



The evolution of free trade networks



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ABSTRACT

This paper considers the evolutionary dynamics of a free trade agreement (FTA) network formation game among N countries. We first explore the static model introduced by Goyal and Joshi (2006) and precisely characterize the set of pairwise stable FTA networks. Then, we develop a dynamic model under random perturbations and identify long-run outcomes to remove prediction uncertainty inherited from static analysis. The results show that both partial free trade and global free trade will result when there are only three countries. However, when more countries are involved, only the complete FTA network emerges.

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1. Introduction

During the last 50 years from the birth of the GATT to the establishment of the WTO, major trade agreements have been signed through a *multilateral* mechanism. Starting in the 1980s, *bilateralism and regionalism* have become increasingly prevalent as a complementary settlement.¹ As a result, an average WTO member belongs to six preferential trade agreements (PTAs) or free trade agreements (FTAs) (World Bank, 2005). Given that WTO members embrace both bilateralism and multilateralism at the same time, a natural question emerges: would global free trade be easier to achieve if all countries were to pursue trade liberalization but only on a bilateral basis? To address this issue, we consider a static model and extend it to a dynamic framework to check the effect of bilateralism on globalization.

We begin with a benchmark model proposed by Goyal and Joshi (2006). In an imperfect competition model, there are N ($N \geq 3$) symmetric countries; each country has one single firm; all firms compete in the segmented market of each country; countries discuss free trade agreements bilaterally, remove trade barriers for FTA partners and impose optimal tariff rates on non-FTA partners. In the static analysis, we use *pairwise stability* to characterize all equilibria (Proposition 2). The stability of the complete FTA network implies the attainment of global free trade (Goyal and Joshi, 2006). In addition, we prove the existence of other stable FTA regimes where each can be partitioned into fully intraconnected trading blocs. This result

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¹ According to the official website of the WTO, up to February 2010, some 511 regional trade agreements were notified to it. Of these, free trade agreements and partial trade agreements accounted for over 90% of them.

suggests that the trade liberalization process may end up with partial free trade and undermine the spirit of multilateralism. The prediction uncertainty underlying multiple static equilibria motivates us to implement further dynamic analysis.

First, we develop an unperturbed dynamic model in which countries sequentially create or delete bilateral FTA links. In each period, a pair of countries is randomly chosen. If the FTA link between the two countries is already in force, a decision has to be made whether to delete it; otherwise, a decision has to be made whether to create a link. Countries only care about the immediate gains acquired in the next period and make a myopic best-response decision on the basis of them. This assumption can be justified by the myopic behavior of limited-term government. The convergence of the unperturbed dynamics is guaranteed, and the result shows that the set of limit states coincides with the set of equilibria in the static framework (Proposition 5).

Then, we establish randomly perturbed dynamics by introducing stochastic mutations. When two countries are selected, there is a sufficiently small but strictly positive probability that errors will occur when they make their decisions. The FTA link is deleted when it should be kept, and is added when it should not. In reality, when a country contemplates bilateral FTA relations with others, occasional mistakes are inevitable. These errors may arise for a variety of reasons. It could be due to exogenous factors beyond government control.² Or it may be due to limited information or miscalculation of social welfare. It can also be explained by “political externalities” as proposed by Ethier (2004). To capture the long-run effect of these uncertainties, we use *stochastic stability* (Kandori et al., 1993; Young, 1993) to explore which FTA networks are observable for most of the time when stochastic mutations cease. These equilibria are referred to as *stochastically stable FTA networks*. Our results show that when $N=3$, all pairwise stable FTA networks are stochastically stable, but that the partial one with two linked countries and a singleton may appear with higher probability (Proposition 6). When $N \geq 4$, the unique stochastically stable equilibrium is the complete FTA network (Proposition 7). That is, the number of countries plays a crucial role when investigating the merit of bilateralism and multilateralism.

This paper contributes to the study of FTA network formation. Although we employ the endogenous tariff model proposed by Goyal and Joshi (2006) as the benchmark, there are differences. To complement their argument, we characterize all pairwise stable equilibria and show that other partial free trade regimes may emerge as equilibrium outcomes besides global free trade. The major difference is that we depart from their static framework and delve into dynamic analysis. By investigating stochastic stability of static equilibria, we find that the world trading system is the unique stochastic stable network when four or more countries are involved. To compare the effect of two different mechanisms of revision opportunities on the long-run convergence of FTA network formation, Daisaka and Furusawa (2011) conduct simulations of Goyal and Joshi’s (2006) model with endogenous tariffs. However, their simulation analysis does not take into account prediction uncertainty and random perturbation. Foti et al. (2013) investigate the robustness of the world trade network. They employ weighted network analysis and conclude that the densely connected trade networks are more robust for small shocks but less robust in the face of large, cascading shocks.³ Another closely related paper is that of Furusawa and Konishi (2007). They develop a model that is richer as it allow for aspects such as different market sizes and industry sizes among countries. As in Goyal and Joshi (2006), their analysis also belongs to the static framework.⁴

This paper is also related to the exploration of the strategic stabilities of different trading regimes. Much of the existing literature has been concerned with the static framework (Kemp and Wan, 1976; Krugman, 1991; Krishna, 1998; Levy, 1997). As far as we aware, work on dynamic analysis has been restricted to a three-country environment and has investigated the “stumbling” effects of FTA on global free trade (Aghion et al., 2007; Macho-Stadler and Xue, 2007; Mukunoki and Tachi, 2006; Seidmann, 2009). By contrast, our paper considers an N -country dynamic model. When three countries are involved, our results are consistent with the conclusions of the existing literature. However, when more countries are involved, we find that global free trade is the unique stochastically stable equilibrium.

The paper is organized as follows. Notation and explanation of the basic model are introduced in Section 2. In Section 3, we characterize the set of pairwise stable free trade networks. In Section 4, we examine the convergence of unperturbed dynamics and investigate stochastically stable FTA networks based on perturbed dynamics. Section 5 concludes. Proofs are contained in the Appendix.

2. Notation and basic model

We consider an N -country model, $N \geq 3$, where all firms (one firm in each country) produce a homogenous good at a constant marginal cost γ . Each country’s ability to sell in foreign markets, however, depends on the level of import tariffs set by different countries. In country i ’s market, the demand function is assumed to be linear: $P_i = \alpha - Q_i$, where $\alpha > \gamma$. All firms compete in country i in a Cournot fashion. Define Q_i^j as the output of firm j in country i . Then $Q_i = \sum_{j \in \mathbf{N}} Q_i^j$.

2.1. Free trade agreement (FTA) networks

Let $\mathbf{N} = \{1, 2, \dots, N\}$ be the set of symmetric countries. For any two countries $i, j \in \mathbf{N}$, the pairwise relationship between them is captured by a binary variable, $g_{ij} \in \{0, 1\}$. $g_{ij} = 1$ if there is a bilateral free trade agreement between countries i and j and $g_{ij} = 0$ otherwise; conventionally, $g_{ii} = 1$. Thus, $g = \{(g_{ij})_{i,j \in \mathbf{N}}\}$ defines an undirected graph, and it is referred to as a *free*

² Such factors can be illustrated by the existence of KoPA in South Korea. The organization aims to struggle against neoliberal globalization.

³ This method has also been used to investigate financial network (Chinazzi et al., 2013; Iori et al., 2008).

⁴ Investigation on the dynamic process of Furusawa and Konishi’s (2007) model constitutes an interesting topic. The first task is to characterize all equilibria in the static framework. Due to the intricacy of their setting, it is not an easy task.

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