that agents live for two periods, where $\bar{L}$, a^x, and a^y are time invariant. Lifetime utility, U,. is the sum of the expected utilities in the two periods, $U_i, i = 1, 2$ Thus in autarky

$$\begin{aligned} U &= U_1 + U_2 \\ U_1 &= \alpha \log(X_1^c - \widetilde{x} - s^x) + (1-\alpha)\log(Y_1^c - \widetilde{y} - s^y) \\ U_2 &= \alpha \log(X_2^c - \widetilde{x} + s^x) + (1-\alpha)\log(Y_2^c - \widetilde{y} + s^y) \end{aligned}$$

where the variables are defined as before with the subscript $i = 1, 2$ denoting the time period. and where s^i is the transfer of good i from period 1 to period 2. Note that s^i must be non-negative. In autarky. $s^i = 0$ for $i = x, y$ because L_1^x and L_2^x will be allocated optimally so that the marginal utility of consumption in the two periods is identical.

[7] One could think of this as a reduced form of a steady state from a Galor and Weil (2000) style growth model. A fuller description of the dynamics of the Galor Weil (2000) model would entail analyzing the interaction of trade and transfers with technological progress and human capital accumulation and fertility. While these are clearly fundamentally important issues they are distinct from the effect of income inequality, transfers and trade risk explored in this paper.

3.2 International Trade

If agents can trade at international price p^* then their lifetime expected utility, EU, is the sum of the expected utilities in the two periods, $EU_i, i = 1, 2$, which now has to account for the possibility of trade distruption in either or both of the two periods. Thus lifetime expected utility is given by

$$\begin{aligned}
EU &= EU_1 + EU_2 \\
EU_1 &= \pi\alpha\log(X_1^p - \widetilde{x} - s_\pi^x) + \pi(1-\alpha)\log(Y_1^p - \widetilde{y} - s_\pi^y) \\
&\quad +(1-\pi)\alpha\log(X_1^c - \widetilde{x} - s_{1-\pi}^x) + (1-\pi)(1-\alpha)\log(Y_1^c - \widetilde{y} - s_{1-\pi}^y) \\
EU_2 &= \pi[\pi\alpha\log(X_2^p - \widetilde{x} + s_\pi^x) + \pi(1-\alpha)\log(Y_2^p - \widetilde{y} + s_\pi^y) \\
&\quad +(1-\pi)\alpha\log(X_2^c - \widetilde{x} + s_\pi^x) + (1-\pi)(1-\alpha)\log(Y_2^c - \widetilde{y} + s_\pi^y)] \\
&\quad +(1-\pi)[\pi\alpha\log(X_2^p - \widetilde{x} + s_{1-\pi}^x + \pi(1-\alpha)\log(Y_2^p - \widetilde{y} + s_{1-\pi}^y) \\
&\quad +(1-\pi)\alpha\log(X_2^c - \widetilde{x} + s_{1-\pi}^x) + (1-\pi)(1-\alpha)\log(Y_2^c - \widetilde{y} + s_{1-\pi}^y)]
\end{aligned}$$

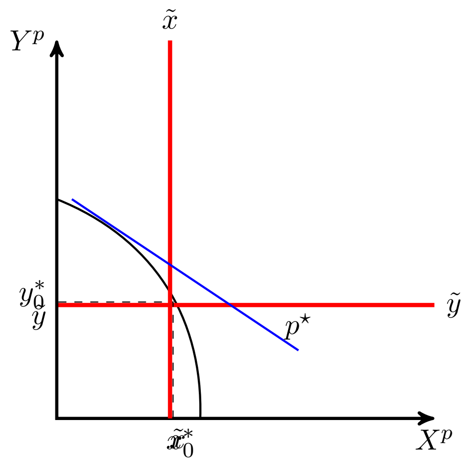
where the variables are defined as before with the subscript $i = 1, 2$ denoting the time period. and where s_π^i is the transfer of good i from period 1 to period 2 when there is no trade in period 1 and $s_{1-\pi}^i$ is the transfer of good i from period 1 to period 2 when there is trade in period 1 for $i = x, y$. As before s_π^i and $s_{1-\pi}^i$ must be non-negative. Under international trade there may be positive transfers as it may be utility enhancing to mitigate the possibility of trade disruption in periuod 2 by saving resources in period 1 and transfering them to period 2 in order to allow a greater level of trade. However as the level of income approaches the subsistence level these transfers must also tend to zero.

3.2.1 Example of a Transfer Paradox

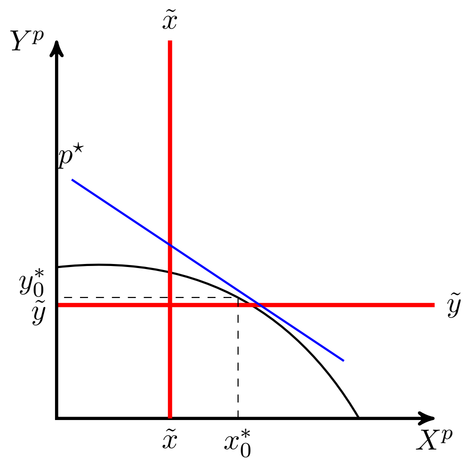
To demonstrate existence an example is sufficient. Consider a two country would economy with two countries A and B . Suppose country A is very close to subsistence and so the optimal trade policy is very close to autarky Consequently under free trade country B will be close to its autarkic equilibrium. However if country B transfers enough resources at the end of period 1 to country A so that the subsistence constraint is less binding then both country A and B may benefit from the increased trade.

Assume that in each country $\bar{L} = 40$, $\gamma = \frac{1}{2}, \beta = \frac{1}{2}, \alpha = \frac{1}{2}, \pi = \frac{1}{10}, \widetilde{x} = 4$, and $\widetilde{y} = 4$. We assume that country A has $a^{y,A} = \sqrt{40}, a^{x,A} = 0.644$ and for country B $a^{y,B} = \frac{10}{\sqrt{40}}, a^{x,B} = \sqrt{40}$, where $a^{i,j}$ is productivity parameter for sector i in country j where $i = x, y$ and $j = A, B$. Thus country A has a comparative advantage in producing Y and country B has a comparative advantage in producing X. Under free trade because of the subsistence constraint both countries will operating very close to their autarkic position. In country A, $X^{c,A} = Y^{c,A} = X^{p,A} = Y^{p,A} \approx 4$. and in country B as in the example above $Y^{c,B} = Y^{p,B} = 7.9$ and $X^{c,B} = X^{p,B} = 24.4$. This case is depicted in Figure 3

However suppose now that after period 1 country B transfers T units of good X to country



(a) The Economy Near subsistence



(b) The economy far away from subsistence

Figure 3: The transfer to the near subsistence economy move the equilibrium to the international trade lines in the second period leading to increased utility in both economies.

A. Country A's maximization problem in period 2 now becomes

$$\begin{aligned} Max_{\{L^x\}} &= [\pi\alpha \log(X_2^p - \widetilde{x} + T) + \pi(1-\alpha)\log(Y_2^p - \widetilde{y}) \\ &\quad + (1-\pi)\alpha \log(X_2^c - \widetilde{x} + T) + (1-\pi)(1-\alpha)\log(Y_2^c - \widetilde{y})] \end{aligned}$$

The transfer clearly mitigates the subsistence constraint and so alters country A's production decisions. If we set $T = 4$ then in this example country A will choose to specialize more in the production of Y and in equilibrium $X^{p,A} \approx 1.10$ and $Y^{p,A} \approx 38.5$ and country B to specialize more in the production of X and in equailibrium $X^{p,B} \approx 34.45$ and $Y^{p,A} \approx 5.08$. This allows consumption of $X^{c,A} \approx 19.85$ and $Y^{p,A} \approx 21.87$ and $X^{c,B} \approx 19.7$ and $Y^{c,A} \approx 21.71$ with the equilibrium price $p^* \approx 1.1275$.

Expected Utility in both countries has increased as a result of the transfer. Country A is unaffected in period 1 and benefits in period 2, but for country B the loss in period 1 from the transfer has to be weighed against the gains in period. The expected utility in country B without the transfer is

$$2 \times [\alpha \log(24.4 - 4) + (1-\alpha)\log(7.9 - 4)] = 4.16$$

and the expected utility in country B with the transfer is

$$\begin{aligned} &\alpha \log(24.4 - T - 4) + (1-\alpha)\log(7.9 - 4) + \\ &\pi[\alpha \log(34.45 - 4) + (1-\alpha)\log(5.08 - 4)] + (1-\pi)[\alpha \log(19.7 - 4) + (1-\alpha)\log(21.71 - 4)] \\ &= 4.79 \end{aligned}$$

and so utility in both countries has increased

Note that we have not derived the optimal level of transfer and assumed that the decision to make the transfer was made after the first period. Both the ability to adjust production in period 1 and the optimal choice of transfer will allow for an even greater gain from trade for country B and so reinforces the point.

3.2.2 A Simple Example with Leontief Preferences and Constant Returns to Scale

The previous example was calculated numerically. In this section we provide a closed form solution using the constant returns to scale model with Leontief Preferences. Suppose now that agents live for two periods and so maximize the following two period Leontief Preferences utility function

$$u = \begin{cases} \text{Min}(\text{E}[(X_1^c - \widetilde{x}), (Y_1^c - \widetilde{y})]) + Min(E(X_2^c - \widetilde{x}), (Y_2^c - \widetilde{y})]) & \text{for } X_i^c \geq \widetilde{x} \text{ and } Y_i^c \geq \widetilde{y} \text{ i=1,2} \\ \text{-}\infty & \text{if } X_i^c < \widetilde{x} \text{ or if } Y_i^c < \widetilde{y} \text{ i=1,2} \end{cases}$$

which implies that utility is maximized by maximizing total income over the two periods subject to the subsistence constraint in each period and then dividing income so that $X^c = Y^c$.

Consider the case where $\widetilde{x} = \widetilde{y} = 4$ and in country A $L^A = 40, a^{y,A} = 1$ and $a^{x,A} = 9$. Then in autarky country A would have $X^c = Y^c = X^p = Y^p = 4$ in both periods Suppose there was another country B that had $L^B = 40, a^{y,B} = 4$ and $a^{x,B} = 1$. Then in autarky country B would have $X^c = Y^c = X^p = Y^p = 8$ in both periods. As above in this case the free trade equilibrium is identical. However in a two period model, if country B consumed only $X^c = Y^c = 4$ in period 1 and transferred 4X to country A then in the following period country A could produce $Y^p = 40$ and trade with country B who would produce $X^p = 40$. At international price $p^* = 1$ country A would trade 18Y for 18X to consume 22 of both goods, and country 2 would also have 22Y and 22X to consume. Thus the transfer of goods from B to A will have increased global trade and production in both countries. The expected utility of country A has clearly improved. If trade is disrupted the transfer makes their utility identical to autarky, but if it isn't disrupted then utility has increased to 18. Country B will lose out in case of trade disruption and will have utility of 0, but will gain if trade is not disrupted obtaining utility of 18 which is more than its autarkic utility of 8. Thus so long as the probability of trade disruption, is not too high , $\pi < \frac{5}{9}$ country B will also have benefitted from the transfer.

4 Conclusion

This paper has demonstrated the large potential benefits of international cooperation and provided a new mechanism by which a 'Transfer Paradox' may occur by adding a subsistence constraint to standard models of international trade together with a potential shock to trade. Economies will not want trade to the extent that it leaves them with less than subsistence if trade is disrupted. Transfers that take an economy away from subsistence will give it scope to benefit from trade and this may benefit the whole world economy including the transferring economy. This logic is not only applicable to the agricultural sector. The analysis suggests that economies will not wish to completely specialize away from the production of any good and technology vital to the production process.

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