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Chemnitz Economic Papers, No. 018, February 2018

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Endogenous Climate Coalitions and Free Trade - Building the Missing Link

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January 31, 2018

Abstract

In this paper, we discuss the endogenous formation of climate coalitions in an issue-linkage regime. In particular, we propose to build a link to the issue of preferential free trade. Trade privileges exclusively granted to members of the climate coalition work as an incentive mechanism for countries to join in. A multi-stage strategic trade framework is used in which coalition (fringe) countries can dispose of a policy set comprising a discriminatory import-tariff on dirty goods as well as producer emission permits traded on a common (local) permits market. A fairly novel modelling of the preferential free trade area is incorporated which is at the core of our approach. We find strong support for the claim that trade liberalization can promote relatively large and effective climate coalitions compared to the single issue regime. As a policy implication, negotiations on international climate treaties and free trade arrangements should be interlinked.

JEL classification: Q54, Q56, F18, F15, Q58

Keywords: Climate Change, International Environmental Agreements, Free Trade, Issue Linkage, Emission Permits

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1 Introduction

As the issue of global warming is becoming increasingly severe, new collective strategies are discussed in international climate policy. Although the Paris Agreement provides a global deal and a more realistic policy framework for post-2020 climate change action, it is also criticized for the 'pledge and review' mechanism. This mechanism has been adopted to implement the bottom-up approach agreed upon in the 2011 Durban Platform. The problem is that the nationally determined contributions (NDCs) registered at the UNFCCC so far do not even come close to the ambition required to meet the ('well below') two-degree target (Climate Action Tracker Partners, 2018). Moreover, insights from experimental game theory indicate that the review process is unlikely to be able to straighten things out (Barrett/Dannenberg, 2016). From an environmental point of view, the sad truth is that the Paris Agreement does not seem to have led to a 'broad-and-deep' cooperation outcome.

Therefore, more and more economists demand that any collective action going beyond those NDCs needs to be accompanied by trade-related measures to induce reluctant countries to raise efforts. In the literature, such trade incentive tools have been designed either to privilege countries cooperating on the climate issue or to penalize countries not doing so. The aim is to increase both, participation in international environmental agreements (IEAs) and their effectiveness in reducing greenhouse gas emissions by overcoming the trade-off between these two objectives (Barrett, 2003, Finus, 2003, Nordhaus, 2015 and many others). For this purpose, the mechanism of *issue linkage* has been developed[4] and intensively studied[5] by the non-cooperative literature. Following Ederington (2010), it can be classified into the two types of *negotiation linkage* and *enforcement linkage*, according to the focus of the analysis. Contributions to the first category are typically aimed at studying how cross-issue negotiations on climate change and trade liberalization may affect the process of coalition building (such as Barrett, 1997, Finus/Rundshagen, 2000, Conconi/Perroni, 2002, and Kuhn/Pestow/Zenker, 2015a, 2015b, 2017). The idea is that the excludable benefits of

[4] Early contributions within the context of general - non-environmental - intergovernmental negotiations include Tollison/Willett (1979), Stein (1980), and Sebenius (1983) before they have been adapted for problems of transboundary pollution, as done by Folmer/von Mouche/Ragland (1993), Folmer/von Mouche (1994), Ragland (1995), Cesar/de Zeeuw (1996), Bennett/Ragland/Yolles (1998), and Spagnolo (1999).

[5] Authors such as Carraro/Siniscalco (1995, 1998, 2001), Carraro (1999), and Carraro/Marchiori (2003) have discovered issue linkage as an incentive mechanism for coalition formation because linked issues may constitute club goods or quasi-club goods. However, they do not necessarily refer to trade-related measures; instead other club goods such as cooperation in R&D have been focused as well (e.g. by Carraro/Siniscalco, 1997, Katsoulacos, 1997, Botteon/Carraro, 1998, Buchner et al., 2002, and Kemfert, 2004).

enjoying trade privileges can off-set the incentive to free-ride on the environment.[6] By contrast, in the second category, issue linkage is understood as the possibility of cross-issue retaliation in order to enforce international cooperation among countries within an existing agreement. Most prominently, trade sanctions are given consideration using a strategic trade framework (e.g. in Abrego et al., 2001, Ederington, 2002, Bajona/Ederington, 2012, and Limão, 2005, 2007). It is evident that this notion of linkage to trade policy issues is quite similar to the related approach of border tax adjustments that have become a popular means to combat carbon leakage (see e.g. Bucher/Schenker, 2010 and Fischer/Fox, 2012). Although the threat of such punitive measures has the potential to create enforcement power, there is disagreement on the imposition concerning their credibility on the one hand, and their compliance with the non-discrimination rules of the WTO on the other (Ederington, 2010).

This paper is naturally rooted in the literature on negotiation linkage. Compared to previous approaches, the establishment of a free trade agreement among the IEA signatories is neither combined with a trade ban nor with a common tariff against non-signatories. Instead, following Kuhn/Pestow/Zenker (2015a, 2015b, 2017), a formal analysis for a more general kind of an incentive mechanism for coalition formation is provided for the n-country case. Given a world of bilateral trade regulation, signatories of a climate coalition should benefit if, at the same time, they could join a free trade arrangement and enjoy the trade privileges provided while they may maintain their tariff regimes vis-à-vis non-signatory countries.[7] To introduce a scheme of discriminating tariffs and to determine the trade pattern prevailing in the presence of a free trade area, Kuhn/Pestow/Zenker (2015a, 2015b, 2017) have proposed an appropriately modified trade model. This framework gets now amended to consider the case of an international market for tradable emission permits which is implemented within the climate coalition.

In this paper, we consider a model in the tradition of the strategic trade theory using a Stackelberg leader-follower framework. Its basic concept goes back to Eichner/Pethig (2012, 2013a, 2013b, 2015a, 2015b) and has been extended by Kuhn/Pestow/Zenker (2015a, 2015b, 2017) to

[6] This mechanism will obviously only come into effect if countries do not have the option of 'cherry-picking' between the issues. Most contributions adhere to the requirement of a simultaneous membership in both (partial) agreements. Nevertheless, several authors such as Conconi/Perroni (2002) and Carraro/Marchiori (2003) investigate mixed membership by allowing partially overlapping agreement structures.

[7] Interestingly, the idea of making exclusive market and trade benefits conditional to a deep cooperation on climate change mitigation is currently experiencing a revival within the so-called 'climate club' literature (see e.g. Leal-Arcas, 2011, 2013, Weischer/Morgan/Patel, 2012, Stewart/Oppenheimer/Rudyk, 2013, Victor, 2015, Leycegui Gardoqui/Ramírez, 2015, Keohane/Petsonk/Hanafi, 2017, Stua, 2017, and, for a formal analysis, see Nordhaus, 2015 and Hovi et al., 2017).

consider a case of trade-related negotiation linkage. It includes the environment in form of an unwanted by-product, greenhouse gas emissions, modeled as a global public bad. Accordingly, we build up a multi-sectoral model which comprises an international market stage involving a dirty as well as a clean good, and a policy stage on which countries can strategically employ trade measures as well as environmental measures. In this respect the policy mix comprises tariffs and emission caps. However, what is at the core of our model is a preferential free trade arrangement (PFTA), introduced as an incentive mechanism for the endogenous formation of a climate coalition.

Given that this set-up requires tracing the trade flows among countries inside and outside the free trade area, firms' supplies have to be differentiated according to the various destination markets. Differentiated producer prices and transaction costs naturally have to be taken into account. As a new aspect of the present framework, an international permit market for producers is being implemented inside the climate coalition. Comparing our results to the case of national schemes for tradable permits in which consumers are obliged to participate (Kuhn/Pestow/Zenker, 2015a, 2015b, 2017), we find evidence for the thesis that a PFTA can even better promote the formation of a 'broad-and-deep' climate coalition if producers face a coalition-wide emission trading system. This finding can be attributed to more and better options to coalition countries to channel their strategic policies impacting the market outcomes. In this respect, naturally, terms of trade effects play an important role in deteriorating free riding incentives.

The paper is organized as follows. The next section provides the model with a focus on the microfoundations of the market equilibria and the trade patterns. In addition, strategic policies of fringe and coalition countries are modeled in a Stackelberg leader-follower framework at a given coalition size. The endogenous formation of the stable coalition is then determined. In section 3 the results of the numerical simulation of the analytical model are presented followed by some propositions on the role of the preferential free trade area. Section 4 provides some concluding remarks.

2 The Model

In the following model, we introduce a preferential free trade area which is open to the signatories of an IEA only such that the issue of climate protection is being interlinked with the privileges of trade liberalization. As mentioned above, we draw from the Stackelberg leader-follower framework

by Eichner/Pethig (2013a, 2013b, 2015b) for n countries as a starting point. The implementation of a free trade area may be considered as the main contribution of the enhanced model we are going to introduce. The model consists basically of two levels, namely a policy level and a market level. We will first discuss the policy structure.

2.1 Policy Structure

On the policy level there are n symmetric countries. For maximizing its social welfare each country has at first two instruments at its disposal: emission caps e_i and tariffs t_i. The emission caps are part of an emission trading system which will be described in detail in section 2.2 as will be the tariffs that are levied on the imports of the dirty good. The social welfare function W_i takes consumption utility U_i and global environmental damages D into account that result from the overall consumption of the dirty good. D is equal for all countries due to it being a global public bad. Mathematically the decision problem of country i can be described as follows

$$\max_{e_i,t_i} W_i = U_i - D$$

Since U_i and D are determined by the market equilibrium which is turn dependent on the policy decisions of all other countries, W_i will also be a function of the decisions of all other countries.

In addition, each country has to decide on whether it becomes a coalition member ($i \in C$) or stays out of the coalition, i.e. becomes a fringe country ($i \in F$ with $C \cap F = \emptyset$). In the first case it is coordinating its policy instruments within the coalition and in exchange is participating in the benefits of the free trade area and the first mover advantage of the climate coalition. This framework is modeled as a Stackelberg game with the coalition being the first mover. As usual, first movers are able to anticipate the reactions of the fringe countries which in turn take the decision of the coalition as given. The optimization problem for a given coalition C is thus

$$\max_{e_c,t_i,i\in C} \sum_{i\in C} W_i$$

where W_i depends only on the coalition instruments since the fringe reactions are already internalized at this point. e_c stands for the coalition wide cap.

For ease of notation we assume that the coalition countries are numbered from 1 to m where

m is the size of the coalition. Fringe countries will then be numbered from $m+1$ to n.

Each coalition size results in a certain level of welfare $W_i(m)$ for every country i. For a coalition to be stable neither coalition countries nor fringe countries should have an incentive to leave or join the coalition respectively. That is

$$W_{i\in C}(m) \geq W_{i\notin C}(m-1)$$

$$W_{i\notin C}(m) \geq W_{i\in C}(m+1)$$

The first inequality refers to the internal stability of the coalition, i.e. that no coalition country gains by leaving the coalition, while the second inequality refers to the external stability, that is that no finge country gains by joining the coalition (D'Aspremont et al., 1983). These inequalities endogenize the stable coalition size m^*.

2.2 Market Structure

In order to implement the free trade area for the dirty good one has to be able to selectively levy tarriffs according to the origin of the dirty good which in turn requires to trace trade flows. This not only results in a more differentiated market structure, but the firm's supply of the dirty good has to be differentiated too. Therefore, it is reasonable to assume that a firm's opportunity costs of supplying the dirty good may crucially depend on the market of destination. In general, firms do not only have to cover the various transportation costs at least to some extent but as well must meet country-specific import regulations and standards. As a consequence, the prices of the dirty good on the respective markets differ.

In this respect, obviously our approach is quite similar to the iceberg cost approach, where only a fraction of the shipped good is reaching the destination market (i.e. a fraction "melts off" during transport). Hence, the unit supply prices in the firm's view differ among the respective destination markets although the market price is the same globally. However, the law of one price can hardly be observed to hold in reality. In contrast to the iceberg approach, in our model transaction costs of shipping goods abroad (including transportation) are reflected in the transformation function which entails different opportunity costs of supply. However, in each separate local market the law of one price still applies since total supply as usual is just the sum over the individual supplies

whereever they may origin. In short, the law of one price holds locally but not globally.

The model incorporates a world market for the clean good, local markets for the dirty good, a coalition permit market, and local permit markets in fringe countries. The markets determine incomes and price levels where supply and demand of the various market participants equalize (general equilibrium). Market participants as usual are consumers and producers.

Consumers try to maximize their utility U_i by deciding on the optimal demand for the dirty good e_i^D on their local home market and the clean good x_i^D for a given level of income y_i, a given price on the local market for the dirty good p_i and a given price on the global market for the clean good p_x. The optimization problem of the consumer can therefore be written as follows

$$\begin{aligned} \max_{x_i^D, e_i^D} \quad & U_i\left(x_i^D, e_i^D\right) \\ \text{s.t.} \quad & p_x x_i^D + (p_i + t_i) e_i^D = y_i \end{aligned}$$

The consumer price $(p_i + t_i)$ for the dirty good contains the tariff t_i in addition to the market price p_i. As will become obvious below producers located in the free trade area receive the consumer price due to tax exemption while producers outside receive the producer price p_i only.

Producers on the other hand try to maximize their profits Π_i by deciding on the optimal supply of the dirty good e_{ij}^S to country j, the supply of the clean good x_i^S to the global market and the demand for emission permits. This demand is equal to the total supply of the dirty good. Both coalition and fringe countries face a certain production possibility frontier T, and take policy decisions and prices for goods and permits (π_c, π_i) as given. Accordingly, producers have the following optimization problems

$$\max \Pi_i \;= p_x x_i^S + (p_i + t_i - \pi_c) e_{ii}^S + \sum_{\substack{j \in C, \\ j \neq i}} (p_j + t_j - \pi_c)\, e_{ij}^S + \sum_{j \in F} (p_j - \pi_c) e_{ij}^S \qquad \text{for } i \in C$$

$$\text{s.t.} \quad T\left(x_i^S, e_{i1}^S, \ldots, e_{in}^S\right) = 0$$

$$\max \Pi_i = x_i^S + (p_i + t_i - \pi_i) e_{ii}^S + \sum_{\substack{j \\ j \neq i}} (p_j - \pi_i) e_{ij}^S \qquad \text{for } i \notin C$$

$$\text{s.t.} \quad T\left(x_i^S, e_{i1}^S, \ldots, e_{in}^S\right) = 0$$

Here we have to differentiate between producers of the coalition countries and the fringe countries, because on the one hand the coalition producers buy their emission permits at price π_c on the unified coalition market while fringe producers buy their permites (for price π_i) on their local certificate markets.

On the other hand, coalition producers receive the full price paid by the consumers in the coalition, while fringe producers receive the full price paid only in their home country. This is what constitutes the advantage of the free trade area.

Without the free trade area a coalition producer would only receive the price p_j if he exports the good to another coalition country ($j \in C$) (i.e the first sum in his optimization problem would have to be changed to $\sum_{\substack{j \in C, \\ j \neq i}} (p_j - \pi_c)\, e_{ij}^S$).

The market equilibrium can be now characterized by the following set of equations

Coalition Permit Market: $$\sum_{i\in C, j\in C\cup F} e_{ij}^S = e_c$$

Fringe Permit Markets: $$\sum_j e_{ij}^S = e_i \qquad \forall i = m+1,\ldots,n$$

Local Dirty Good Markets: $$e_i^D = \sum_j e_{ji}^S \qquad \forall i = 1,\ldots,n$$

Global Clean Good Market: $$\sum_j x_j^D = \sum_j x_j^S$$

Coalition Consumer Incomes: $$y_i = \Pi_i + t_i \sum_{j\in F} e_{ji} + \frac{\pi_c e_c}{m} \qquad \forall i = 1,\ldots,m$$

Fringe Consumer Incomes $$y_i = \Pi_i + t_i \sum_{j\neq i} e_{ji} + \pi_i e_i \qquad \forall i = m+1,\ldots,n$$

The first four (sets of) equations simply state the equality of supply and demand for permits in the coalition wide market, permits in the local fringe markets, local markets for the dirty good and the global market for the clean good. Please note that the supply of permits originates from the emission caps set by the countries.

The last two sets of equations describe the income of the consumer which consists of profits Π_i, tariff incomes $t_i \sum e_{ji}$ and a share of the proceeds from the permit markets ($\frac{\pi_c e_c}{m}, \pi_i e_i$ resp. for consumers in the coalition and fringe countries). As can be seen the consumer in the fringe countries receives tariff income from all countries except his own ($j \neq i$), the consumers in the coalition receives tariff income only from fringe countries ($j \in F$).

In the case without free trade the first sum of the equation for the coalition consumer income would have to be changed to $t_i \sum_{j\neq i} e_{ji}$, since the consumer would then also receive tariff income from coalition member countries.

We use the clean good as numeraire and set $p_x = 1$ because Walras' Law applies. This means that one of the market equations can be left out (as can be checked by calculation).

2.3 Performance Measures

The effectiveness of the climate coalition is measured by the proportion (RE) of the welfare gap and the proportion (RW) of the emission gap that can be closed by the climate coalition. The gaps

are the difference between the business as usual scenario (BAU) and the social planner scenario (SP). The first scenario is characterized by the absence of any coalition ($m = 0$), each country deciding on its own, while the second is essentially the grand coalition ($m = n$). Since symmetry implies that every fringe country will have the same level of emissions ($e_i = e_j \ \forall i, j \in F$) and the same welfare level ($w_i = w_j \ \forall i, j \in F$), we will denote these levels by e_F, w_F respectively. Similarly, every coalition country will have the same welfare level ($w_i = w_j \ \forall i, j \in C$) denoted by w_C. The coalition wide emission level is denoted by e_c. [8]

$$RE = \frac{ne_{BAU} - (e_c + (n-m)\, e_F)}{ne_{BAU} - ne_{SP}} \cdot 100$$

$$RW = \frac{(mw_c + (n-m)\, w_F) - nw_{BAU}}{nw_{SP} - nw_{BAU}} \cdot 100$$

2.4 Parametrization and Solution Procedure

For simulation purposes we set the consumption utility to $U_i(x_i^D, e_i^D) = x_i^D + ae_i^D - \frac{b}{2}\left(e_i^D\right)^2$, the production possibility frontier to $T\left(x_i^S, e_{i1}^S, \ldots, e_{in}^S\right) = \overline{x} - x_i^S - \left(\alpha_H \left(e_{ii}^S\right)^2 + \alpha^* \sum_{\substack{j=1,\\ j\neq i}}^{n} \left(e_{ij}^S\right)^2\right)$ and the damage function to $D(e_1^D, \ldots, e_n^D) = \frac{\delta}{2}\left(\sum_{j=1}^n e_j^D\right)^2$.

A note on solving the model: In order to solve it, one has to proceed, so to speak, backwards, first by solving the consumer and producer problems dependent on prices, income, tariffs and caps. Second, determining income and prices with the market equations as functions of tariffs and caps. Third, determining caps and tariffs of the fringe countries by solving their decision problems for given policies of the coalition. Fourth, with the reaction functions of the fringe countries known, one solves the decision problem of the coalition thereby determining the tariff and cap of the coalition, and lastly, one endogenizes the coalition size with the stability criteria.

3 Simulation Results and the Gains of Free Trade

In this section we present the solutions of the model which are computed by means of numerical simulations. The parameter values used are the following: $a = 100$, $b = 20$, $\overline{x} = 20$, $\alpha_H = 2000$,

[8] The effectiveness indicators have been proposed in the literature (e.g. by Eyckmans/Finus, 2007 and Eichner/Pethig, 2013b). These measures are also known as the 'closing the gap' indices. (Eyckmans/Finus, 2007) A similar indicator is the *degree of externality* introduced by Finus (2003) relating the actual and the BAU (emissions and welfare) outcomes to the social optimum.

$\alpha^* = 2200$, $\delta = 10$, and $n = 10$.[9] To endogenize the size of the coalition m^* we consider a variation in coalition sizes in the range of $m \in [1, 10]$. The stable coalition has to meet the stability criteria as defined above. Its size and characteristics will then be assessed against the benchmark scenarios introduced in section 2.3.

Figure 1 depicts the stability result of the simulation. As **Figure 1** suggests, only the grand

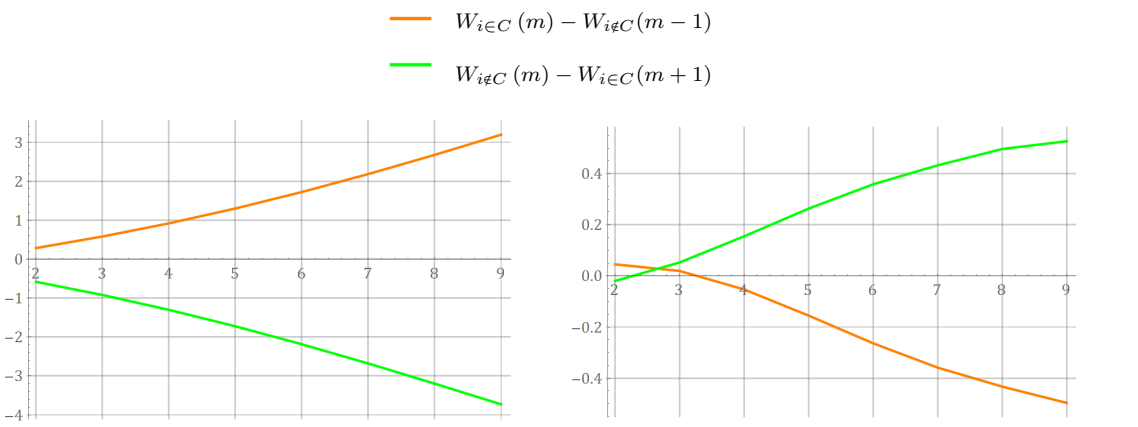

Figure 1.a: Climate Coalition with PFTA ($m^* = 10$)

Figure 1.b: Climate Coalition without PFTA ($m^* = 3$)

Figure 1: Coalition Stability in the Stackelberg Equilibrium

coalition of size $m^* = 10$ turns out to be externally and internally stable; hence, it should receive our special attention.

In order to emphasize the impact of the preferential free trade arrangement on the coalition-building process, the grand coalition has to be compared to a scenario where the PFTA is ruled out. In this way we are able to determine to what extent the PFTA can contribute to the endogenous formation of a climate coalition. In the absence of any tariff privileges, a traditional IEA is constituted which we may call the $\neg PFTA$ scenario. In this case, the stable coalition is found just as large as size $m^* = 3$, confirming the standard results of the IEA literature.

Emission Outcomes. To give a more detailed picture of the coalition building process specific variables of the model are discussed in the following. Here, in particular, we refer to the policy measures and their impact on trade, the environment, and welfare as viewed against the benchmark scenarios BAU (green line) and SP (red line). For $n = 10$ the SP equally reflects the grand

[9] The parameter choice is made in accordance with Eichner/Pethig (2013b).

coalition.

Let's have a look at the emission outcomes first. As **Figure 2** shows, the total reduction of emissions is increasing in the coalition size, whether there is free trade or not. However, it should be emphasized that the coalition is much more effective when it is linked to a free trade arrangement than otherwise. In fact, the social planner solution gets implemented. The respective values of the relative emissions effectiveness RE are 100 per cent and around 13 per cent.

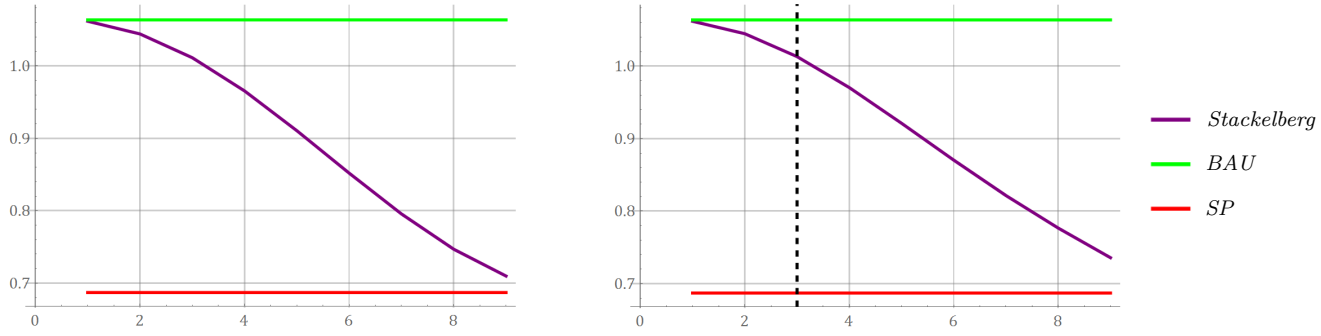

Figure 2.a: Climate Coalition with PFTA ($m^* = 10$)

Figure 2.b: Climate Coalition without PFTA ($m^* = 3$)

Figure 2: Global Emissions in the Stackelberg Equilibrium

An even more detailed picture can be obtained if we move on to the country level, contrasting fringe and coalition countries.

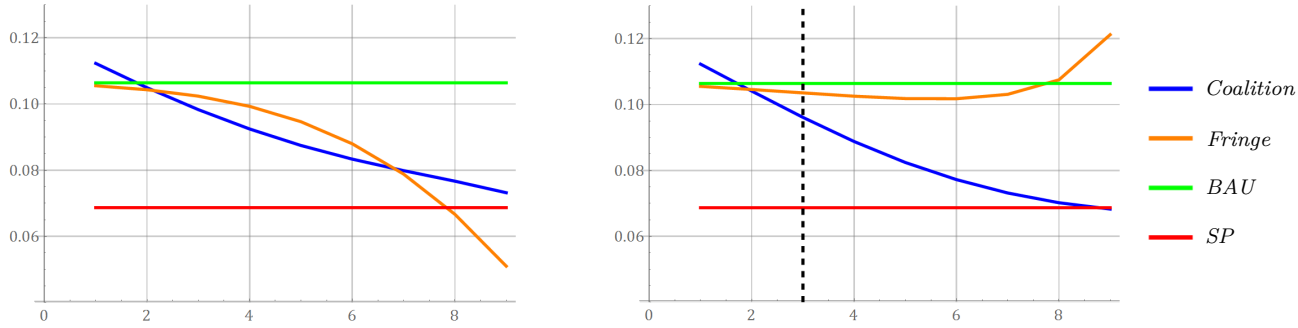

Figure 3.a: Climate Coalition with PFTA ($m^* = 10$)

Figure 3.b: Climate Coalition without PFTA ($m^* = 3$)

Figure 3: National Emission Caps in the Stackelberg Equilibrium

Figure 3 shows the national emission caps set by each country individually depending on the coalition size. In general, what can be observed again is that the linked agreement is much more effective in terms of emissions reduction. While the members of the grand coalition prefer to set

strict caps leading to a full internalization of the climate externality, small coalitions are obviously forced to allow for much higher caps close to those in the BAU-scenario which in turn are used by fringe countries too. At the same time, this policy brings about a shift in the consumption pattern on the market level, away from the dirty good towards the clean good, as can be seen in **Figure 4**.

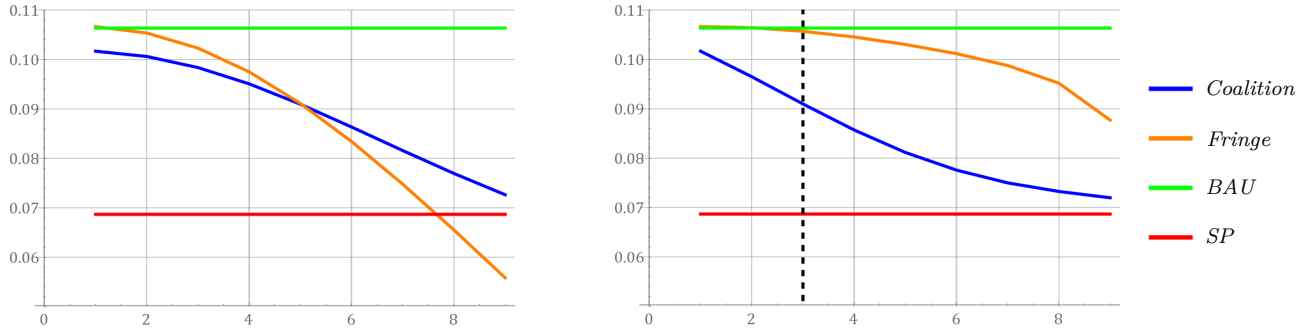

Figure 4.a: Climate Coalition with PFTA ($m^* = 10$)

Figure 4.b: Climate Coalition without PFTA ($m^* = 3$)

Figure 4: Consumption of the Dirty Good in the Stackelberg Equilibrium

In case of small coalitions consumption of the dirty good in fringe countries is comparably high, not much different from the BAU-consumption level. Dirty consumption in the coalition is lower but still high relative to that of the social planner. However, as the coalition size increases, there is a continuous shift of consumption towards the clean good. The reason why fringe countries decide to reduce dirty consumption even more than coalition members may be explained by inspection of the respective tariff policies as well as the ToT-effects in the following figures.

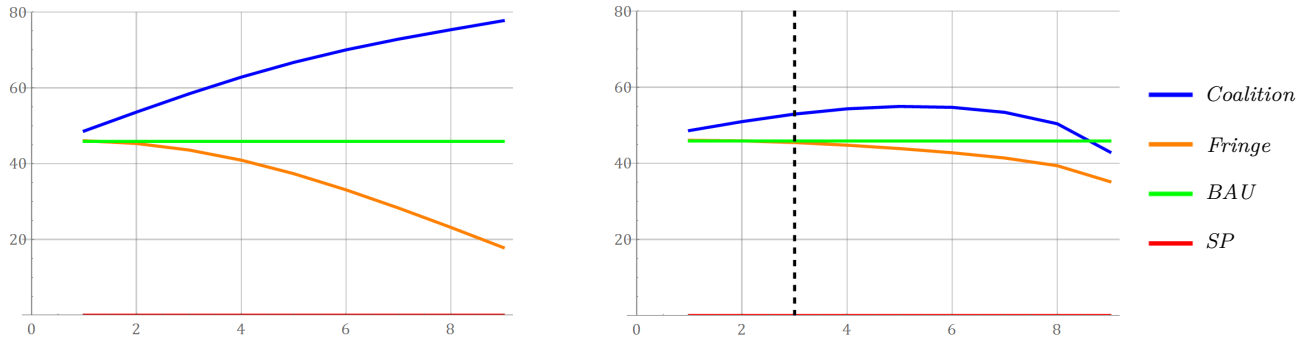

Figure 5.a: Climate Coalition with PFTA ($m^* = 10$)

Figure 5.b: Climate Coalition without PFTA ($m^* = 3$)

Figure 5: Tariff Rates in the Stackelberg Equilibrium

Trade Policies. As already indicated in a strategic trade regime countries usually want to impose

tariffs on imports, in particular to shift the terms of trade favorably. However, in this model trade policies should be much more seen in their role of constituting the free trade privileges as part of the policy set available to coalition countries. In the end, trade policies are identified to work exactly just in that way in our approach. In **Figure 5.b**, both, fringe and coalition countries turn out to pursue a protectionistic tariff policy just like countries in the BAU scenario would do, by setting almost the same rates. But, as coalition sizes increase the tariff rates of fringe and coalition countries are diverging, with much higher rates on side of the coalition. Obviously, fringe countries are no longer able to retaliate accordingly. These strategies clearly work in favour of the coalition deteriorating the fringe countries' ToT such that more and more countries prefer to join in. Finally, the grand coalition as the only one stable is being formed. At this point, countries entirely dispense with any trade measures.

Terms of trade. Next, we would like to argue that fringe and coalition countries' terms of trade are the driving force behind the trade policies shown above. In view of the fact that there is no single world market for the dirty good but rather there are n local markets, the terms on which a coalition country $i \in C$ can export the dirty good is given by the price it receives on a fringe market relative to the coalitional price, i.e. $TOT_C = \frac{p_F}{p_C}$. Likewise, the terms of trade of a fringe country $i \notin C$ must then be the reciprocal value of this price ratio, $TOT_F = \frac{p_C}{p_F}$.[10] The findings for the numerical simulation are shown in **Figure 6**.

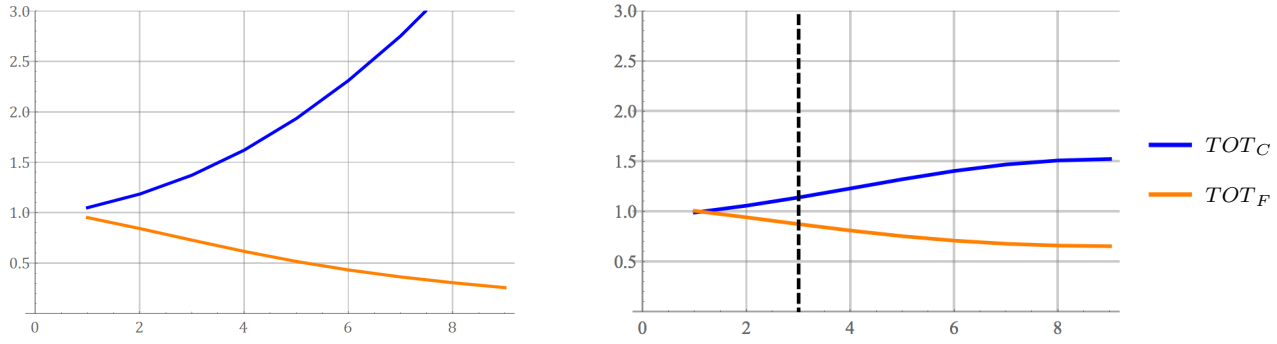

Figure 6.a: Climate Coalition with PFTA ($m^* = 10$)

Figure 6.b: Climate Coalition without PFTA ($m^* = 3$)

Figure 6: Terms of Trade in the Stackelberg Equilibrium

As can be seen in **Figure 6** the terms of trade are improving for the coalition and deteriorating for the fringe countries, the larger the coalition size m. This is of course a consequence of the

[10] Again, this definition of the terms of trade refers to symmetric countries and the clean good as a numeraire.

increasing strategic power of the climate coalition. When the stable coalition is small, that is in the $\neg PFTA$ scenario, the difference in the terms of trade between the two groups turns out to be small, primarily because of the absence of preferential trade privileges. In case of large coalitions, however, the PFTA seems to be very successful in altering the terms of trade in favour of the coalition such that the ToT pretty much fall apart. In this sense, free trade provides a competitive advantage to coalition firms over fringe firms as far as trade volumes and prices of the dirty good are concerned.

Welfare Outcomes. The previous findings raise the issue of the induced change in welfare from a national as well as a global perspective. As **Figure 7** suggests, the linked agreement can lead to a large increase in global welfare at the stable coalition size compared to what the single IEA comprising only three members can achieve.

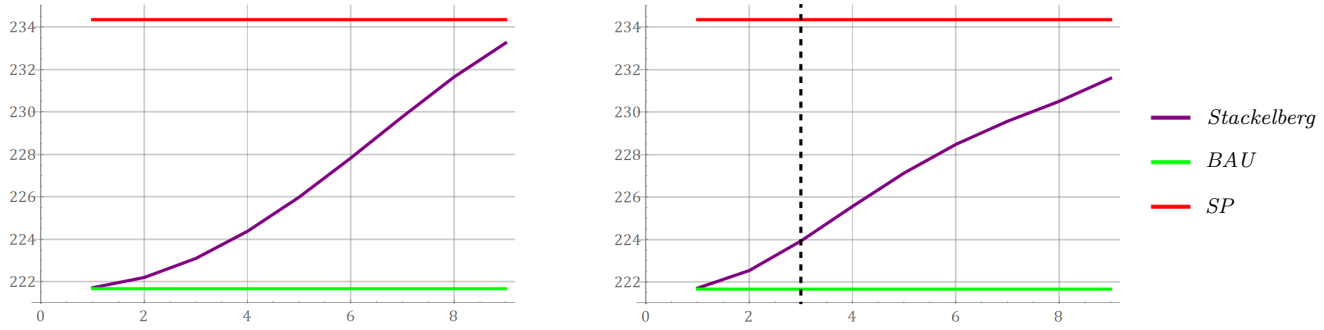

Figure 7.a: Climate Coalition with PFTA ($m^* = 10$)

Figure 7.b: Climate Coalition ¬PFTA ($m^* = 3$)

Figure 7: Global Welfare in the Stackelberg Equilibrium

These outcomes are mainly driven by the reduction of climate damages relative to the BAU level and is naturally to the advantage of all countries. Notwithstanding, the welfare results still differ between coalition and fringe countries as depicted in **Figure 8**. Hence, they must be explained by the consumption component of the welfare function.[11] This conclusion is supported by the fact that individual welfare levels are nearly always above the BAU level although both coalition and fringe countries suffer a loss in consumption utility.

In the absence of free trade the welfare outcomes diverge for coalition and fringe countries from the beginning, with the latter exceeding the former. This result is even reversed in case of free

[11] It is worth mentioning that the mitigation of climate damages nevertheless is an important welfare component.

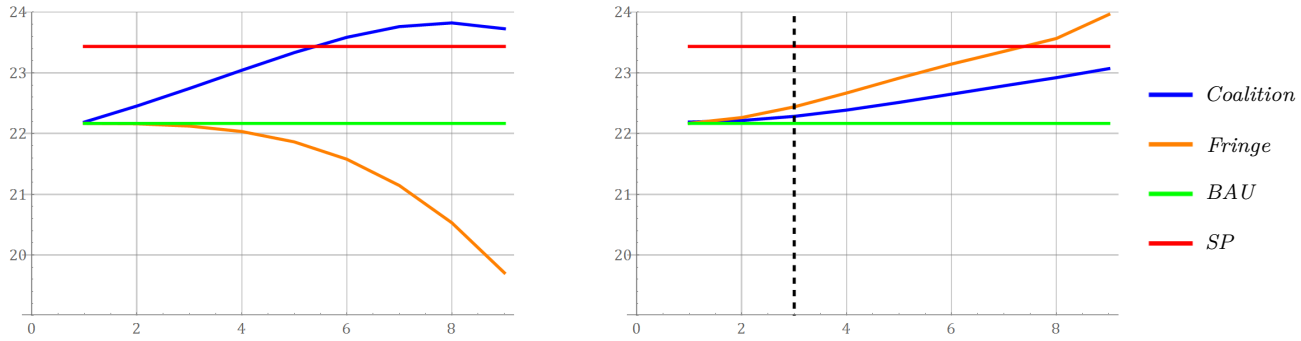

Figure 8.a: Climate Coalition with PFTA ($m^* = 10$)

Figure 8.b: Climate Coalition without PFTA ($m^* = 3$)

Figure 8: National Welfare in the Stackelberg Equilibrium

trade which leads to a strong decline of fringe welfare. This can be attributed to the distribution of consumption utility between both groups of countries and illustrates how the free trade area can provide strong incentives to the formation of climate coalitions.

Economic Intuition. In order to explain how the policy outcomes materialize and how policies will govern prices and the trade pattern, we would like to give an economic intuition for the simulation results. Although both, coalition and fringe countries have two policy tools available, they use these instruments very differently to maximize welfare: on the one hand, coalition countries opt for pretty strict emission caps to internalize the climate externality and refrain from distortionary tariffs. This finding is clearly a result of the fact that, as the coalition grows in size, the environment gets more and more valued. At the same time, terms of trade improve, remarkably not at the expense of environmental quality. If free trade is not an issue, fringe countries, on the other hand, opt for pretty lax caps but high tariff rates. In their view, emission damages are almost external and free-riding thus seems to be welfare-enhancing.

What we would like to emphasize, above all, is that the outcomes are perfectly in line with what we had in mind with the implementation of a PFTA. It can be shown that free trade has a major impact on the market for the clean good which, in turn, alters consumption utilities and the welfare of countries. More precisely, production of the dirty good will be restricted in the coalition which makes it necessary to net import the dirty good from the fringe countries to meet the excess demand. Then the coalition has the position as an exporter on the world market for the clean good. In contrast, fringe countries must increase production of the clean good since exports of the dirty good to the coalition are not as profitable as under unilateral tariff policies. Moreover, they

have to curb consumption even below the BAU level. The change in the consumption possibilities of the clean good changes consumption utility for coalition countries favorably and it deteriorates that of the fringe. Finally, this leads to the grand coalition which is successful in preserving the environment while no country is opting for a free ride.[12]

4 Sensitivity Analysis

In the following, we are conducting a sensitivity analysis to quantify the advantage of a free trade area in terms of effectiveness and stability for different parameter values. The results of a variation in the production coefficients are shown below in **Table 1** and **Table 2**, for both (types of) the agreements considered.

α_H	250	500	750	1000	1250	1500	1750	2000	2250	2500
α^*	275	550	825	1100	1375	1650	1925	2200	2475	2750
m^*	4	4	10	10	10	10	10	10	10	10
RE	35.05%	35.53%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
RW	51.47%	50.97%	100.0%	100.0%	100.0%	100.0%	100.00%	100.00%	100.0%	100.0%

Table 1: Variations of α_H and α^* in the Linked Agreement

Table 1 provides an insight into the interrelation between the stability and effectiveness outcomes and the parametrization: First, for the scenario with the preferential free trade agreement, the stable coalition size m^* is guaranteed on wide of parameter values beginning with values of $\alpha_H = 750$ and $\alpha^* = 875$. This is an expected outcome because, as the dirty good becomes more expensive in terms of the clean good, the incentives of the countries to take a free ride decrease. The relative effectiveness of the climate coalition is increasing as measured by RW and RE.

For the purpose of comparison, the production coefficients α_H and α^* have also been altered for the $\neg PFTA$ scenario, as **Table 2** illustrates.

Most interestingly, the findings of the parametric variation turn out to be much less favorable if the Stackelberg game is conducted without a preferential free trade area. For the values considered, the stable coalition always includes three members and does not grow with an increase in opportunity costs which contrasts with the outcome above. In addition, the relative effectiveness

[12]For more information please refer to the additional simulation results on the trade pattern in the appendix.

α_H	250	500	750	1000	1250	1500	1750	2000	2250	2500
α^*	275	550	825	1100	1375	1650	1925	2200	2475	2750
$m^*_{\neg PFTA}$	3	3	3	3	3	3	3	3	3	3
$RE_{\neg PFTA}$	18.50%	19.79%	18.63%	17.29%	16.09%	15.07%	14.20%	13.45%	12.80%	12.22%
$RW_{\neg PFTA}$	30.14%	32.00%	29.79%	27.18%	24.68%	22.32%	20.07%	17.85%	15.63%	13.37%

Table 2: Variations of α_H and α^* in the Conventional IEA ($\neg PFTA$ Scenario)

in emissions as well as in welfare is somewhat decreasing in α_H and α^* which clearly implies that the incentives to abate emissions diminish if the dirty good becomes more expensive in terms of the clean good.

The sensitivity analysis for the other parameters shows that the stable coalition sizes in the respective regimes are insensitive to a wide range of parameter changes in a, b, $\overline{x}$, δ.

a	70.	80.	90.	100.	110.	120.
m^*	10	10	10	10	10	10
RW	1	1	1	1	1	1
RE	1	1	1	1	1	1

Table 3: Variations of a in the Linked Agreement

b	5	10	15	20	25	30
m^*	10	10	10	10	10	10
RW	1	1	1	1	1	1
RE	1	1	1	1	1	1

Table 4: Variations of b in the Linked Agreement

δ	4	6	8	12	14	16
m^*	10	10	10	10	10	10
RW	1	1	1	1	1	1
RE	1	1	1	1	1	1

Table 5: Variations of δ in the Linked Agreement

5 Concluding Remarks

The objective of this paper has been to address the role of trade liberalization for the endogenous formation of climate coalitions if the environmental policy instrument is implemented on the supply side as well as on a coalitional scale to internalize climate damages. We find strong support for joint negotiations on climate change mitigation and preferential free trade involving producers in a common cap-and-trade emission trading scheme within the coalition. This result is to be explained by the behavior of perfectly competitive firms being determined not only by the prices on local markets of destination but also by the domestic permit price to be paid. Thereby, strong options for effective price discrimination against non-coalition countries are created. Compared to the case of a national emission trading scheme obligating consumers (see Kuhn/Pestow/Zenker, 2015a, 2015b, 2017), trade privileges can be better exploited by the climate coalition because positive policy effects on the markets of other coalition members are found to be amplified and adverse effects are found to be attenuated whereas the opposite applies to the impacts on the fringe markets.

Therefore, the PFTA perfectly serves as an incentive mechanism to discourage free-riding behavior, leading to a grand coalition of size $m^* = n$ in the numerical simulation which implements the social optimum. Moreover, it has been shown that the relative advantage of negotiation linkage can be sustained for a large variation in opportunity costs of the dirty good. The findings are driven by a favorable shift of the terms of trade (ToT). That enables the coalition to shift a considerable part of the burden of mitigation to the group of fringe countries by manipulating the prices on the fringe markets. In contrast, coalition countries succeed in insulating its own markets comparably well against leakage effects. The increased stringency is accompanied by a trade barrier established vis-à-vis free-riders which makes fringe consumers much worse off since they must curb demand for both, the dirty and the clean good. That is why *all* countries find it beneficial to join the coalition.

Although, in our framework, issue linkage with trade liberalization is found to have the potential to promote and sustain a broad and deep international cooperation on climate change, it represents a double-edged sword with regard to the policy implications. More precisely, the coalition's strategy of imposing protectionist tariff policies is likely to give rise to conflict with the current

WTO framework[13], given that it is neither consistent with GATT Art. XXIV nor with GATT Art. XX. However, in pathing the way to a legislation of the tariff regime involved in such an incentive mechanism (such as done by Leycegui Gardoqui/Ramírez, 2015) one should keep in mind that dirty products have to be dealt with in this case. Sooner or later, an explicit amendment to the WTO regulatory framework to cope with externality arising from climate change with appropriate trade-related incentives is inevitable.

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[13] Even though there are numerous exemptions from the Most-Favoured-Nation principle, all of them are subject to strict requirements with regard to the establishment of trade barriers vis-à-vis other WTO members.

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Appendix

Further Market Outcomes for the Simulation

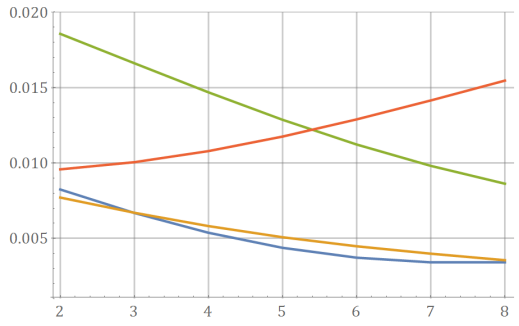

Figure 9.a: Climate Coalition with PFTA ($m^* = 10$)

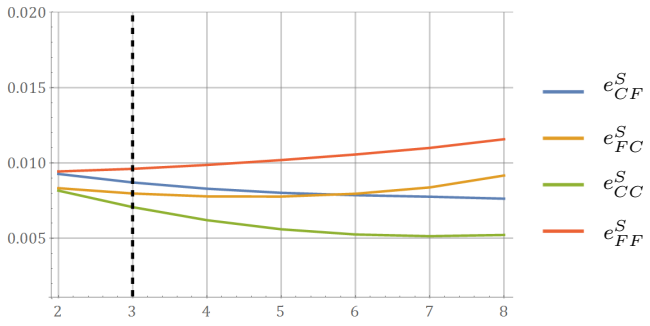

Figure 9.b: Climate Coalition without PFTA ($m^* = 3$)

Figure 9: Individual Supplies of the Dirty Good in the Stackelberg Equilibrium

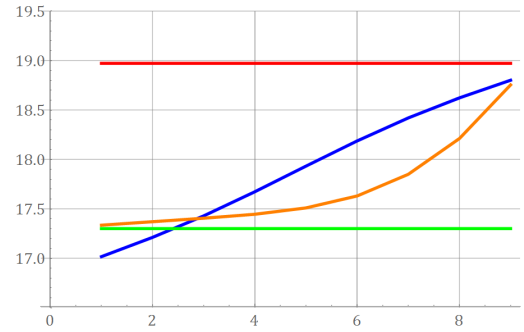

Figure 10.a: Climate Coalition with PFTA ($m^* = 10$)

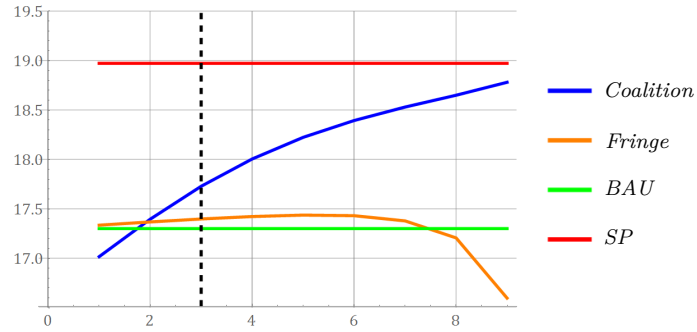

Figure 10.b: Climate Coalition without PFTA ($m^* = 3$)

Figure 10: Production of the Clean Good in the Stackelberg Equilibrium

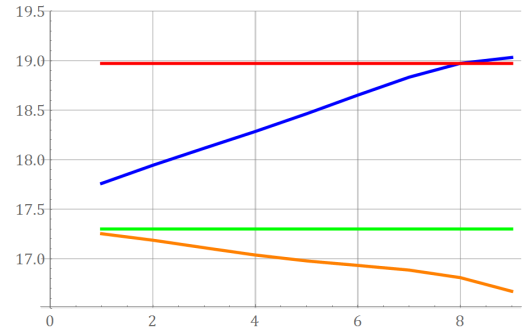

Figure 11.a: Climate Coalition with PFTA ($m^* = 10$)

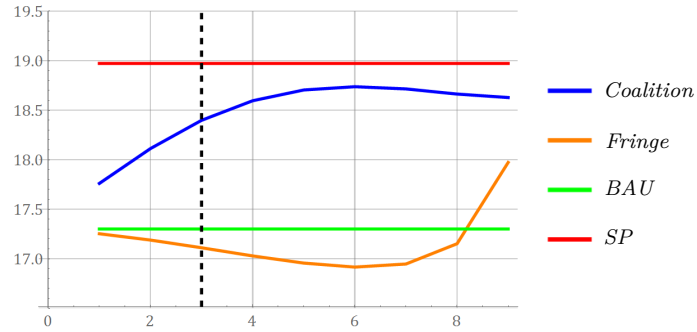

Figure 11.b: Climate Coalition without PFTA ($m^* = 3$)

Figure 11: Consumption of the Clean Good in the Stackelberg Equilibrium

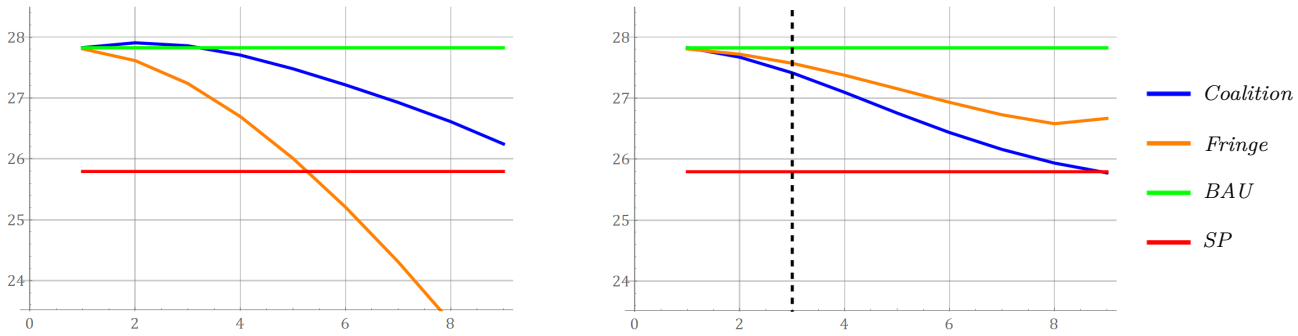

Figure 12.a: Climate Coalition with PFTA ($m^* = 10$)

Figure 12.b: Climate Coalition without PFTA ($m^* = 3$)

Figure 12: Consumption Utility in the Stackelberg Equilibrium

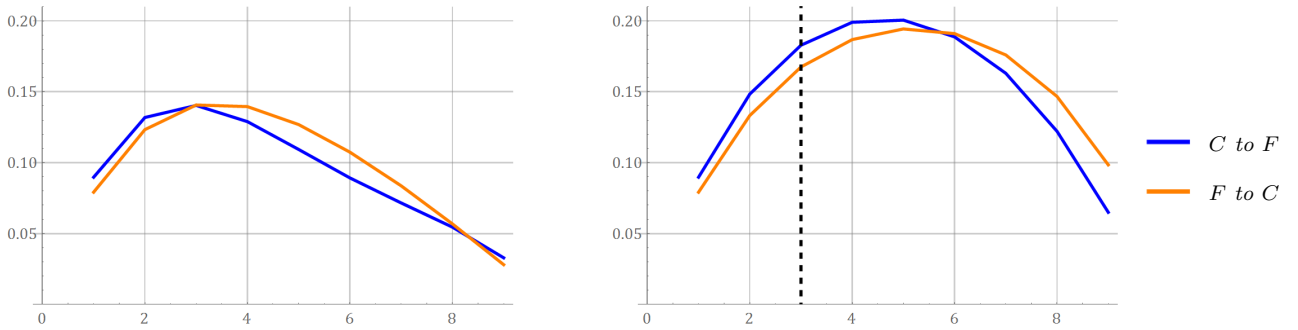

Figure 13.a: Climate Coalition with PFTA ($m^* = 10$)

Figure 13.b: Climate Coalition without PFTA ($m^* = 3$)

Figure 13: Inter-Group Trade Patterns for the Dirty Good in the Stackelberg Equilibrium

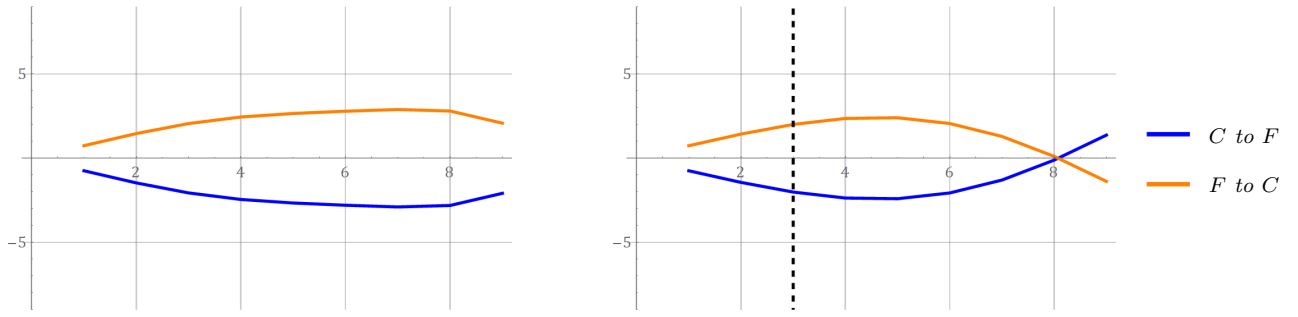

Figure 14.a: Climate Coalition with PFTA ($m^* = 10$)

Figure 14.b: Climate Coalition without PFTA ($m^* = 3$)

Figure 14: Inter-Group Trade Patterns for the Clean Good in the Stackelberg Equilibrium