Mathematical Social Sciences 76 (2015) 118–124

Contents lists available at ScienceDirect

Mathematical Social Sciences

journal homepage: www.elsevier.com/locate/econbase

# Farsightedly stable tariffs ☆

Ryo Kawasaki *, Takashi Sato, Shigeo Muto

*Department of Social Engineering, Graduate School of Decision Science and Technology, Tokyo Institute of Technology, 2-12-1 O-okayama, Meguro-ku, Tokyo 152-8552, Japan*

## HIGHLIGHTS

- This paper explores the farsighted stable sets of the tariff game.
- The farsighted stable sets are all singletons.
- Each set is a Pareto efficient and strictly individually rational tariff profile.
- The results hold regardless of whether coalitional deviations are allowed or not.

## ARTICLE INFO

*Article history:*
Received 23 December 2013
Received in revised form
23 April 2015
Accepted 1 May 2015
Available online 8 May 2015

## ABSTRACT

This article analyzes the tariff negotiation game between two countries when the countries are sufficiently farsighted. It extends the research of Nakanishi (2000) and Oladi (2005) for the tariff retaliation game in which countries take into account subsequent retaliations that may occur after their own retaliation. We show that when countries are sufficiently farsighted, all farsighted stable sets of the tariff game of Nakanishi (2000) are singletons, which are Pareto efficient and strictly individually rational tariff combinations. These results hold regardless of whether coalitional deviations are allowed or not.



## 1. Introduction

This article analyzes the tariff negotiation game between two countries when the countries are sufficiently farsighted. Primary papers in the literature, such as Johnson (1953–1954) envision a scenario in which countries choose an optimal tariff rate given that the other country does not change its tariff rate. Tower (1975) and Rodriguez (1974) have carried this analysis over to the game in which countries have the option of choosing import or export quotas and compared the effects of these quotas to tariffs. Although not explicit in their formulation, the authors employ an equilibrium concept similar to that of Nash equilibrium. In these models, each country successively chooses a tariff rate or a quota level under the assumption that the other country stays put.

However, when each country chooses such an optimal level, it does not take into account the consequences of such actions that it triggers, including the possibility that the other country may retaliate in response. Recently, Nakanishi (1999), for the quota game, and Oladi (2005) and Nakanishi (2000), for the tariff game, have applied the theory of social situations of Greenberg (1990) to the export quota game and the tariff game respectively to capture this possibility in their model. They show that the set of Pareto efficient tariffs, including those that are not individually rational, constitute one of many stable sets of the game. However, the domination relation that their findings are based on does not take into account the situation in which players are not myopic. Moreover, their results rely on the allowance of coalitional deviations—that is, a simultaneous deviation by more than one player.

In this paper, we analyze the stable outcomes in tariff games when players can sufficiently take into account the consequences of their deviations and are only interested in the final outcomes as results of such deviations. To do so, we apply the farsighted stable set to tariff games.

There has been a growing literature of the application of farsighted stable set of Chwe (1994). The starting point of the

☆ The authors thank an associate editor, two anonymous reviewers, Keisuke Bando, Shin Kishimoto, and seminar participants at Kyoto University for comments and suggestions. This paper has been circulated under the title "Farsighted Stable Sets of Tariff Games", TERG Discussion Paper No. 281, Tohoku University. The authors thank the Japan Society for the Promotion of Science (JSPS) for financial support through the Research Activities Start-up No. 22830010, the Grants-in-Aid for Young Scientists (B) No. 26780115, and the Grants-in-Aid for Scientific Research (B) Nos 24310110 and 26285045.

* Corresponding author.
*E-mail addresses:* kawasaki.r.aa@m.titech.ac.jp (R. Kawasaki), muto@soc.titech.ac.jp (S. Muto).

http://dx.doi.org/10.1016/j.mathsocsci.2015.05.001
0165-4896/

argument for the farsighted stable set start with the argument by Harsanyi (1974) and Chwe (1994) that the classic stable set of von Neumann and Morgenstern (1953) uses a domination relation that is myopic. Attempting to take into account sequences of deviations that may occur, Harsanyi (1974) and Chwe (1994) define a domination relation, called indirect domination, which is then used to define the farsighted stable set. Farsighted variations of the stable set have been applied to, for example, exchange economies Greenberg et al. (2002), games in characteristic function form (Beal et al., 2008; Bhattacharya and Brosi, 2011), and coalition formation and matching markets (Diamantoudi and Xue, 2003, 2007; Herings et al., 2010; Mauleon et al., 2011; Klaus et al., 2011). In strategic form games, Suzuki and Muto (2005) and Kamijo and Muto (2010) show that farsightedness is the key element in reaching Pareto efficient outcomes, while previous research has not been able to yield such results. This message has to be taken cautiously since they allow coalitional deviations—that is, simultaneous deviation by multiple players. The juxtaposition of the results in Suzuki and Muto (2000), Masuda (2002), Nakanishi (2009), and Kawasaki and Muto (2009) reveal that there is not a direct relationship between the efficiency of the results in farsighted stable sets and the rules of the game governing the allowance of coalitional deviations.

In light of the aforementioned papers in the literature, we analyze the farsighted stable sets of two different versions of the tariff game of Nakanishi (2000): one that allows coalitional deviations and one that does not. We consider the first case in order to compare our results to that of Oladi (2005) and Nakanishi (2000). Then, we consider the second case and show that we can obtain similar results. The tariff game that disallows coalitional deviations can be interpreted as an alternating negotiation game in which one player proposes one tariff, while in the next step, the other player can respond. This model is closely related to Nakanishi (1999), which also restricts deviations to those made by individual players in a quota retaliation game.

We show that in both cases, a tariff combination of the two countries that is Pareto efficient and strictly individually rational constitutes a singleton farsighted stable set. Moreover, no other types of farsighted stable sets exist in these two games. Thus, the rules of the game regarding coalitional deviations do not affect the outcome of the results, although the proof of the statement is far more involved in the second game.

One possible criticism to this approach is that it requires the players to be able to foresee events multiple steps ahead. However, as will be apparent in the proofs of the statements of this paper, we do not need to assume a substantial amount of farsightedness to establish the results. All of the results hold when player can foresee at least four steps ahead.

The rest of the paper proceeds as follows. In the next section, we introduce two models of the tariff game as mentioned in the introduction. In Section 3, we review the literature on farsighted stable sets and provide key definitions and their properties. In Sections 4 and 5, we present the results for the two models. In Section 6, we provide some interpretation of the results and discuss connections to Cournot duopoly games, which have very similar strategic features as the game considered here.

## 2. The tariff game

In this section, we introduce the tariff game. Let $G = (N, (X_i)_{i\in N}, (U_i)_{i\in N})$ be a game in strategic form where $X_i$ is the set of strategies for player $i \in N$. In the tariff game, $X_i$ is the set of tariffs from which a country can choose. $U_i$ is the payoff function for player $i$.

To incorporate farsightedness into this framework, Chwe (1994) defines the effectiveness relation $\rightarrow_S$ for each $S \subseteq N$ as a binary relation on $X = \prod_{i\in N} X_i$ such that $x \rightarrow_S y$ denotes that players in $S$ can realize the outcome $y$ when $x$ is the status quo. A concrete definition of $\rightarrow_S$ depends on the context of how the game is defined—including, for example, whether coalitional deviations are allowed or not.[1] The difference of the two models considered in this paper come from how this relation is defined.

When simultaneous deviations by multiple players are allowed, we have for each $S \subseteq N$,

$$x \rightarrow_S y \Leftrightarrow x_i = y_i \quad \forall i \in N \setminus S,$$

where the latter condition is dropped if $S = N$. This assumption is also made in Nakanishi (2000) and Oladi (2005).

In this paper, we also consider a model which disallows coalition deviations. In this situation, we consider deviations of the following form:

$$x \rightarrow_i y \Leftrightarrow x_j = y_j \quad \forall i,\ j \in N, i \neq j.$$

The above condition states that only one player can deviate at a time. Nakanishi (1999) imposes this condition on the quota retaliation game.

Let $N = \{1, 2\}$ be the set of players, where each player is a country. Throughout these two terms will be used interchangeably. We retain the features in tariff games of Mayer (1981), Dixit (1987), and Oladi (2005); and we include some (but not all of the) additional regulatory assumptions made in Nakanishi (2000) and in Nakanishi (2010). In particular, we assume that there are two goods, A and B, where country 1 imports good A, and country 2 imports good B. We assume perfect competition for the two goods involved and no transport costs. Let $p_A$ be the price of good A in country 2, and $p_B$ be the price of good B in country 1.

Let $X_i$ represent the set of tariffs that country $i \in N$ can choose and is defined as $X_i = (-1, \bar{t}_i]$ where $\bar{t}_i$ represents the highest tariff rate that is permitted. Justifiably, this upper bound on tariff is what is called the prohibitive rate of tariff. See, for example, Dixit (1987). A negative tariff rate is defined to be a subsidy from one country to the other; the value $-1$ is not included in the set, since the prices would be undefined. Although a negative tariff rate seems impractical, we include the possibility here to make direct comparisons between our results and those of Oladi (2005).[2] All of our results hold (much more easily) if we restrict our attention to only nonnegative tariff rates. $X = X_1 \times X_2$ represents the set of possible outcomes resulting from the choices of countries 1 and 2. Throughout this paper we call an element $t \in X$ a tariff profile or simply an outcome. For $t = (t_1, t_2) \in X$, the price of good A in country 1 is $p_A(1 + t_1)$, and the price of good B in country 2 is $p_B(1 + t_2)$.

Following Nakanishi (2000), define $X^o$ as the set of tariff profiles at which there is no trade, because either country or both have set a relatively high tariff rate, thereby discouraging trade. We assume that $X^o$ contains tariff profiles $x$ such that $x_i = \bar{t}_i$ and $x_j > 0$. We let $U_i(x) = \bar{u}_i$ for all outcomes $x \in X^o$. Let $X^* = X \setminus X^o$ be the set of tariff profiles at which there is a positive amount of trade.

We assume that the utility functions defined on the tariff profiles are continuous on $X$; for each fixed $x_j$, $U_i$ is strictly quasi-concave in $x_i$ within the region $X^*$; and for each fixed $x_i$, $U_i$ is decreasing in $x_j$ along $X^*$.[3]

A tariff profile $x$ is said to be *Pareto dominated* by another tariff profile $y$ if $U_i(x) \leq U_i(y)$ for all $i$ and $U_j(x) < U_j(y)$ for some $j$. In that instance, we also say that $y$ *Pareto dominates* $x$, and we denote

[1] The effectiveness relation is a simplified form of the inducement correspondence in the theory of social situations. See Greenberg (1990) for details.

[2] Nakanishi (2000) does consider this case as well but not as the main model.

[3] For a detailed explanation of the assumptions of the utility functions and derivations from primitives such as exports and imports, see Mayer (1981), Dixit (1987), and Oladi (2005).