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Global Agreements in Agriculture: A Network Approach with Market Intermediaries

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Abstract

Global trade agreements in agriculture have been unsuccessful. Current explanations argue that this outcome reflects the fact that governments have motivations other than maximising social welfare. At the current state of the knowledge, there is not a suitable framework that can be used either to assess the veracity of these explanations or determine how these biases influence the international trade structure. The objective of this article is to fill this gap by proposing a formal international trade network adapted to study the issue of global agreements in agriculture. The network approach outlined here accounts for the bias of government policies towards farmers or consumers; but we also allow for intermediaries in agricultural markets that have the potential to exercise market power are largely ignored in current approaches to modelling agricultural trade. We show that accommodating these features of agricultural markets offers important insights in understanding why promoting free trade in agricultural markets has proved to be so elusive.

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1. Introduction

Traditional models in economics can broadly be grouped in two groups, namely: (i) models that study the interaction of small groups of individuals (game theory); and (ii) models that study the interaction among large groups (competitive markets and general equilibrium). According to Goyal (2015), a number of phenomena appear to arise in between these two extremes. In recognising this gap, a relatively new branch in economics referred to as economic networks has been developed. This new approach has the potential to identify heterogeneous economic behaviour of individual inserted in a network, and how this behaviour is affected by their relative position in the network.

This paper introduces the concept of networks as applied to international trade and in particular, provides new insights into why global free trade has been difficult to achieve in the context of WTO negotiations. Specifically, it builds on recent work associated with Goyal and Joshi (2006) which applied network bilateral trade agreements but here we make several amendments to their network approach to accommodate some of the characteristics of protectionism in agricultural markets⁴. The key insight that emerges from this theoretical analysis is that it is necessary to account for the existence of intermediaries in agricultural markets (a feature that most current models of agricultural trade fail to do) and specifically that the existence of imperfect competition exercised by intermediaries combined with the balance of political influence these intermediaries may exert is consistent with the difficulties of achieving global free trade in agricultural markets. While the insights from a network approach to international trade which assumes welfare maximisation is consistent with standard prescriptions that global free trade should be the equilibrium outcome, the combination of biased welfare functions, relative position in the network and intermediaries with market power change the equilibrium outcome. As such, the approach outlined here has important implications for how one should model trade liberalisation as well as insights explaining why standard prescriptions of the benefits of trade liberalisation have proved to be difficult to achieve in practice.

The background concerns have been well-documented: first, liberalising agricultural trade has proved to be difficult with the current Doha Round negotiations ground to a halt; second, against these attempts, most governments throughout the world have policies which are either biased to producers or consumers (Anderson *et al.* 2013 provide extensive evidence of these patterns of protection). However, while the bias of agricultural policies is well-known, this seldom appears explicitly in quantitative assessments of trade liberalisation. In addition, while studies on the industrial organisation of the food sector recognise the importance of limited firms with market power, this seldom features in assessments of trade liberalisation in agricultural markets.

⁴ An overview of key concepts in networks can be found in Jackson (2008). For a different perspective of networks in global trade, see Chaney, (2014).

This paper develops a network approach that accommodates these issues and extends the recent work of Goyal and Joshi (2006) to account for the above factors that are pertinent to addressing agricultural trade issues. Most obviously, we include farmers' welfare in aggregate welfare and allow for the bias in the government welfare function that may be biased towards farmers (or, alternatively, consumers). But we also include intermediaries that procure from the farming sector and distribute to consumers and that these intermediaries may exercise market power. In addition, we allow for a potential bias towards the profits of these intermediaries in aggregate welfare. It is this extension that provides some insights that highlight barriers to agricultural trade liberalisation: intermediaries in agricultural markets that have the potential to exercise market power is one of the reasons why-in the context of a network approach-establishing global free trade in agricultural markets has proved to be elusive. However, we also found the surprising and novel result that even in a scenario without policy bias, countries may be unwilling to sign a global agreement depending on whether they are located in a privileged position in the network. This result proves the advantage of adopting an international trade network approach to study the issue of agricultural trade liberalisation. These observations have direct significance for modelling agricultural markets more generally and the interpretation why current approaches to addressing agricultural trade issues have important gaps.

It is important to highlight, however, the fact that the economic network approach has an important disadvantage. That is, many theoretical applications based on this approach become intractable in mathematical terms, a fact that is formally stated by Goyal (2015): *"The tension arises from problems of tractability: models with fully rational agents and general network structures are difficult to analyze, especially in terms of deriving a clear relation between the network structure and individual behavior. It is also difficult to incorporate heterogeneity in a tractable way within a network model with fully rational agents"* (p. 4). In the context of international trade networks, the problem of tractability is also present in the original international network model developed by Goyal and Joshi (2006). Because our proposed international network is a more complex extension of that model, we have unfortunately inherited this problem. It is for this reason that the analysis developed in this article is based on simulations that assumes the following: a world composed of four countries; symmetric countries in terms of market size and farmers' productivity; and exogenous tariffs. Even under these extreme simplifications, we found that global free trade is not stable in many scenarios. We also offer generalisations based on key results obtained in the simulations. That is, particular networks showing key results informing about factors explaining the lack of progress of global agreements in agriculture were generalised for N countries. These generalisations are the basis for ongoing extensions that account for asymmetric countries and endogenous tariffs that will be offered in future articles.

The paper is organised as follows. Section 2 outlines the main features of the framework and the key features of the Goyal and Joshi (2006) paper. We also highlight the extensions where we accommodate features of agricultural markets and the characteristics of agricultural protection. We also outline the

stability concepts that are applied in network analysis including, in this case, the refinement of the stability concept to address more accurately features of trade agreements in world trade. In Section 3, we outline the main results. In Section 4, we summarise and conclude.

2. The Model

2.1. The Network Model by Goyal and Joshi (2006)

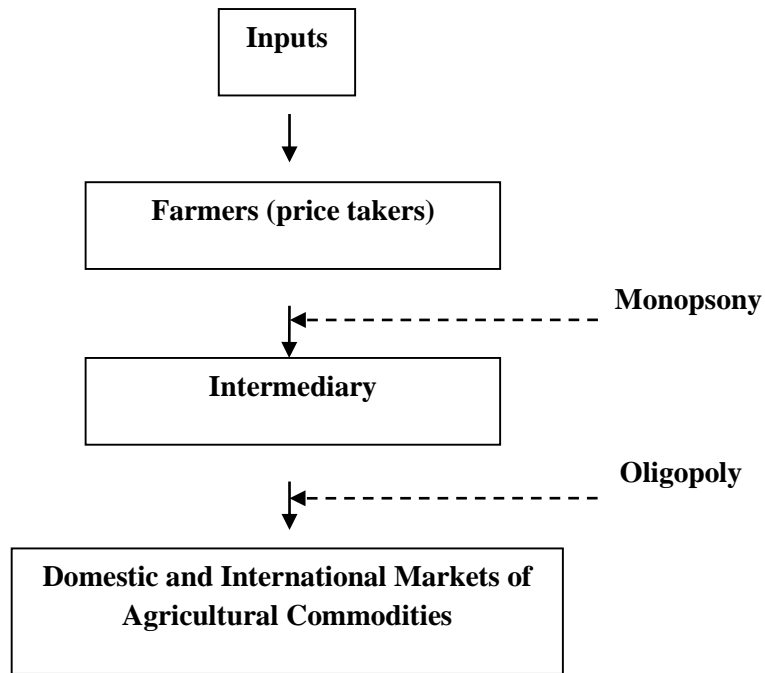
Formally, an international agreement between countries i and j is described by a link, given by a binary variable $g_{ij} \in \{0,1\}$ with $g_{ij} = 1$ if an agreement exists between countries i and j and $g_{ij} = 0$ otherwise. A network $g = \{(g_{ij})_{ij \in N}\}$ is a description of the international agreements that exist among a set $N = \{1, \dots, N\}$ of identical countries, where N is the total number of countries. Networks g^c and g^e are the complete network (*i.e.* $g_{ij} = 1$ for all $i, j \in N$) and the empty network (*i.e.* $g_{ij} = 0$ for all $i, j \in N$). Let G denote the set of all possible networks, $g + g_{ij}$ denote the network obtained by replacing $g_{ij} = 0$ in network g by $g_{ij} = 1$, and $g - g_{ij}$ denote the network obtained by replacing $g_{ij} = 1$ in network g by $g_{ij} = 0$. Let $N_i(g) = \{j \in N: g_{ij} = 1\}$ be the set of countries with whom country i has an international trade agreement in network g . Assume that $i \in N_i(g)$ so that $g_{ii} = 1$. The cardinality of $N_i(g)$ is denoted $\eta_i(g)$. In this model $\eta_i(g)$ is also the number of active firms in country i because of the assumption that each country has only one firm (note that the domestic firm in country i is included in $\eta_i(g)$). Let $L_i(g) = \{(g_{ij})_{ij \in N} : j \in N_i(g)\}$ be the set of links existing in country i in network g . Note that $g_{ii} \in L_i(g)$. Let $h_i \subset L_i(g) - \{g_{ii}\}$ be a link subset, and let μ_i be the cardinality of h_i . This latter notation is used in the definition of the alternative stability concept adopted in this research. Let $\Gamma(g)$ be a subset of countries in network g . $\Gamma(g)$ is said to be a complete component if: (i) $g_{ij} = 1$ for all $i, j \in \Gamma(g)$; and (ii) $g_{ik} = 0$ for all $i \in \Gamma(g)$ and all $k \notin \Gamma(g)$. On the other hand, $\Gamma(g)$ is said to be an incomplete component if there exists at least two countries $i, j \in \Gamma(g)$ such that $g_{ij} = 0$.

2.2. First Extension: Introducing the Agricultural Sector

The original model of Goyal and Joshi (2006) assumes that firms play oligopolistic competition in the domestic and international markets. However, it omits an extremely important player who operates in the agricultural sector. This corresponds to the farming sector. In order to introduce this sector into the analysis, a parsimonious version of the food supply chain described by McCorriston (2002) was adopted. The food chain considered in this article is characterised by two main actors: farmers and intermediaries. Farmers in this case are assumed

to be input and output price takers. On the other hand, it is assumed the existence of one intermediary in each country of the world who purchases the agricultural output produced by domestic farmers. Each intermediary is assumed to have monopsonistic power in the inter-phase farmers-intermediary and oligopolistic power in both the domestic and international markets of agricultural commodities. A scheme of this food chain description is presented in Figure 1.

Figure 1. Vertically related food chain



The model considered in this section was designed following the vertically related food chain presented in Figure 1 above. The modelling approach was based on the imperfect competition framework developed by White (1996). The solution of the model is presented as follows.

2.2.1. The farming sector

In this model it is assumed that the farming sector is formed of a single group of farmers who are price takers and produce a homogeneous crop denoted by $q_i^f(g)$ (i.e. this is the total output produced by the farmers in country i and in network g). It is assumed that this output is the input purchased by the domestic intermediary. Since the latter is the only buyer of this input, this individual faces a non-horizontal supply function of the homogeneous crop. Consequently, the single supply function of the agricultural sector is described as follows.

$$p_i^f(g) = \frac{1}{2} \phi_i q_i^f(g) \quad (1)$$

Where $p_i^f(g)$ is the price of the homogeneous crop that is paid to farmers and ϕ_i is a positive coefficient that captures how sensitive the price paid to farmers to changes in the total output sold by these individuals is (White, 1996). Using this expression, producer surplus in network g (i.e. $PS_i(g)$) is given by:

$$PS_i(g) = p_i^f q_i^f(g) - \frac{1}{2} \phi_i \int_0^{q_i^f} q_i^f(g) dq_i^f(g) \quad (2)$$

2.2.2. The intermediary

Because the output produced by the agricultural sector is at the same time the input purchased by the intermediary, the production function of the latter corresponds to a Leontief production function. For simplicity this function is represented as:

$$q_i(g) = q_i^f(g) \quad (3)$$

Where $q_i(g)$ is the total output of the homogenous crop that is sold by the intermediary in network g in the domestic and international markets. For convenience, this output is expressed as:

$$q_i(g) = q_1^{(i)}(g) + q_2^{(i)}(g) + \dots + q_j^{(i)}(g) + \dots + q_{N_i}^{(i)}(g) \quad (4)$$

Where $q_j^{(i)}(g)$ is the output exported by country i to country j . Using Expressions 1, 2 and 3, the total cost related to the output exported to an arbitrary country j faced by the intermediary of country i in network g is:

$$TC_j^{(i)}(g) = p_i^f q_j^{(i)}(g) = \frac{1}{2} \phi_i q_j^{(i)}(g) q_i(g) \quad (5)$$

On the other hand, the inverse demand function faced by intermediaries who compete in country j is assumed to be the following linear function:

$$P_j(g) = \alpha_j - Q_j(g) = \alpha_j - \sum_{i \in N_j(g)} q_j^{(i)}(g) \quad (6)$$

Where $Q_j(g) = \sum_{i \in N_j(g)} q_j^{(i)}(g)$ is total output sold in the domestic market of country j and in network g ; and $P_j(g)$ is the retailer price of the homogeneous good in this market. Using Expressions 5 and 6, each intermediary $i \in N_j(g)$ (i.e. intermediaries competing in country j) is assumed to choose $q_j^{(i)}(g)$ (the output sold by intermediary of country i in country j) in order to maximise the following profit function:

$$\pi_j^{(i)} = q_j^{(i)}(\alpha_j - \sum_{i \in N_j(g)} q_j^{(i)}(g)) - \frac{1}{2} \phi_i q_j^{(i)}(g) q_i(g) \quad (7)$$

2.2.3. The government

As in the case of Goyal and Joshi (2006), governments are assumed to maximise a weighted welfare function. In the extended version of the international network model, this function is described as:

$$W_i(g) = a_i CS_i(g) + b_i \sum_{j \in N_i(g)} \pi_j^{(i)}(g) + c_i PS_i(g) \quad (8)$$

where $CS_i(g) = Q_i^2(g)/2$ is consumer surplus in country i ; $\pi_j^{(i)}(g)$ is the profit made by country i in country j ; $PS_i(g)$ denotes producer surplus in country i ; and a_i , b_i and c_i are exogenous weights that the government puts on consumer surplus, total profits made by the domestic intermediary, and producer surplus, respectively.

2.2.4. Solving the game

Assume homogeneous countries (i.e. $\alpha_i = \alpha$ and $\phi_i = \phi$ for all $i \in N$). After solving the Cournot-Nash game played by the intermediaries, the following results are obtained:

$$q_j^{(i)}(g) = \frac{2\alpha(1+\phi) + \phi \sum_{i \in N_j(g)} q_{i-j}(g) - \phi(1+\phi + \eta_j(g))q_{i-j}(g)}{2(1+\phi + \eta_j(g))} \quad (9)$$

$$q_i(g) = \sum_{j \in N_i(g)} \frac{2\alpha(1+\phi) + \phi \sum_{i \in N_j(g)} q_{i-j}(g) - \phi(1+\phi + \eta_j(g))q_{i-j}(g)}{2(1+\phi + \eta_j(g))} \quad (10)$$

$$Q_i(g) = \frac{2\alpha(\phi+1)\eta_i(g) - \phi(\phi+1) \sum_{j \in N_i(g)} q_{j-i}(g)}{2(1+\phi + \eta_i(g))} \quad (11)$$

$$\pi_j^{(i)}(g) = \frac{(2-\phi)}{2} \left(\frac{2\alpha(1+\phi) + \phi \sum_{i \in N_j(g)} q_{i-j}(g) - \phi(1+\phi + \eta_j(g))q_{i-j}(g)}{2(1+\phi + \eta_j(g))} \right)^2 \quad (12)$$

$$CS_i(g) = \frac{1}{2} \left(\frac{2\alpha(\phi+1)\eta_i(g) - \phi(\phi+1) \sum_{j \in N_i(g)} q_{j-i}(g)}{2(1+\phi + \eta_i(g))} \right)^2 \quad (13)$$

$$PS_i(g) = \frac{\phi}{4} (q_i(g))^2 = \frac{\phi}{4} \left(\sum_{j \in N_i(g)} q_j^i(g) \right)^2 = \frac{\phi}{4} \left(\sum_{j \in N_i(g)} \frac{2\alpha(1+\phi) + \phi \sum_{i \in N_j(g)} q_{i-j}(g) - \phi(1+\phi + \eta_j(g))q_{i-j}(g)}{2(1+\phi + \eta_j(g))} \right)^2 \quad (14)$$

Where the term $q_{i-j}(g)$ corresponds to the total output exported by country i minus the output that this country exports to country j (i.e. $q_{i-j}(g) = q_i(g) - q_j^{(i)}(g)$). This term can be calculated by solving the following matrix system (this system is based on Equation 9):

(15)

$A^{-1}B$ is satisfied, where:

$$q = (q_1^{(1)} \quad q_2^{(1)} \quad \dots \quad q_1^{(2)} \quad q_2^{(2)} \quad \dots \quad q_1^{(N)} \quad q_2^{(N)} \quad \dots \quad q_N^{(N)})^T$$

$$A =$$

$$B = \alpha \left(\frac{1+\phi}{1+\phi+\eta_1(g)} \quad \frac{1+\phi}{1+\phi+\eta_2(g)} \quad \dots \quad \frac{1+\phi}{1+\phi+\eta_1(g)} \quad \frac{1+\phi}{1+\phi+\eta_2(g)} \quad \dots \quad \frac{1+\phi}{1+\phi+\eta_1(g)} \quad \frac{1+\phi}{1+\phi+\eta_2(g)} \quad \dots \quad \frac{1+\phi}{1+\phi+\eta_N(g)} \right)^T$$

Using Expressions 12, 13 and 14, the weighted welfare function considered by the government of country i is:

$$\begin{aligned}
W_i(g) &= a_i CS_i(g) + b_i \pi_i(g) + c_i PS_i(g) \\
&= \frac{a_i}{2} \left(\frac{2\alpha(\phi+1)\eta_i(g) - \phi(\phi+1) \sum_{j \in N_i(g)} q_{j-i}(g)}{(1+\phi+\eta_i(g))2} \right)^2 \\
&\quad + b_i \sum_{j \in N_i(g)} \frac{(2-\phi)}{2} \left(\frac{2\alpha(1+\phi) + \phi \sum_{i \in N_j(g)} q_{i-j}(g) - \phi(1+\phi+\eta_j(g))q_{i-j}(g)}{2(1+\phi+\eta_j(g))} \right)^2 \\
&\quad + c_i \frac{\phi}{4} \left(\sum_{j \in N_i(g)} \frac{2\alpha(1+\phi) + \phi \sum_{i \in N_j(g)} q_{i-j}(g) - \phi(1+\phi+\eta_j(g))q_{i-j}(g)}{2(1+\phi+\eta_j(g))} \right)^2
\end{aligned} \tag{16}$$

2.3. Second Extension: Introducing an Alternative Stability Concepts

Researchers in the area of International Trade Networks have adopted the pairwise stability concept developed by Jackson and Wolinsky (1996) to identify the set of stable international networks (see for instance Goyal and Joshi, 2006; and Furusawa and Konishi, 2007).

Unfortunately pairwise stability is not the most appropriate stability concept to study global agreements in agricultural because this concept assumes that countries cannot break or sign more than one agreement simultaneously. That is, because a global agreement in agriculture involves a commitment made by all the countries in the world, this is equivalent to sign all possible bilateral agreements by all the countries of the world simultaneously, a fact that is not captured by pairwise stability. In addition, a global agreement can only be sustained if no country has an incentive to deviate from the agreement by breaking one or more agreements simultaneously. This suggests, therefore, that an appropriate stability concept to study the issue of global agreements in agriculture is the one that allows countries to: (i) sign all the possible bilateral agreements simultaneously (i.e. to sign a global agreement); and (ii) break one or more

agreements simultaneously. These considerations were introduced into the original model of Goyal and Joshi (2006) in order to propose a more suitable stability concept named in this article *Global Treaty Stability*. This concept is explained as follows.

The global treaty stability is a refinement of strongly pairwise stability which is based on the following definitions (see Gilles and Sarangi, 2004a, 2004b, 2005; Gilles *et al.*, 2006). The marginal benefit of country i when deleting (simultaneously) $h_i \in L_i(g)$ international agreements is $D_i(g, h_i) = S_i(g) - S_i(g - h_i) \in \mathbb{R}$. Using this concept, a network $g \in G$ is said to be *strong link deletion proof* if for every player $i \in \mathcal{N}$ and every $h_i \in L_i(g)$ it holds that $D_i(g, h_i) \geq 0$. Let $D_S \subset G$ be the set of strong link deletion proof networks. On the other hand, a network $g \in G$ is said to be *link addition proof* if $S_i(g + g_{ij}) > S_i(g)$ implies that $S_j(g + g_{ij}) < S_j(g)$ for all $i, j \in \mathcal{N}$. Let $A \subset G$ be the set of link addition proof networks. Using these concepts, strongly pairwise stability is defined as follow: A network $g \in G$ is strongly pairwise stable if g is strong link deletion proof as well as link addition proof.

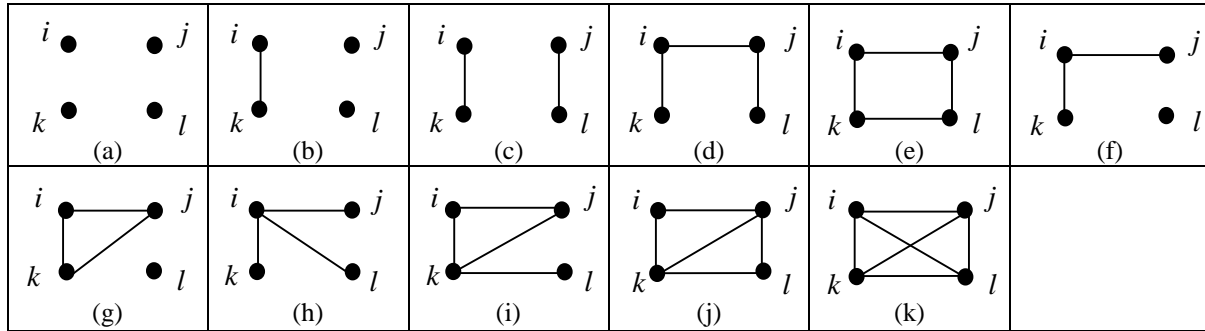
The proposed global treaty stability replaces the link addition proof condition of strongly pairwise stability by an alternative condition that has been named *global treaty proof*. This is explained as follows. Let the marginal benefit of country i when forming a global agreement be $\Omega_i(g^c) = W_i(g^c) - W_i(g)$. A network $g \in G$ is *global treaty proof* if for at least one country $i \in N$ it holds that $\Omega_i(g^c) \leq 0$. In words, a network $g \in G$ is *global treaty proof* if at least one country $i \in N$ does not have an incentive to form a global agreement. Let $G_T \subset G$ be the set of global treaty proof networks. Using this definition, a network $g \in G$ is said to be *global treaty stable* if g is strong link deletion proof (i.e. if for every player $i \in N$ and every $h_i \in L_i(g)$ it holds that $D_i(g, h_i) = W_i(g) - W_i(g - h_i) \geq 0$) as well as global treaty proof (i.e. g is global treaty stable if and only if $g \in D_S \cap G_T \subset G$). That is, network g is global treaty stable if: (i) at least one country is not willing to form a global trade agreement; and (ii) no country has an incentive to break one or more international agreements.

3. Global Agreements and International Trade Networks

As explained in the introduction, the international model becomes intractable in mathematical terms when it considers fully rational agents and general network structures. In order to overcome this problem to some extent, simulations that considers a world composed four

symmetric countries under exogenous tariffs are considered as a first approximation for the analysis of global agreements in agriculture. These countries are denoted as i, j, k and l . The set of possible international trade networks that these countries can form is presented in Figure 2.

Figure 2. Relevant networks considered in the simulation



Note that several possible networks were omitted. For example, country l in network g in this figure is a singleton. Similar networks could have been introduced in order to represent the cases when the other countries are singleton. However, information about these networks can be inferred from network g as a result of the assumption of symmetrical countries. In order to include the omitted networks in the analysis that follows, we adopt the following definition. The set Δ_j corresponds to the set of networks in G that have the same structure as network j in Figure 2. This implies that the set of all possible networks when the world is composed of four countries is: $G = \Delta_a \cup \Delta_b \cup \Delta_c \cup \Delta_d \cup \Delta_e \cup \Delta_f \cup \Delta_g \cup \Delta_h \cup \Delta_i \cup \Delta_j \cup \Delta_k$.

One of the novelties of the proposed model is the introduction of the farming sector into the original framework by Goyal and Joshi (2006). Because the incidence of this sector is captured by the coefficient ϕ (i.e. the degree of monopsonistic power exercised by the intermediaries), the simulations considers three different values of this parameter: (i) $\phi = 0$; (ii) $\phi = 0.5$; and (iii) $\phi = 1.5$. It was found that these values provide a reasonable range of possible levels of monopsonistic power because values of ϕ equal or large than 2 generate unrealistic negative levels of profits (see Equation 12). The results of the simulations were obtained from the equations described in the previous section and are presented as follows.

3.1. Simulation 1: $\alpha = 1$ and $\phi = 0$

This simulation assumes that intermediaries do not exercise monopsonistic power (i.e. they face a horizontal supply at the farming level implying that producer surplus is equal to zero)

which is equivalent to the original model by Goyal and Joshi (2006). To see this, note that when $\phi = 0$, the welfare function defined in Equation 16 converges to the following expression:

$$W_i(g) = a_i CS_i(g) + b_i \pi_i(g) = \frac{a_i}{2} \left(\frac{\alpha \eta_i(g)}{1 + \eta_i(g)} \right)^2 + b_i \sum_{j \in N_i(g)} \left(\frac{\alpha}{1 + \eta_j(g)} \right)^2 \quad (17)$$

But this is the original welfare function employed by Goyal and Joshi. Given this fact, we use the results obtained under $\phi = 0$ as a benchmarks in order to evaluate the effect of introducing the farming sector on the international trade system (i.e. when $\phi > 0$ in the other simulations). The results are presented in Tables 1, 2 and 3 in Appendix A.

3.1.1. The case of unbiased governments

We start the analysis of global trade agreements by considering the case when governments are politically unbiased. That is, when $a_i = b_i = 1$ in the welfare function defined in Expression 17. As explained in Section 2.3, global treaty stable networks correspond to the intersection between strong link deletion proof networks and global treaty proof networks (i.e. $D_S \cap G_T \subset G$). Let us first consider the strong link deletion proof networks (i.e. networks in which no country has an incentive to break one or more agreements simultaneously).

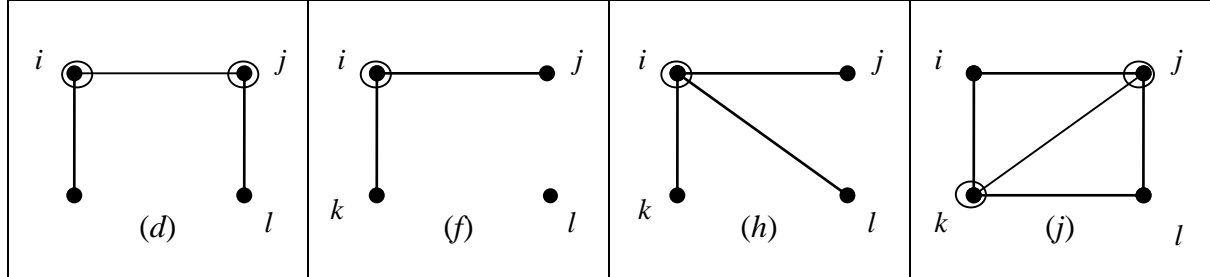
In considering the information presented in Table 3, it is inferred that network k is strong link deletion proof because country l does not have an incentive to break the link with country i when passing from network k to network j ; two links with countries i and j when passing from network k to network i ; or its three links when passing from network k to network g . This is because in the first, second and third cases, welfare in country l decreases from 4.800 to 0.4238, 0.3733 and 0.3759, respectively. Using this line of reasoning, it is inferred that the only network that is not strong link deletion proof is network i in Figure 2 because in this case country l has an incentive to break its agreement with country k when passing from network i to network g . It is concluded, therefore, that $D_S = G - \Delta_i$.

In relation to global treaty proof networks, it is inferred from Table 3 that networks d, f, h, i and j are all global treaty proof networks. Consequently, the set of global treaty proof networks is given by $G_T = \Delta_d \cup \Delta_f \cup \Delta_h \cup \Delta_i \cup \Delta_j \cup k$. To understand this, consider for example network d . If countries in this network signed a global agreement, then welfare in countries i and j would decrease from 0.5174 to 0.4800, and welfare in countries k and l would increase from 0.3958 to 0.4800. Because a global agreement implies a decrease in welfare in countries i and j , it is inferred that these countries would be unwilling to sign this agreement, and this explains why this network is global treaty proof.

In considering the analysis developed above, it is concluded that the set of strongly treaty stable networks is $D_S \cap G_T = \Delta_d \cup \Delta_f \cup \Delta_h \cup \Delta_j \cup k$. In terms of Figure 2, these networks are networks

d, f, h, j and k . The networks different from global free trade (i.e. network k) are presented in Figure 3.

Figure 3. Strongly treaty stable networks for the unbiased case



In this figure, the nodes with an eccentric circle represent countries that are unwilling to sign a global agreement in agriculture, and the nodes without an eccentric circle correspond to countries that are willing to sign the agreement. Notice that the former countries have something in common: all of them have a larger number of links and are connected with countries having a small number of links. That is, they occupy a central position in the network. This actually explains their unwillingness to sign a global agreement: having a large number of agreements allows them to obtain high levels of consumer surplus because their domestic markets become more competitive. At the same time, they obtain high levels of profits in foreign countries because the domestic markets of the latter are less competitive as a consequence of the lower number of agreements. Consequently, it is a good strategy to occupy a central position in the network because countries can obtain higher levels of welfare than in global free trade.

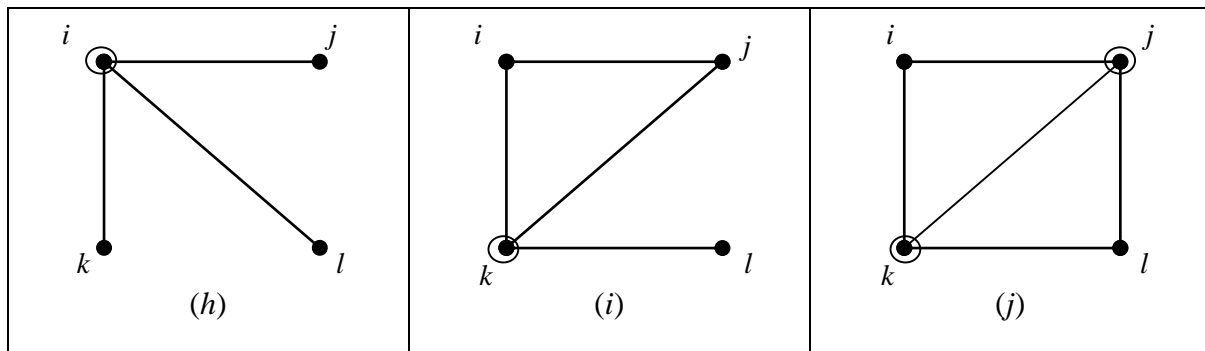
This result has three main implications. Firstly, the structure of the current network affects the behaviour of governments in terms of willingness to sign a global agreement in agriculture. This is a novel result that has not been identified by alternative modelling approaches. Secondly, this simulation assumes unbiased countries. This implies that the failure of a global agreement is not necessarily explained by policy bias as suggested by related studies. In our setting, unbiased countries can also be unwilling to sign this agreement depending on their position in the network. Finally, while global free trade is also global treaty stable, it may not be reached when countries occupy a privileged position in other networks.

3.1.2. The case of biased governments

In order to determine global treaty stability when governments are politically biased, we consider two extreme cases, namely: when governments are biased in favour of consumers (i.e. $a_i = 1$ and $b_i = 0$ in Expression 17); and when governments are biased in favour of intermediaries (i.e. $b_i = 1$ and $a_i = 0$ in Expression 17).

In considering the information presented in Table 1, it is concluded that all networks are strong link deletion proof; and networks h , i , j , and k are global treaty proof. To understand this latter result, consider for example network j . In this network, countries j and k obtain a level of consumer surplus equal to 0.3200. Because this level of consumer surplus is the same as the level that these countries can obtain in global free trade, these countries are indifferent between signing and not signing a global agreement in agriculture. This explains why network j is strong treaty proof. Consequently, the set of global treaty stable networks when governments are biased in favour of consumers is $D_S \cap G_T = \Delta_h \cup \Delta_i \cup \Delta_j \cup k$. In terms of Figure 2, these networks correspond to networks h , i , j and k . The networks different from global free trade are presented in the following Figure:

Figure 4. Strongly treaty stable networks: the case of governments biased in favour of consumers



In this case, the nodes with an eccentric circle represent countries that are indifferent between signing and not signing a global agreement, and nodes without an eccentric circle correspond to countries that are willing to sign the agreement. The reason of why the former are indifferent is explained by the fact that all these countries have an agreement with the rest of the countries. Thus, because consumer surplus in a country depends only on the number of agreements present in that country when there are not monopsonistic power (i.e. when $\phi = 0$), they achieve the same level of consumer surplus as in global free trade. As we will see shortly, these motivations change when there is a farming sector.

On the other hand, when governments are biased in favour of intermediaries, the only strong link deletion proof network is the empty network (i.e. network a in Figure 2), and this network is also global treaty proof. This means that the only global treaty stable network in this case is the empty network. According to this result, if governments were biased in favour of intermediaries, then countries would be in autarky. The reason is because in autarky, these individuals obtain high monopoly rents which are higher than the profit they could obtain in global free trade. We don't observe this type of pattern in the real world. This suggests, therefore, either that governments are not completely biased in favour of intermediaries, or that the missing farming sector in the original model by Goyal and Joshi plays a key role in explaining the observed international patterns in agriculture.

3.1.3. Main results obtained in Goyal and Joshi's world

In summary, global treaty stability in Goyal and Joshi's model predict three main results. Firstly, when governments are politically unbiased, countries that occupy a central position in the network are unwilling to sign a global agreement in agriculture. Second, when governments are biased in favour of consumers, countries that have links with all the countries of the world are indifferent between signing and not signing the agreement. Finally, when governments are biased in favour of intermediaries, no country is willing to sign a global agreement in agriculture. We use these results as a benchmark to explore how the network structure and governments incentives change when adding the farming sector into the analysis.

3.2. Simulations 2 and 3: $\alpha = 1$ and, $\phi = 0.5$ and $\phi = 1.5$

In this section we introduce the farming sector by allowing positive values of the coefficient ϕ . In order to identify the effect of this sector on the international network structure and incentives of policymakers, two values of ϕ were considered. One for low degree of monopsonistic power (i.e. $\phi = 0.5$), and the other for high levels of monopsonistic power (i.e. $\phi = 1.5$).

In contrast to the original model by Goyal and Joshi (2006), the existence of a farming sector creates interdependence between countries that are directly or indirectly linked throughout the cost structure faced by the intermediaries. This interdependence affects all the components of the welfare function. To see this, note that the numerator of the Consumer Surplus function in Expression 13 in an arbitrary country i contains the following expression:

$$2\alpha(\phi+1)\eta_i(g) - \phi(\phi+1) \sum_{j \in N_i(g)} q_{j-i}(g), \text{ where the term } \sum_{j \in N_i(g)} q_{j-i}(g) \text{ denotes the output sold by}$$

partner countries in countries other than i . According to this expression, if country i has an agreement with country j and the latter increases the output exported to, say, country k , then consumer surplus in country i decreases. The reason is because the higher output exported to country k by country j pushes the price paid to farmers in the latter country up, as can be inferred from Equation 1. This higher price implies higher cost faced by the intermediary in country j . In order to adjust to this additional cost, the intermediary decreases the output sold in other markets, including the domestic market of country i . This lower output increases market power in these markets negatively affecting the level of consumer surplus obtained by consumers. On the other hand, consider the Equation 12 which represents the profit made by the intermediary of country i in country j . The numerator of this Equation contains the following expression:

$$2\alpha(1+\phi) + \phi \sum_{i \in N_j(g)} q_{i-j}(g) - \phi(1+\phi + \eta_j(g))q_{i-j}(g). \text{ By rearranging terms, this expression}$$

$$\text{becomes: } 2\alpha(1+\phi) + \phi \sum_{l \in N_j(g) - \{i\}} q_{l-j}(g) - \phi(\phi + \eta_j(g))q_{i-j}(g), \text{ where the term } \sum_{l \in N_j(g) - \{i\}} q_{l-j}(g) \text{ is the}$$

output sold by the partners of country i in countries other than j , and the term $q_{i-j}(g)$ is the output sold by the intermediary of country i in countries other than country j . According to the

expression above, an increase in $\sum_{l \in N_j(g) - \{i\}} q_{l-j}(g)$ positively affects the profit made by the

intermediary of country i in country j . The reason is because when a partner country l increases the output sold to, say, country k , the price paid to farmers in country l increases. The intermediary in country l adjusts to this higher cost by reducing the level of output sold in other markets, included the domestic market of country j . This lower output increases market power in the latter positively affecting the profit made by the intermediary of country i in country j . In contrast, the term $q_{i-j}(g)$ reduces the profit made by this individual in that market. To see this, note that when the intermediary of country i increases the level of output sold to, say, country u , the price that this individual pay to the farming sector increases. This higher cost negatively affect the level of profit that this individual make in other markets including the domestic market of country j . Finally, consider the Equation 14 which corresponds to producer surplus obtained by the farming sector in country i . This equation is a monotonic transformation of the total output sold by the intermediary in this country implying that producer surplus increases as this output increases. This is because an additional level of total output pushed the price paid to farmers up. Now, consider the Equation 9 which correspond to the output exported by the intermediary of country i to country j . The numerator of this equation contains the expression $2\alpha(1+\phi) + \phi \sum_{i \in N_j(g)} q_{i-j}(g) - \phi(1+\phi+\eta_j(g))q_{i-j}(g)$. By rearranging terms, this

expression becomes $2\alpha(1+\phi) + \phi \sum_{l \in N_j(g) - \{i\}} q_{l-j}(g) - \phi(\phi + \eta_j(g))q_{i-j}(g)$ where, as explained

above, the term $\sum_{l \in N_j(g) - \{i\}} q_{l-j}(g)$ is the output sold by the partners of country i in countries other

than j , and the term $q_{i-j}(g)$ is the output sold by the intermediary of country i in countries other than country j . In considering the producer surplus function, an increase in $\sum_{l \in N_j(g) - \{i\}} q_{l-j}(g)$

positively affects producer surplus obtained by the farming sector of country i . The reason is because when a partner country l increases the output sold to, say, country k , the price paid to farmers in country l increases. The intermediary in country l adjusts to this higher cost by reducing the level of output sold in other markets, included the domestic market of country j . This lower output increases market power in the latter. In response to this higher level of market power in the domestic market of country j , the intermediary of country i increases the level of output exported to this country, and this additional output causes an increase in the price paid to the farming sector in country i . This higher price is what causes an increase in the level of producer surplus obtained by these farmers. In contrast, the term $q_{i-j}(g)$ reduces the level of producer surplus obtained by the farming sector in country i . To see this, note that when the intermediary of country i increases the level of output sold to, say, country u , the price that this individual pay to the farming sector increases. In response to this higher cost, the intermediary adjust by reducing the output sold in other markets negatively affecting the level of producer surplus obtained by the farming sector in country i .

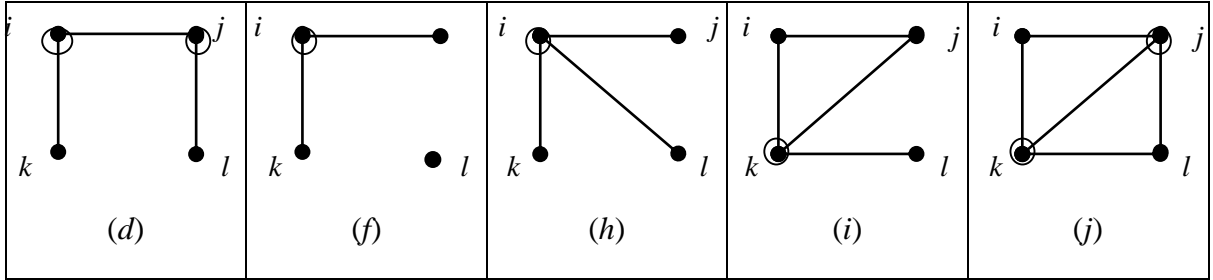
This complex interconnection across countries creates externalities that are not captured by the original model by Goyal and Joshi. The introduction of these externalities into the analysis is

what makes the proposed international network model a more complete and realistic description of the trade system in agriculture. The interconnection across countries and the associated externalities are used to explain some of the results obtained in the following simulations.

3.2.1. The case of unbiased governments

We start the analysis by considering the case when governments are unbiased. The information that is needed for the simulation that assumes $\phi = 0.5$ is presented in Table 10 an Appendix B, and the information that is needed for the simulation that assumes $\phi = 1.5$ is presented in Table 11 in Appendix B. Using the information presented in these tables, it was possible to identify the sets of global treaty stable networks under $\phi = 0.5$ and $\phi = 1.5$. The results revealed that under these assumptions, the sets of global stable network for both simulations are the same and correspond to $D_S \cap G_T = \Delta_d \cup \Delta_f \cup \Delta_h \cup \Delta_i \cup \Delta_j \cup k$. In terms of Figure 2, these networks are networks d, f, h, i, j and k . The networks different from global free trade (i.e. network k) are presented in Figure 5.

Figure 5. Strongly treaty stable networks for the unbiased case



As before, the nodes that have an eccentric circle in this figure represent countries that are unwilling to sign a global agreement in agriculture.

The results of the simulations revealed that the global treaty stable networks identified in the original model by Goyal and Joshi for the unbiased case (see Figure 3) are also globally treaty stable in the simulations considered in this section. However, a new stable network emerged when the farming sector is present which corresponds to network i . The stability of this network is explained by the farming sector. To see this, note that when $\phi = 0$ (i.e. in Goyal and Joshi's world), country l in network i has an incentive to break its existing link with country k when passing from network i to network g (see Figure 2). This happens because the decrease in consumer surplus after the link deletion is not as large as the increase in total profit implying that the deletion causes a net gain in welfare in country l . However, when the farming sector is present, the link deletion causes a decrease in producer surplus which, in addition to the decrease in consumer surplus, offset the gain in total profit which implies a net loss of welfare after the agreement is broken. This result suggests, therefore, that when the farming sector is

present, a larger number of networks different from global free trade may be global treaty stable.

On the other hand, it is interesting to note that in all the global treaty stable networks presented in Figure 5, the level of welfare obtained in each country is larger when the farming sector is present. This is explained as follows. Firstly, the information presented in Appendices A and B shows that consumer surplus increases when introducing the farming sector. This is explained by the fact that monopsonistic power increases the cost faced by intermediary when they buy the agricultural good to the farming sector. This higher cost reduces the output sold by these individuals to target markets increasing their level of market power. This higher level of market power, in turn, encourages the intermediaries to increase the output sold in these markets increasing in this way the level of competition. The net effect is, therefore, a decrease in market power which is captured as higher levels of consumer surplus. Secondly, the level of profits made by the intermediaries is lower when there is a farming sector. This is explained by the fact that these individuals face higher costs when buying the agricultural good to the farming sector given the monopsonistic power exercised by the intermediaries. Finally, producer surplus enters as a third component in the welfare function when there is a farming sector. Consequently, the reason of why welfare is larger when there is a farming sector is because the higher level of consumer surplus and the additional welfare coming from producer surplus offset the lower level of total profits obtained by the intermediaries.

In terms of the political incentives of governments, the results presented in Figure 5 show that countries that occupy a central position in the network are unwilling to sign a global agreement in agriculture. As explained in Section 3.1.1, this is a privileged position because central countries achieve high levels of consumer surplus as a consequence of the larger numbers of agreements they have with respect to non-central countries, and they obtain high levels of profits in foreign markets of countries that have low degree of integration. What is new in the simulations is the fact that the privileged central position is reinforced when there is a farming sector because governments can achieve high levels of producer surplus when exporting the agricultural good to countries with low degree of competition. This suggests, consequently, that the existence of a farming sector reinforces the behaviour against a global agreement of countries that occupy a central position in the network.

3.2.2. The case of biased governments

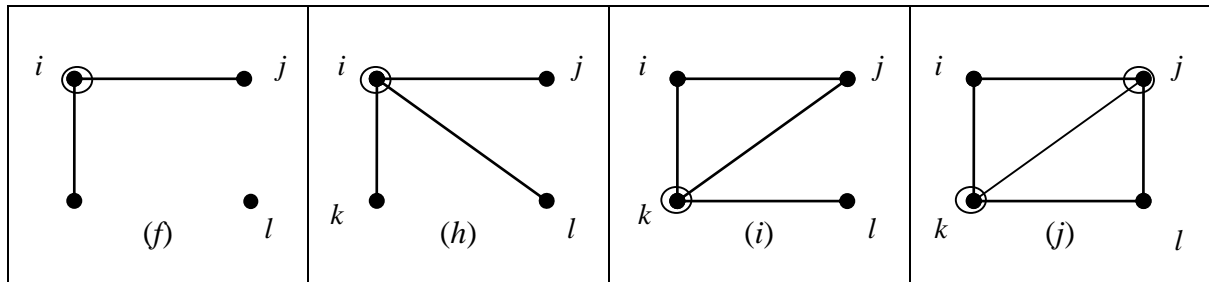
We saw in Section 3.1.2 that when governments are biased in favour of consumers, the set of global treaty stable networks is the set shown in Figure 4. In these networks, the nodes with an eccentric circle represent countries that are indifferent between signing and not signing a global agreement in agriculture. The simulation under the assumption of $\phi = 0.5$ revealed that the same networks are global treaty stable. However, in this case the countries that were indifferent are now unwilling to sign a global agreement in agriculture. This is due to the externalities caused by the farming sector on consumer surplus: the intermediaries in the unwilling countries face higher costs when exporting to less integrated countries. This higher cost implies that these

individuals sell a lower level of output in the domestic market of the unwilling countries. This, in turn, encourages the intermediaries of other countries to increase the output exported to the unwilling countries causing a gain in consumer surplus. This effect is diluted in global free trade because of the higher degree of international integration. On the other hand, when $\phi = 1.5$, not only the networks presented in Figure 4 are global treaty stable, but also network f as country i is unwilling to sign a global agreement. The stability of this network is explained by the same externality related to the farming sector. This finding suggests, again, that the number of global treaty stable networks different from global free trade increases when there is a farming sector.

On the other hand, the same result presented in Section 3.1.2 was found for both simulations (i.e. $\phi = 0.5$ and $\phi = 1.5$) when governments are biased in favour of intermediaries: the only global treaty stable network in these simulations is the empty network. This finding implies that this result is robust throughout different levels of monopsonistic power.

Finally, another novelty in this analysis with respect to the original model by Goyal and Joshi is that our approach allows governments to be biased in favour of the farming sector. The results obtained from the information presented in Table 8 in Appendix B revealed that the set of global treaty stable networks in this case is the set $\Delta_f \cup \Delta_h \cup \Delta_i \cup \Delta_j \cup k$. In terms of Figure 2, these networks correspond to networks f, h, i, j and k . These networks (excluding network global free trade) are shown in the following figure.

Figure 6. Strongly treaty stable networks for the case of governments biased in favour of the farming sector



This figure shows a similar pattern than that described above: countries that occupy a relatively central position in the network are unwilling to sign a global agreement in agriculture. This happens because the level of output exported by the intermediaries of these countries to less integrated countries is large as the domestic markets of the latter have lower degree of competition. This high level of output implies that farmers in the unwilling countries are paid high prices, and this explains why these countries obtain high levels of producer surplus in these networks. On the other hand, when $\phi = 1.5$, the set of global stable networks is the set $\Delta_h \cup \Delta_i \cup \Delta_j$. In terms of Figure 2, these networks correspond to networks h, i and j . It is interesting to notice that in this case network f is not global treaty stable. This finding suggests that when

monopsonistic power is too large, the price paid to farmers is too high to sustain some determined networks. Only in this case global free trade is preferred.

3.3. Some generalisations

As described in the introduction, one of the main disadvantages of the network approach is the problem of tractability. In order to overcome this problem to some extent, we have adopted some simulations based on a world composed of four countries. This section selects some key results identified in these simulations with the purpose of offering generalisations. In order to illustrate the key result that countries that occupy a central position in the network are unwilling to sign a global agreement in agriculture, we focus on the case of unbiased cases. However, the same generalisation applies to the biased cases.

Consider the networks presented in Figures 3 and 5. As discussed above, these networks are global treaty stable. Assume now that each of these networks is a component (i.e. a subset of countries) of a network of size N . The idea is to prove that a network of this size that contains these components is global treaty stable. We already know from the results of the simulations that countries in these components are unwilling to break one of more existing agreements. This is because the strong link addition proof condition of global treaty stability does not depend on the size of the network. Consequently, what we need to prove is that the central countries in the components (i.e. the nodes with an eccentric circle in Figures 3 and 5) are unwilling to sign a global agreement. For this purpose, consider the welfare function in global free trade when the size of the network is Z .

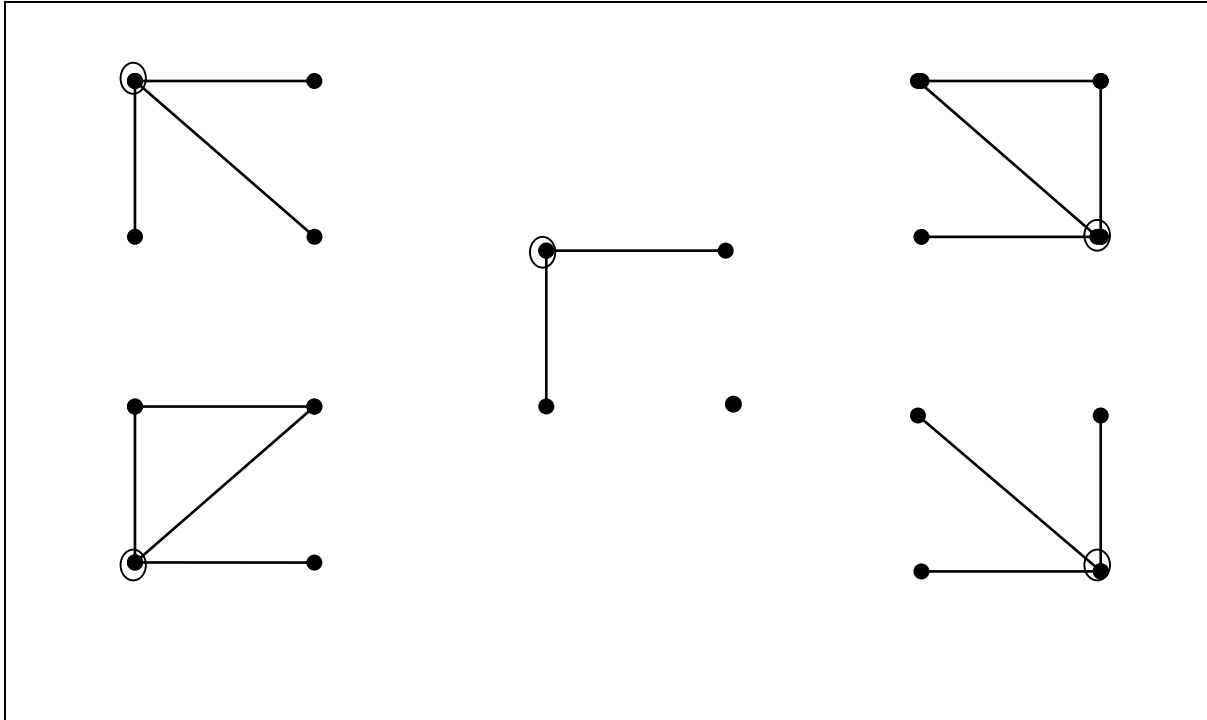
$$W_i(g^c) = CS_i(g^c) + \pi_i(g^c) + PS_i(g^c) = \frac{2\alpha^2(\phi+1)^2 N^2}{[2(1+\phi+N) + \phi(\phi+1)(N-1)]^2} + \frac{2\alpha^2(\phi+1)^2 (2-\phi)N}{[2(1+\phi+N) + \phi(\phi+1)(N-1)]^2} + \frac{\alpha^2(\phi+1)^2 N^2 \phi}{[2(1+\phi+N) + \phi(\phi+1)(N-1)]^2} \quad (18)$$

When $\phi = 0$, this expression converges to $(N^2 + 2N)/2(N+1)^2$. On the other hand, each country in Figure 3 obtains a level of welfare that is equal or larger than $0.5 + \varepsilon$ for some $\varepsilon > 0$, as can be seen in Table 3. Simple calculation shows that $0.5 + \varepsilon > (N^2 + 2N)/2(N+1)^2 = W_i(g^c)$ implies $2N^2\varepsilon + 4N\varepsilon^2 + 2\varepsilon + 1 > 0$. Because this inequality holds for all some $\varepsilon > 0$, it is concluded that the countries with an eccentric circle in Figure 3 are unwilling to sign a global agreement. On the other hand, when $\phi = 0.5$, Expression 18 converges to $(5.625N^2 + 6.75N)/(2.75N + 2.25)^2$. Using this expression, it was found that the central countries in networks h and i in Figure 5

would be unwilling to sign a global agreement. Finally, when $\phi = 1.5$, Expression 18 converges to $(21.875N^2 + 6.25N)/(5.75N + 1.25)^2$. Using this expression, it was found that the central countries in networks f , h and i in Figure 5 would be unwilling to sign a global agreement.

It is inferred from these results that networks composed of components with countries that occupy a central position in them are global treaty stable. An example for the case of $\phi = 1.5$ is presented in the following figure.

Figure 7. A strongly treaty stable network



In this figure, each component can be considered as a block of trade having a country that occupies a central position in them. These countries, identified with an eccentric circle, are unwilling to sign a global agreement. As a consequence, the collapse of an agreement is explained by the existence of these countries.

Conclusions

The results obtained in this study revealed interesting new insights that explain the failure of a global agreement in agriculture. We found that this failure can indeed be explained by policy

biases as suggested by related academic works. However, there is another factor that prevents the signature of this agreement even in a world where governments are not politically biased. It corresponds to the relative position of countries in the international network. We found the novel result that countries that occupy a central position in a block of countries are unwilling to sign a global agreement because this position in the network allows them to obtain higher levels of welfare than in global free trade. The unwillingness of these countries is reinforced when there is a farming sector because the level of producer surplus obtained by countries that are located in these strategic positions is high. This result is in line with the main idea behind the economics of networks: the structure of the current network affects the behaviour of individuals. In the current investigation, the structure of the international trade network affects the behaviour of policymakers in terms of their willingness to sign an agreement.

Given the problem of tractability, the investigation was developed under the assumption of symmetric countries and exogenous tariffs. The relaxation of these assumptions is left for future research.

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Appendix A

Information used in the simulation for $\phi = 0$

Table 1: Consumer Surplus

Networks	Countries			
	<i>i</i>	<i>j</i>	<i>k</i>	<i>l</i>
<i>a</i>	0.1250	0.1250	0.1250	0.1250
<i>b</i>	0.2222	0.1250	0.2222	0.1250
<i>c</i>	0.2222	0.2222	0.2222	0.2222
<i>d</i>	0.2813	0.2813	0.2222	0.2222
<i>e</i>	0.2813	0.2813	0.2813	0.2813
<i>f</i>	0.2813	0.2222	0.2222	0.1250
<i>g</i>	0.2813	0.2813	0.2813	0.1250
<i>h</i>	0.3200	0.2222	0.2222	0.2222
<i>i</i>	0.2813	0.2813	0.3200	0.2222
<i>j</i>	0.2813	0.3200	0.3200	0.2813
<i>k</i>	0.3200	0.3200	0.3200	0.3200

Table 2: Profits made by intermediaries

Networks	Countries			
	<i>i</i>	<i>j</i>	<i>k</i>	<i>l</i>
<i>a</i>	0.2500	0.2500	0.2500	0.2500
<i>b</i>	0.2222	0.2500	0.2222	0.2500
<i>c</i>	0.2222	0.2222	0.2222	0.2222
<i>d</i>	0.2361	0.2361	0.1736	0.1736
<i>e</i>	0.1875	0.1875	0.1875	0.1875
<i>f</i>	0.2847	0.1736	0.1736	0.2500
<i>g</i>	0.1875	0.1875	0.1875	0.2500
<i>h</i>	0.3733	0.1511	0.1511	0.1511
<i>i</i>	0.1650	0.1650	0.2761	0.1511
<i>j</i>	0.1425	0.2050	0.2050	0.1425
<i>k</i>	0.1600	0.1600	0.1600	0.1600

Table 3: Welfare

Networks	Countries			
	<i>i</i>	<i>j</i>	<i>k</i>	<i>l</i>
<i>a</i>	0.3750	0.3750	0.3750	0.3750
<i>b</i>	0.4444	0.3750	0.4444	0.3750
<i>c</i>	0.4444	0.4444	0.4444	0.4444
<i>d</i>	0.5174	0.5174	0.3958	0.3958
<i>e</i>	0.4688	0.4688	0.4688	0.4688
<i>f</i>	0.5660	0.3958	0.3958	0.3750
<i>g</i>	0.4688	0.4688	0.4688	0.3750
<i>h</i>	0.6933	0.3733	0.3733	0.3733
<i>i</i>	0.4463	0.4463	0.5961	0.3733
<i>j</i>	0.4238	0.5250	0.5250	0.4238
<i>k</i>	0.4800	0.4800	0.4800	0.4800

Appendix B

Information used in the simulations for $\phi = 0.5$ and $\phi = 1.5$

Table 4: Consumer Surplus ($\phi = 0.5$)

Networks	Countries			
	<i>i</i>	<i>j</i>	<i>k</i>	<i>l</i>
<i>a</i>	0.1800	0.1800	0.1800	0.1800
<i>b</i>	0.2997	0.1800	0.2997	0.1800
<i>c</i>	0.2997	0.2997	0.2997	0.2997
<i>d</i>	0.3713	0.3713	0.2925	0.2925
<i>e</i>	0.3674	0.3674	0.3674	0.3674
<i>f</i>	0.3818	0.2888	0.2888	0.1800
<i>g</i>	0.3674	0.3674	0.3674	0.1800
<i>h</i>	0.4400	0.2789	0.2789	0.2789
<i>i</i>	0.3596	0.3596	0.4266	0.2854
<i>j</i>	0.3571	0.4171	0.4171	0.3571
<i>k</i>	0.4101	0.4101	0.4101	0.4101

Table 5: Consumer Surplus ($\phi = 1.5$)

Networks	Countries			
	<i>i</i>	<i>j</i>	<i>k</i>	<i>l</i>
<i>a</i>	0.2551	0.2551	0.2551	0.2551
<i>b</i>	0.3075	0.2551	0.3075	0.2551
<i>c</i>	0.3075	0.3075	0.3075	0.3075
<i>d</i>	0.3340	0.3340	0.2945	0.2945
<i>e</i>	0.3287	0.3287	0.3287	0.3287
<i>f</i>	0.3546	0.2924	0.2924	0.2551
<i>g</i>	0.3287	0.3287	0.3287	0.2551
<i>h</i>	0.3925	0.2842	0.2842	0.2842
<i>i</i>	0.3232	0.3232	0.3670	0.2855
<i>j</i>	0.3163	0.3510	0.3510	0.3163
<i>k</i>	0.3401	0.3401	0.3401	0.3401

Table 6: Profits made by the intermediary ($\phi = 0.5$)

Networks	Countries			
	<i>i</i>	<i>j</i>	<i>k</i>	<i>l</i>
<i>a</i>	0.2700	0.2700	0.2700	0.2700
<i>b</i>	0.2248	0.2700	0.2248	0.2700
<i>c</i>	0.2248	0.2248	0.2248	0.2248
<i>d</i>	0.2036	0.2036	0.2040	0.2040
<i>e</i>	0.1838	0.1838	0.1838	0.1838
<i>f</i>	0.2241	0.2031	0.2031	0.2700
<i>g</i>	0.1839	0.1839	0.1839	0.2700
<i>h</i>	0.2330	0.1954	0.1954	0.1954
<i>i</i>	0.1768	0.1768	0.1959	0.1945
<i>j</i>	0.1669	0.1706	0.1706	0.1669
<i>k</i>	0.1536	0.1536	0.1536	0.1536

Table 7: Profits made by the intermediary ($\phi = 1.5$)

Networks	Countries			
	<i>i</i>	<i>j</i>	<i>k</i>	<i>l</i>
<i>a</i>	0.1276	0.1276	0.1276	0.1276
<i>b</i>	0.0768	0.1276	0.0768	0.1276
<i>c</i>	0.0768	0.0768	0.0768	0.0768
<i>d</i>	0.0564	0.0564	0.0768	0.0768
<i>e</i>	0.0548	0.0548	0.0548	0.0548
<i>f</i>	0.0587	0.0771	0.0771	0.1276
<i>g</i>	0.0548	0.0548	0.0548	0.1276
<i>h</i>	0.0532	0.0793	0.0793	0.0793
<i>i</i>	0.0553	0.0553	0.0468	0.0782
<i>j</i>	0.0548	0.0440	0.0440	0.0548
<i>k</i>	0.0424	0.0424	0.0424	0.0424

Table 8: Producer surplus ($\phi = 0.5$)

Networks	Countries			
	<i>i</i>	<i>j</i>	<i>k</i>	<i>l</i>
<i>a</i>	0.0450	0.0450	0.0450	0.0450
<i>b</i>	0.0749	0.0450	0.0749	0.0450
<i>c</i>	0.0749	0.0749	0.0749	0.0749
<i>d</i>	0.0999	0.0999	0.0671	0.0671
<i>e</i>	0.0918	0.0918	0.0918	0.0918
<i>f</i>	0.1095	0.0659	0.0659	0.0450
<i>g</i>	0.0918	0.0918	0.0918	0.0450
<i>h</i>	0.1444	0.0615	0.0615	0.0615
<i>i</i>	0.0873	0.0873	0.1250	0.0620
<i>j</i>	0.0825	0.1119	0.1119	0.0825
<i>k</i>	0.1025	0.1025	0.1025	0.1025

Table 9: Producer surplus ($\phi = 1.5$)

Networks	Countries			
	<i>i</i>	<i>j</i>	<i>k</i>	<i>l</i>
<i>a</i>	0.1913	0.1913	0.1913	0.1913
<i>b</i>	0.2307	0.1913	0.2307	0.1913
<i>c</i>	0.2307	0.2307	0.2307	0.2307
<i>d</i>	0.2482	0.2482	0.2276	0.2276
<i>e</i>	0.2466	0.2466	0.2466	0.2466
<i>f</i>	0.2525	0.2256	0.2256	0.1913
<i>g</i>	0.2466	0.2466	0.2466	0.1913
<i>h</i>	0.2666	0.2212	0.2212	0.2212
<i>i</i>	0.2434	0.2434	0.2611	0.2249
<i>j</i>	0.2428	0.2576	0.2576	0.2428
<i>k</i>	0.2551	0.2551	0.2551	0.2551

Table 10: Welfare ($\phi = 0.5$)

Networks	Countries			
	<i>i</i>	<i>j</i>	<i>k</i>	<i>l</i>
<i>a</i>	0.4950	0.4950	0.4950	0.4950
<i>b</i>	0.5994	0.4950	0.5994	0.4950
<i>c</i>	0.5994	0.5994	0.5994	0.5994
<i>d</i>	0.6748	0.6748	0.5636	0.5636
<i>e</i>	0.6430	0.6430	0.6430	0.6430
<i>f</i>	0.7154	0.5578	0.5578	0.4950
<i>g</i>	0.6431	0.6431	0.6431	0.4950
<i>h</i>	0.8174	0.5358	0.5358	0.5358
<i>i</i>	0.6237	0.6237	0.7475	0.5419
<i>j</i>	0.6065	0.6996	0.6996	0.6065
<i>k</i>	0.6662	0.6662	0.6662	0.6662

Table 11: Welfare ($\phi = 1.5$)

Networks	Countries			
	<i>i</i>	<i>j</i>	<i>k</i>	<i>l</i>
<i>a</i>	0.5740	0.5740	0.5740	0.5740
<i>b</i>	0.6150	0.5740	0.6150	0.5740
<i>c</i>	0.6150	0.6150	0.6150	0.6150
<i>d</i>	0.6386	0.6386	0.5989	0.5989
<i>e</i>	0.6301	0.6301	0.6301	0.6301
<i>f</i>	0.6658	0.5951	0.5951	0.5740
<i>g</i>	0.6301	0.6301	0.6301	0.5740
<i>h</i>	0.7123	0.5847	0.5847	0.5847
<i>i</i>	0.6219	0.6219	0.6749	0.5886
<i>j</i>	0.6139	0.6526	0.6526	0.6139
<i>k</i>	0.6376	0.6376	0.6376	0.6376