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Trade Blocs and Currency Blocs: A Package Deal?

MARION KOHLER

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Trade blocs and currency blocs: a package deal? *

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Abstract

The size of a bloc of countries practising some form of coordination of monetary policy is limited by the incentive to free ride that the formation of the bloc creates. However, when the threat of a trade war is introduced, this restriction on the size of the bloc is diminished.

*I want to thank Michael Artis and Mark Salmon for helpful discussions and comments. All remaining errors are mine. Comments are most welcome. E-mail: kohler@datacomm.iue.it .

1 Introduction

The last decade has seen progress in international economic integration in various parts of the world. Formal regional economic arrangements have probably progressed the furthest in Europe with the creation of a customs union in 1956, the common market in 1992 and the prospects of a European Monetary Union by the end of the decade. Similar developments, can be observed in the Western Hemisphere with NAFTA and MERCOSUR. Though there are no formal monetary arrangements analogous to the EMS, many of these countries are *de facto* heavily dollarised since, when they decide to peg their currency they peg to the dollar. In South-East Asia, ASEAN provides the plan to form a free trade area, strengthening suspicions of a Japanese sphere of influence in Asia.

A number of empirical studies (Frankel and Wei [9], [8]) have investigated this link between trade blocs and currency blocs. The theoretical motivation behind attempts to strengthen currency links in free trade areas is seen in the reduction of the extent to which exchange rate risk discourages imports and exports, and thereby the promotion of stronger trade links. Based on similar arguments, the literature on the optimal exchange rate peg promotes the peg of an effective exchange rate based on the direction of total trade that is, bilateral rates of major trading partners have more weight¹.

This paper provides a complementary explanation for the link between trade policy and monetary policy coordination. The use of policy instru-

¹For a comprehensive survey on the optimal peg literature, see Williamson [21]

ments may be graduated in a way to make cooperation at the ‘lower’ level enforceable by the threat that, were it to fail, ‘higher’ level instruments would be used non-cooperatively. Basevi et al. [1] formalize such a game in a model for two countries which is based on a two-period general equilibrium model with articulated micro foundations typically used in trade policy models. Monetary policy is effective because it is assumed that wages are fixed at a level above the Walrasian equilibrium level and are rigid downwards: this creates unemployment. Domestic money expansion which reduces unemployment will create a positive externality since it worsens the terms of trade of the home country. The country would like to cooperate in order to internalize the externality. It can enforce this cooperation by means of threatening to impose tariffs on the foreign good. These tariffs hurt the foreign economy whilst they do not affect the domestic economy in the model chosen by Basevi et al.. The latter feature, however, is due to very specific assumptions on how the tariff revenue is spent and to the policy objective function which maximizes the utility of the representative consumer.

While we will use the basic framework of Basevi et al., we will apply it to a standard shock-stabilization game of monetary policy coordination, supplemented with the possibility to perform tariff policy. We will analyze the size of a ‘stable’ coalition in the context of an n country model. It has been shown that the free-rider incentive in monetary policy games can restrict the stable coalition size, see Martin [15] and – for the type of model used here – Kohler [11]. We will show in this paper that the prospect of a trade war can enlarge the stable coalition size considerably. The actual

size of the stable coalition is determined by the feasible – that is, credible – size of the punishment tariff.

The chapter is structured as follows. Section 2 presents the basic model and the reduced form; the mathematical derivation of the model can be found in appendices A and B. Section 3 presents a model of coalition formation with a package deal (mathematical solutions in appendix C). The stable coalition sizes are discussed in section 3.3 while sections 4.1 and 4.2 discuss possible limits of the model with respect to the dynamics of coalition formation and the credibility of the punishment, respectively. The results of simulations performed for section 3.3 and 4.1 are presented in detail in appendix D. Section 5 concludes.

2 The underlying economy

The individual country's economy is described by a standard model of monetary policy which rests on quadratic payoff functions and a linear and static macroeconomic model. It is consistent with the models in Canzoneri and Henderson [4], [5], Persson and Tabellini [17] and Buiter et al. [2]. We complement the model of Canzoneri and Henderson [4] with tariff policy and extend it to the n country case.

All variables are in natural logarithms, and are expressed in terms of deviations from their values in a zero-disturbance equilibrium except for τ_{ij} which is the (ad valorem) tariff imposed by country i on good j . For simplicity, I refer for instance to the deviation of the money supply (log) from its zero-disturbance value as 'money supply'. The domestic coun-

try's variables are indexed by i while $j = 1 \dots n, j \neq i$ denotes the foreign countries. We will use a symmetric model, i.e. identical structures in all economies, since this allows us to focus on aspects of the coalition formation process which are not driven by differences amongst countries but which are intrinsic to the process itself.

Each country specializes in the production of a national good, but consumes all other goods, as well.

Output y_i increases in employment l_i , subject to decreasing returns to scale, and decreases with some (world) productivity disturbance x (independently distributed with mean 0).

$$y_i = (1 - \alpha)l_i - x \quad 0 < \alpha < 1 \quad (1)$$

Profit-maximizing firms hire labour up to the point at which real wages are equal to the marginal product of labour. The money wage is denoted w_i while p_i is the GDP deflator:

$$w_i - p_i = -\alpha l_i - x \quad (2)$$

Home wage setters set w at the beginning of the period so as to fix employment at a full-employment level ($l_i = 0$) if disturbances are zero and expectations are fulfilled. They minimize the expected deviation of actual employment from full-employment by setting the nominal wage:

$$w_i = m_i^e \quad (3)$$

where m_i^e is the expected money supply². Actual labour demand might

²Equations 1, 2 and 4 give $m = w + l$. Home wage setters solve the optimization problem $\min_w E[n^2] = \min_w E[(m - w)^2]$. This is obviously minimized by setting w equal to m^e . For the time being we will set $m_i^e = 0$.

differ due to unexpected disturbances. It is assumed that the wage setters guarantee that labour demanded is always supplied.

The market equilibrium for money is realized when the money supply satisfies a simple Cambridge equation:

$$m_i = p_i + y_i \quad (4)$$

where m_i is the money supply.

Besides the tariffs which affect demand for the foreign goods directly, the real exchange rate³, z_{ij} , is the only source of spillovers across countries. Defined as the relative price of the foreign good j , we can write z_{ij} as:

$$z_{ij} = (e_{ij} + p_j - p_i) \quad (5)$$

where e_{ij} is the nominal exchange rate and p_i (p_j) is the own-currency price of home (foreign) country goods. Thus a positive value of z_{ij} reflects a real depreciation.

Real aggregate demand for good i is given by⁴:

$$y_i = \underbrace{(1 - \beta) y_i}_{\text{domestic private demand}} + \underbrace{\sum_{\substack{j=1 \\ j \neq i}}^n \frac{\bar{\tau}_{ij}}{1 + \bar{\tau}_{ij}} \frac{\beta}{n-1} y_i}_{\text{domestic government demand}} + \underbrace{\sum_{\substack{j=1 \\ j \neq i}}^n \frac{1}{1 + \bar{\tau}_{ji}} \frac{\beta}{n-1} y_j}_{\text{foreign private demand}} + \delta \sum_{\substack{j=1 \\ j \neq i}}^n z_{ij} +$$

$$\underbrace{\sum_{\substack{j=1 \\ j \neq i}}^n \eta_1^{ij} \theta_{ij}}_{\text{effect of domestic tariffs}} - \underbrace{\sum_{\substack{j=1 \\ j \neq i}}^n \eta_2^{ji} \theta_{ji}}_{\text{effect of foreign tariffs}} + \underbrace{\sum_{\substack{j=1 \\ j \neq i}}^n \sum_{\substack{h=1 \\ h \neq i}}^n \eta_3^{jh} \theta_{jh}}_{\text{trade diversion effect}}$$

³ z_{ij} denotes the *world* market real exchange rate. Consumers face an 'actual' real exchange rate which includes the tariff mark-up on the price of the foreign good.

⁴ The demand functions are derived from a combination of loglinearization and linear approximation of the expenditure functions, see appendix A.1.

Since consumers spend a fixed share $1 - \beta$ ($0 < \beta < 1$) of their income on the domestic good (and, hence, $\frac{\beta}{n-1}$ on each foreign good), demand for the domestic good rises with y_j , $j = 1, \dots, n$. The foreign demands for the domestic good have to be ‘deflated’ by the respective tariffs, since the consumer price for a good imported from i is $e_{ji}p_i(1 + \tau_{ji})$. τ_{ij} denotes the tariff which country i imposes on goods imported from country j while θ_{ij} is defined as the deviation of $\ln(1 + \tau_{ij})$ from its equilibrium value.

The tariff revenues are spent by the government exclusively on domestic goods; these purchases are denoted by the second term of the demand equation⁵.

A rise in the relative price z_{ij} of a foreign good shifts world demand from the foreign good to the home good by δ . A rise in domestic tariffs on imports shifts domestic demand towards the own good by η_1^{ij} , foreign tariffs imposed on the domestic good shift foreign demand away from good i

⁵A standard assumption in trade policy models is that the tax revenues are redistributed to the consumers. In our model this would change only the size of the demand elasticities with respect to tariffs. η_1 and η_2 , the tariff effects on the demand for the domestic good, will be smaller under redistribution since part of the tariff revenues are now spent on foreign goods. The effect on ‘third country’ demand, η_3 , will be larger for the same reason. Eventually, this will lead to a situation where the damage the tariff imposes on the domestic economy is larger while the damage for the foreign economy is smaller. The reason is that, while having the same direct impact on domestic CPI, the exchange rate movement induced by tariffs is not as favourable for the domestic country as in the case considered in the paper here. Hence, though there will still be a tariff which can sustain full cooperation, the tariff punishment is more likely not to be credible in the case of redistribution. We will discuss the issue of credibility of the punishment in depth below.

towards their own good by η_2^{ji} ($\eta_1, \eta_2 > 0$; note that η_2 enters *negatively* in eqn. (6)).

While η_1 and η_2 represent the effects of a tariff on the two countries which are directly affected, η_3 represents an inverse of the *trade diversion* effect known from the theory of customs unions (see Viner[20]). A tariff imposed from country i on good j will reduce domestic demand for good j . In a two country framework there is only one way to spend the reduced outlay on the foreign good: the domestic good. In a multi-country framework, however, there is the possibility of substituting towards all remaining goods. This additional effect on countries 'outside' the tariff is denoted by η_3 .

Model symmetry and trade balance require that tariffs are zero in the disturbance-free equilibrium that is, we are in a world-wide free trade area where no need for policy intervention arises, and that $\eta_1^{ij} = \eta_1$, $\eta_2^{ij} = \eta_2$ and $\eta_3^{ij} = \eta_3$ for all $i \neq j$ that is, the responses to tariff changes are the same for all goods⁶.

Consequently, the goods market equilibrium can be written as:

$$\beta y_i - \frac{\beta}{n-1} \sum_{\substack{j=1 \\ j \neq i}}^n y_j = \delta \sum_{\substack{j=1 \\ j \neq i}}^n z_{ij} + \eta_1 \sum_{\substack{j=1 \\ j \neq i}}^n \theta_{ij} - \eta_2 \sum_{\substack{j=1 \\ j \neq i}}^n \theta_{ji} + \eta_3 \sum_{\substack{j=1 \\ j \neq i}}^n \sum_{\substack{h=1 \\ h \neq i}}^n \theta_{jh} \quad (6)$$

The budget constraint requires that the decrease of demand for a foreign good on which a tariff is imposed is matched by an increase in demand for all other goods: $\eta_2 = \eta_1 + (n-2)\eta_3$. Tariffs and real exchange rates are part of the consumer prices. Hence, the respective elasticities of the demand functions, η_1 , η_2 and δ , can be expressed as function of each other

⁶For the proof see appendix A.2.

which gives: $\delta = \eta_1 + \eta_2 - \frac{\beta}{n-1}$. That is, a rise in the real exchange rate between two goods can be compared to the situation when a bilateral tariff is imposed where the domestic tariff is positive and the foreign tariff is negative (a import subsidy) such that both tariffs shift consumption towards the relatively cheaper good. However, the shift of consumption towards the domestic good is larger when caused by tariffs than by a real exchange rate depreciation since in the former case – additionally to the substitution effect – the tariff revenues are spent exclusively on the domestic good (this is denoted by the term $\frac{\beta}{n-1}$)⁷.

The consumer price index q_i is a weighted average of the domestic and the foreign good prices where all prices are weighted according to the expenditure shares of the goods.

$$q_i = (1 - \beta)p_i + \frac{\beta}{n-1} \sum_{\substack{j=1 \\ j \neq i}}^n (e_{ij} + p_j + \theta_{ij}) = p_i + \frac{\beta}{n-1} \sum_{\substack{j=1 \\ j \neq i}}^n (z_{ij} + \theta_{ij}) \quad (7)$$

Inflation may be imported via an appreciation of the foreign currency which is equivalent to a depreciation of the domestic currency. An increase in domestic tariffs will increase the CPI in the first place. However, as we will see below, the tariff will cause a real appreciation of the domestic currency which exerts an opposite effect on the domestic CPI.

2.1 Policymakers' objectives

The policymaker in the home country has access to two policy instruments, m_i , which we identify with money growth, and τ_{ij} which we identify with

⁷For the proof of these propositions, see appendix A.2.

the tariff rate imposed on imports from country j . He evaluates the effects of monetary and trade policy according to a ‘welfare’ function defined as a linear quadratic payoff-function over CPI-inflation and employment.

$$L_i = \frac{1}{2} (\sigma l_i^2 + q_i^2) \quad (8)$$

where σ denotes the relative weight the policymaker gives to the objective ‘full-employment’.

Monetary policy comes into effect when there is an (unexpected) symmetric productivity disturbance shock x . Private agents sign nominal contracts for wages. The policy maker knows the realization of the shock when setting m , but private agents have no information about it. This can reflect a genuine information advantage or else the relative costs of decision making: monetary policy can be altered at very short notice, whereas wage contracts cannot. This asymmetric information over the shock provides the role for stabilization policies⁸.

2.2 Reduced form of the economy’s behaviour

We can reduce equations (1) to (7) to two equations for each country⁹. They determine the constraints for the policymaker’s optimization problem. The money supply m_i and the tariffs τ_{ij} are free as instruments for minimizing the loss function.

⁸For an extensive discussion of this interpretation, see Persson and Tabellini [17].

⁹The reduced form is explicitly derived in appendix B.

The reduced forms for l_i, q_i are:

$$l_i = m_i \quad (9)$$

$$q_i = \lambda m_i - \kappa \sum_{\substack{j=1 \\ j \neq i}} m_j + \underbrace{\frac{\beta}{n-1} \left[\left(1 - \frac{\eta_1}{\delta}\right) \sum_{\substack{j=1 \\ j \neq i}}^n \theta_{ij} + \frac{\eta_2}{\delta} \sum_{\substack{j=1 \\ j \neq i}}^n \theta_{ji} - \frac{\eta_3}{\delta} \sum_{\substack{j=1 \\ j \neq i}}^n \sum_{\substack{h=1 \\ h \neq i}}^n \theta_{jh} \right]}_{\Theta} + x \quad (10)$$

with¹⁰:

$$\lambda = \alpha + \frac{\beta^2(1-\alpha)}{\delta(n-1)} > 0$$

$$\kappa = \frac{\lambda - \alpha}{n-1} > 0$$

$$\delta = \eta_1 + \eta_2 - \frac{\beta}{n-1}$$

$$\eta_3 = \frac{1}{n-2}(\eta_2 - \eta_1) \quad \eta_1, \eta_2, \eta_3, \delta > 0 \quad \text{in most cases.}$$

To set the basic policy problem, let us consider a symmetric world productivity disturbance which gives rise to a stabilization game. Without policy intervention a negative disturbance ($x > 0$) will have no effect on the countries' employment and increases CPIs. Each country's employment is unaffected because its nominal output is unaffected; a productivity disturbance lowers a country's real output (according to equation (1)) and raises the price of its output by equal amounts (according to equation (4)). Marginal productivity of labour falls, so firms will keep employment constant only if increasing output prices lower real wages. All CPIs increase because

¹⁰The proof for the signs of the coefficients can be checked in appendix A.2 and B for $\eta_1, \eta_2, \eta_3, \delta$ and λ, κ , respectively.

all output prices rise. There are no changes in real exchange rates since outputs fall by the same amount in all countries because we have assumed symmetry and, hence, trade is still balanced.

If we add an international capital market like in Canzoneri and Henderson [5] or Kohler [11] real interest rates would have to change in order to equilibrate the goods markets¹¹. Since the real and the nominal exchange rate do not change, perfect substitutability on the international capital markets requires that the real interest rates in all countries rise by the same amount.

In short, a negative productivity shock will leave employment unchanged and increase CPI inflation.

Each policymaker – facing a loss function which increases in the square of employment and CPI deviations – now has an incentive to contract the money supply a little bit in order to lower inflation. He accepts the small loss from reducing employment below the full employment level in favour of the significant gain from lowering inflation.

¹¹When we include a capital market, only part of the income is used for consumption while the other part of the income is saved. Hence, the fall in output (supply) is not matched by the fall in demand for this good. A rise in real interest rates which reduces consumption further will reequilibrate the goods markets. Whether in this case nominal interest rates rise or fall depends on the size of two model parameters. When the real interest rate elasticity of goods demand is lower than the income elasticity of savings, nominal interest rates will rise; if it's the other way around, nominal interest rates will fall (see Kohler [11]).

Monetary policy Contractionary monetary policy in country i alone produces an anti-inflationary effect through two channels: the reduction of the domestic output price and the export of inflation via the real exchange rate. Domestically, a reduction in the money supply has to be matched by a fall in nominal output (eqn. (4)) which affects both real output and prices (eqn. (1), (2)). The fall in output will reduce employment (eqn. (1)) while the fall in prices lowers CPI inflation. The export of inflation follows from the appreciation of the real exchange rate. The fall in output prices improves the terms of trade, lowers the prices of imports and thus lowers inflation. Abroad, the price of imports is increased, thus causing inflation. This externality is reflected in the negative coefficient (κ is positive) of foreign monetary policy in equation (10). If all policymakers contract money supplies, they vainly try to reduce their domestic inflation by attempting to appreciate their currencies against each other. The exchange rate in the end remains unchanged but all policymakers have contracted too much with respect to their optimal money supply. This could be avoided if all countries coordinated producing a less contractionary monetary policy¹².

Tariff policy Tariff policy affects inflation without affecting employment. Domestically, nominal output is unaffected (eqn. (4) and – with the marginal productivity of labour unchanged – there is no change in employment, real output and output price (eqn. (1), (2)). The relative

¹²Canzoneri and Gray [3] were the first to formalize this type of monetary policy game which subsequently became the standard argument in favour of international monetary policy coordination. The same type of model was analyzed by Canzoneri and Henderson [4] and [5] and Persson and Tabellini [17], among others.

'consumer' price of the foreign good has increased through the tariff. Since this shifts domestic demand towards the own good, the domestic currency appreciates and, eventually, real demand for the domestic good does remain constant (eqn. (6)). Consequently, imposing tariffs on imports has two contrasting effects on the domestic inflation: an anti-inflationary effect ($-\frac{\eta_1}{\delta}$) through the appreciation of the real exchange rate which makes foreign goods less expensive and a direct inflationary effect since tariffs make imported goods more expensive for the consumer. Depending on which effect dominates we can distinguish three cases: tariff policy reduces domestic inflation ($\frac{\eta_1}{\delta} > 1$), tariff policy affects only the foreign economies ($\frac{\eta_1}{\delta} = 1$) and tariff policy hurts the domestic economy ($\frac{\eta_1}{\delta} < 1$). Only in the first case, countries may want to try to use tariff policy instead of antiinflationary monetary policy. They will not have to 'hurt' the domestic economy by creating unemployment through anti-inflationary monetary policy but can export inflation without domestic costs. However, tariffs are an unsuitable instrument to fight inflation since it will lead directly into a trade war when the other countries try to shift the real exchange rate back to its 'original' value. A world with tariffs all over the place is not desirable since it puts all countries in a worse position with higher CPIs, but the same real exchange rates. In the two latter cases, countries are not able to use tariff policy as a 'direct' instrument to fight inflation; however, they may consider to use tariff threats to induce cooperation in the monetary field since tariffs always hurt the foreign economies by exporting inflation.

Since δ and η_1 can be expressed in terms of the expenditure function, we

can trace the three cases back to the properties of the underlying utility function or, more precisely, to the signs of the cross price effects¹³.

Tariff policy reduces inflation when the cross price effect is negative which occurs when we have *normal goods* which are *complements*. A typical example are Leontieff type utility functions, where the consumer wants to consume a basket of goods where the goods (in real terms) have fixed shares.

Tariff policy does not affect the domestic economy¹⁴ when there are no cross price effects; that is when the consumption of good i does not depend on the price of good j . This is for instance the case when the consumer spends always a fixed nominal share of his income on each good.

Tariff policy hurts the domestic economy when the cross price effects are positive. This is the case when goods are *normal goods* and *substitutes*. This case covers all 'standard' utility functions like CES or Cobb-Douglas utility functions.

If not otherwise noted, we will restrict ourselves in what follows to the last case which seems to be the most reasonable representation of consumption behaviour for a country with respect to a whole range of goods. Tariff policy will therefore hurt the domestic economy (a little bit) and the foreign

¹³For a detailed account, see appendix A.2, eqn. (15).

¹⁴This case is in some sense the counterpart to the model in Basevi et al. [1]. In their model, tariffs do not affect the domestic economy although the crossprice effects are positive. The crucial difference to our model is that Basevi's model targets private utility. The assumption of unproductive government purchases financed through tax revenues leads to a reduction of private utility. This negative effect is counterbalanced by an increase in domestic production and real income due to the shift of domestic demand towards the own good.

economy (even more).

3 Coalition formation with a package deal

In the previous section we have outlined how policy makers will react to a negative productivity shock if they do not cooperate at all. Since they impose negative externalities on each other there is scope for improvement through cooperation. For this reason, the literature on international monetary policy coordination has – starting with the seminal work of Hamada [10] – argued that coordination is beneficial for all parties involved¹⁵.

In Kohler [11], we have argued that countries may prefer forming a coalition to full coordination and we have solved the model with monetary policy and zero tariffs. The main result was that coalition formation will stop when it reaches a size of three countries. The reason is that the coalition formation process itself causes positive spillovers for the outsiders: the increased discipline within the coalition reduces the negative externalities the coalition countries create for *all* countries, independent of whether they are ‘in’s or ‘out’s. Countries will decide whether to join the union or not on the basis of whether it pays more to reduce imported inflation or to be able to export inflation.

Here, we will modify the type of ‘cooperation deal’ the coalition offers. The coalition will offer all members the possibility to coordinate monetary policy together with zero tariffs whereas the outsiders will face tariffs imposed on their goods in coalition markets. We will see that there always

¹⁵The type of model used here has been first analyzed by Canzoneri and Gray [3].

exists a tariff high enough that the incentive to free-ride on cooperation in monetary policies vanishes and only a coalition where all countries are members is stable.

3.1 The strategies and the equilibrium

3.1.1 The coalition strategy

A coalition is a subset of countries which optimize a common loss function. The common loss function is a weighted average of the individual countries' loss functions. The relative weights are denoted α_i with $\sum_{k=1}^k \alpha_i = 1$. Since we have a symmetric model structure we will assume that the individual countries' weights are equal, hence, we will set the weight of a coalition member (α_i) equal to $\frac{1}{k}$ for all $i = 1, \dots, k$ ¹⁶.

- The coalition consists of the countries $i = 1, \dots, k$ and optimizes:

$$\mathcal{L} = \sum_{i=1}^k \frac{1}{k} L_i$$

The coalition as a whole plays a Nash strategy in monetary policies against the outsiders.

- The remaining $n - k$ countries play a non-cooperative Nash strategy against all other countries by minimizing their individual loss functions.

¹⁶Typically, these weights are the outcome of a bargaining process. We will assume that – due to the symmetric structure of the countries – the bargaining process will lead to symmetric weights. However, we are aware that the weights are not necessarily proportional to country size as e.g. Casella [6] points out using a model with asymmetric countries.

Since tariffs hurt the domestic economy, setting any tariff above zero is suboptimal for the coalition if we were to consider monetary and tariff policies separately. However, we will see that a positive ‘punishment’ tariff can create an incentive scheme which can overcome the free-riding incentive of monetary policy coordination. The mere *threat* to punish on the trade sector can be sufficient to induce full cooperation. Therefore, it may be in the interest of the coalition to be able to commit to the package deal and to exclude the possibility to set the two policies separately.

We will solve the model by first determining the equilibrium policies for a given coalition size. We will do this by fixing the tariffs on a given level and calculating the optimal monetary policies depending on this level. Then, we will determine the stable coalition size dependent on the chosen ‘punishment’ tariff level. We will see that different tariff levels will sustain different stable coalition sizes. The tariff level which can sustain full cooperation will be called *threshold tariff*.

Roughly speaking, the punishment must be high enough in order to be effective, but low enough in order to be credible. The exact meaning of ‘credible’ has to be answered in the context of the game: within a static game, it means that it pays for the coalition to choose this strategy; within a (infinitely) repeated game, it can be credible through trigger-strategies of the Friedman type and within an extensive game it has to fulfill the criterion of subgameperfection. If the strategy leading to the highest payoff is not a best response, the coalition has to find a way to exclude the best-response strategy i.e. by credibly committing to the punishment strategy. For the moment, we will restrict ourselves to a static game and we will

assume that the coalition offers *only* the package deal but not monetary policy coordination alone. We will relax this assumption later.

Once a coalition member, a country will have to stick to the coalition policy. However, the decision whether a country wants to join the coalition or not has to be incentive compatible for each individual country. Consequently, we will call a coalition “stable” when no country would like to change its affiliation (coalition or fringe) unilaterally. The idea behind this is that an equilibrium with a coalition size where the coalition members prefer to join the fringe or vice versa is not sustainable. We will adopt a stability concept used to examine the stability of cartels in models of industrial organization¹⁷:

$$L_c(k^*, n) < L_{nc}(k^* - 1, n) \quad \text{and} \quad L_{nc}(k^*, n) < L_c(k^* + 1, n)$$

The loss function of a non-member is denoted by $L_{nc}(n, k)$. If it joins the coalition, it will have the loss $L_c(n, k + 1)$. If $L_{nc}(n, k)$ is smaller than $L_c(n, k + 1)$, the country has no incentive to join the coalition and the coalition is called “externally stable”. If, on the other hand no member from the coalition has an incentive to leave the coalition, the coalition is “internally stable”. If both conditions are fulfilled, the coalition is stable, with size k .

We will present now the equilibrium strategies (that is, optimal money supplies) given the coalition size and given the tariff levels¹⁸.

¹⁷The stability condition used here is based on the one proposed by D’Aspremont et al. [7].

¹⁸The results are derived in Appendix C. We will keep the analysis short since this part of the solution (except for the tariffs) has been discussed already in Kohler [11] in

3.1.2 The equilibrium strategies and losses outside the coalition

In order to solve the outsider's optimization problem, we replace n_i and q_i in the loss function by the reduced form equations. This function is minimized with respect to m_i subject to given strategies of the other countries $m_j = \bar{m}_{j,nc}$ for all $j \neq i$ if j is an outsider and $m_j = \bar{m}_{j,c}$ for all j if j is a coalition member. Since we have a symmetric structure in every respect, we can assume that all countries outside the coalition have the same optimal money supply m_{nc}^* . We can derive the money supply of a non-member as a function of the coalition's money supply:

$$m_{nc}^* = \vartheta \kappa \sum_{j=1}^k \bar{m}_{j,c} - \vartheta [\Theta_{nc} + x] \quad (11)$$

$$\text{with: } \vartheta = \frac{\lambda}{\sigma + \lambda^2 - \lambda \kappa (n - k - 1)} > 0$$

where Θ_{nc} is the impact of the tariff structure faced by an outsider. The optimal policy outside the coalition depends positively on coalition policy i.e. the money supplies of a non-member and a coalition member are strategic complements. This means that a less contractionary monetary policy of the coalition members triggers a less contractionary response from the non-members since imported inflation is reduced.

3.1.3 The Nash equilibrium with a coalition

The coalition solves its optimization problem subject to a given money supply of the non-members. We exploit the symmetry assumption $m_{j,c}^* = m_c^*$ for all $j = 1, \dots, k$. This gives a coalition member's reaction function

depth.

which depends on the non-members' money supply. Through equating the reaction functions we obtain the equilibrium of the Nash game with a coalition as:

$$m_c^* = -\rho[\kappa(n-k)\vartheta\Theta_{nc} + \Theta_c] - \rho[\kappa(n-k)\vartheta + 1]x \quad (12)$$

$$m_{nc}^* = -[\omega\Theta_{nc} + \kappa\vartheta k\rho\Theta_c] - [\omega + \kappa\vartheta k\rho]x \quad (13)$$

with:

$$\rho = \frac{\lambda - \kappa(k-1)}{\sigma + (\lambda - \kappa(k-1))(\lambda - \kappa(k-1) - \kappa^2(n-k)\vartheta k)} > 0$$

$$\omega = \kappa^2\vartheta^2 k\rho(n-k) + \vartheta > 0$$

The equilibrium policies in both games are linear functions of the shock x . If the shock is zero, there is no need for a stabilization game and, hence, the optimal policies are zero ($\Theta_c = \Theta_{nc} = 0$ when there are no tariffs). If the shock is negative, i.e. $x > 0$, the optimal policy for all countries is a contractionary monetary policy since ρ and ω are positive¹⁹, respectively.

3.2 The punishment tariff structure

One feature of the model is crucial for the result in the game when only monetary policy is available: countries have only *one* instrument for monetary policy available which does not allow them to impose different externalities on members and non-members. Hence, a free-rider problem occurs which causes instability for coalitions of a size higher than three. With tariff policy, however, countries have an instrument available which allows them to

¹⁹For the proof, see appendix C.

apply a different tariff policy to ‘friends’ or ‘enemies’. Consequently, they could force countries to join the coalition by threatening them to punish them if they do not do cooperate.

In economic terms, the coalition threatens to form a customs union against the outsiders which will worsen the outsiders’ welfare by appreciating the coalition’s currencies and, hence, increasing the outsiders’ inflation.

In order to determine the effects of the punishment on the coalition and the outsiders we will now make some assumptions about a reasonable tariff-punishment structure and, accordingly, evaluate the expression for Θ_c and Θ_{nc} .

- The coalition forms a customs union. This means that all coalition members apply the same tariff to a specific outsider and that tariffs within the coalition are zero.

The assumption of a customs union does not necessarily imply the coalition imposes the same tariff on all outsiders. However, since we have symmetric countries outside the coalition, all outsiders face the same tariff from the coalition.

- Tariffs are only used as means of punishment²⁰ by the coalition which wants to force the outsiders to cooperate. We assume that tariffs will not be used by outsiders to retaliate since a retaliation would be much more costly to an outsider (who has to punish *all* coalition members)

²⁰Since we focus on the case where tariffs hurt the domestic and the foreign economy, tariffs will never be used ‘in the first place’ but only as means of punishment or retaliation. Hence, outsiders have no strategic reason to impose tariffs against each other.

than the damage it imposes on each coalition member. This is true in particular for larger coalitions like the 'package-upgrade' scenario discussed below. All tariffs imposed by non-members will therefore be zero²¹.

We can then simplify Θ_c and Θ_{nc} where θ_c denotes the tariff imposed by the coalition on outsiders. For a coalition member this gives

$$\Theta_c = \frac{\beta}{n-1} \left[1 - \frac{\eta_1}{\delta} - \frac{\eta_3}{\delta} (k-1) \right] (n-k) \theta_c ,$$

for an outsider,

$$\Theta_{nc} = \frac{\beta}{n-1} \left[\frac{\eta_2}{\delta} - \frac{\eta_3}{\delta} (n-k-1) \right] k \theta_c = \frac{\beta}{n-1} \left[\frac{\eta_1}{\delta} + \frac{\eta_3}{\delta} (k-1) \right] k \theta_c$$

²¹If we allow for retaliation tariffs imposed by non-members on the coalition, that is $\theta_{nc} > 0$, we can write Θ as:

$$\Theta_c = \frac{\beta}{n-1} \left[1 - \frac{\eta_1}{\delta} - \frac{\eta_3}{\delta} (k-1) \right] (n-k) \theta_c + \frac{\beta}{n-1} \left[\frac{\eta_2}{\delta} - \frac{\eta_3}{\delta} (k-1) \right] (n-k) \theta_{nc}$$

for a coalition member and

$$\Theta_{nc} = \frac{\beta}{n-1} \left[\frac{\eta_2}{\delta} - \frac{\eta_3}{\delta} (n-k-1) \right] k \theta_c + \frac{\beta}{n-1} \left[1 - \frac{\eta_1}{\delta} - \frac{\eta_3}{\delta} (n-k-1) \right] k \theta_{nc}$$

for an outsider. While the first terms of each equation denote the damages or costs of a punishment tariff imposed by the coalition, the second terms denote the costs or damages of a retaliation tariff imposed by the outsiders. It can be easily checked that the costs of a punishment tariff for the coalition *decrease* with coalition size while the damage it causes for the outsiders increases. In contrast, the costs of a retaliation tariff θ_{nc} for an outsider *increase* with coalition size while the damage it creates for the coalition decreases. Hence, punishment tariffs from the coalition are much more effective and credible than retaliation tariffs from the outsiders when we have higher coalition sizes. This justifies our assumption that outsiders do not retaliate in particular when the coalition is not very small.

In both cases, a tariff imposed by the coalition has a negative impact on the domestic economy since it increases Θ^{22} and, hence, according to eqn. (10) increases the inflation whereas it leaves employment unaffected in the first place. It should be noted, however, that the inflationary impact on the outsiders' economies is increasing with increasing coalition size while the impact on the coalition economies is decreasing.

3.3 The stability of coalitions

The coefficients ρ and ω in the equilibrium policies are non-linear functions of the model parameters. Hence, it is difficult to analyze analytically how the model parameters, in particular k and τ , affect the equilibrium outcome. This is even more the case, if we wish to analyze the stability of the coalition which is determined by differences in the losses which are in turn quadratic in the optimal policies. One possible approach is to perform numerical simulations with specific values for the model parameters whilst varying n , k and τ . We report here only a summary of the most important results; more detailed results and the results of the sensitivity analysis can be checked in Appendix D. We first evaluate how tariffs affect external and internal stability of the coalition and then determine the stable coalition size.

²² η_1 and η_2 are positive which explains an inflationary impact for outsiders. The impact on coalition members is inflationary since $\delta = \eta_1 + \mathcal{F}_j^i + \eta_3(n-2) > \eta_1 + \eta_3(k-1)$ for $k < (n-1)$.

3.3.1 Tariff impact on external and internal stability

The coalition is externally stable when no outsider wants to join the coalition. It is internally stable when no member of the coalition wants to leave it. The graphs in figures 1 to 5 below interpret the stability conditions when we have $n = 22$ countries. When the “gains from changing the group” are negative for both groups, coalition and outsiders, the coalition is stable. A coalition where all countries are members is externally stable by definition since there is no outsider left to join – this explains the “jump” of the graph for external stability from a coalition size of $k = 21$ to $k = 22$.

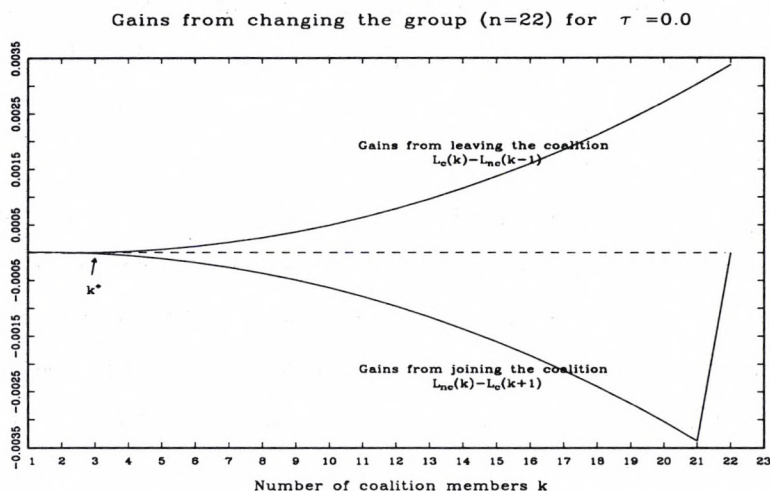


Figure 1: External and internal stability with zero tariffs^a

^aNegative “gains from changing the group” imply that keeping its affiliation does pay and, hence, the group is stable. k^* denotes the coalition size which fulfils both stability criteria.

Figure 1 shows the stability of the coalition when there are no punishment tariffs but only monetary policy. The “Gains from leaving the coalition” represent the internal stability condition ($L_c(k) - L_{nc}(k - 1) \leq 0$); the “Gains from joining the coalition” which could be named “Gains from leaving the fringe” describes the external stability condition ($L_{nc}(k) - L_c(k + 1) \leq 0$). Here, the stable coalition size is three. Above a coalition size of three it pays for countries to leave the coalition and to profit from the spillovers of coalition discipline whilst playing an individually optimal response. With increasing coalition size the potential profits from free-riding become even larger. Below three, on the other hand, it pays to form a coalition with other countries in order to reduce the competitive appreciation of uncoordinated monetary policy. In the monetary policy game with zero tariffs the outsiders are always better off than the coalition members since monetary policies are strategic complements, see Kohler [11].

Figures 2 to 5 show how external and internal stability develops for different tariffs.

The ‘gains from leaving the coalition’ which represent internal instability decrease with increasing coalition size before they start rising again, possibly into the positive area which denotes instability. Two effects shape this function.

The damage which tariffs impose on the outsiders increases with coalition size. On the other hand, the damage which tariffs cause to the coalition economies through inflation of the CPI decreases with coalition size. Combined, these two effects diminish the incentive to leave the coalition with

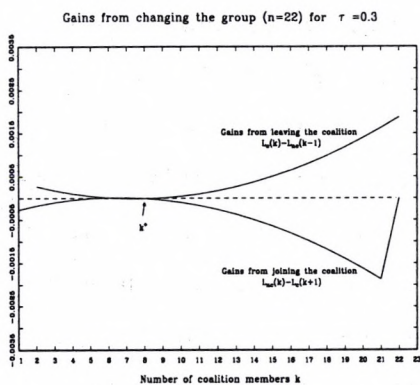


Figure 2: Stability conditions for $\tau = 0.3$

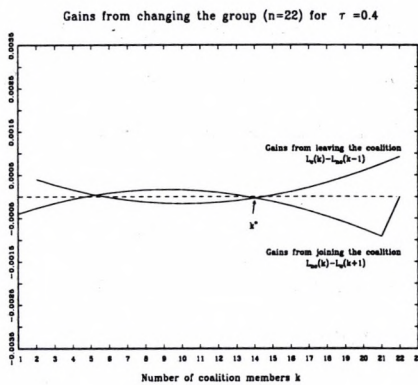


Figure 3: Stability conditions for $\tau = 0.4$

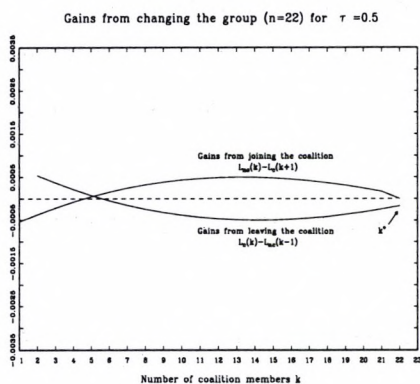


Figure 4: Stability conditions for $\tau = 0.5$

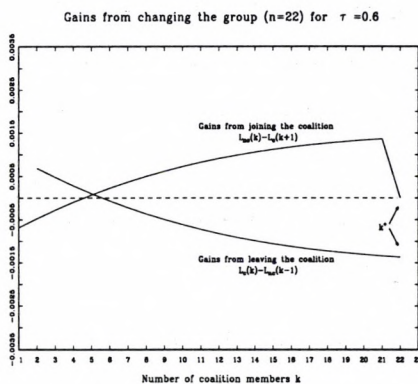


Figure 5: Stability conditions for $\tau = 0.6$

increasing coalition size²³. This is even more the case for higher tariffs,

²³The effect, which η_3 has on the economies can be neglected since, especially for ‘medium’ k , both groups enjoy a similar exposure to ‘third party effects’: $(n-k-1)k\eta_3$ for the outsiders and $(n-k)(k-1)\eta_3$ for the coalition.

since part of the tariff effect is counterbalanced by a more contractionary monetary policy (both optimal monetary policies are negatively dependent on Θ) which increases ‘genuine’ incentives to coordinate monetary policies. This diminishing effect is moderated by the free-riding incentive of monetary policy coordination which can be best observed in the game with zero tariffs. Internal stability without tariffs decreases with coalition size because of the reduced coalition externalities which create a free-riding incentive. When higher coalition sizes are reached, the incentive to free-ride dominates, which explains the U-shaped function for internal stability.

External stability is influenced by the same factors, which now work the other way around. For a low coalition size, incentives to join the coalition are small, since damages are only imposed through few tariffs, whereas the countries imposing the tariffs have to face a relatively high cost, since they have to punish a large outsider group. This stance, however, is counterbalanced by an intrinsic gain from coordinating on monetary policy for low k . With increasing coalition size it becomes more desirable to join the coalition because of the increasing tariff burden outside and the decreasing tariff burden inside the coalition. Finally, the free-riding incentives become dominant here, as well, and the gains from joining the coalition become lesser.

3.3.2 Threshold tariff level

An increase in the tariff τ ‘shifts’ the stability functions: the external stability function is shifted upwards and the internal stability function is shifted downwards. The crucial ‘middle’ part of the function, where

the tariff burden becomes too heavy for the outsiders and the free-riding incentive is not yet large enough for coalition members to leave, is larger the higher the tariff. If this ‘middle’ part, where the coalition is externally not stable and internally stable, extends over the full coordination point of $k^* = n$, we can reach full coordination as a stable coalition since at this point the coalition is externally stable, since there are no countries left to contemplate the participation decision.

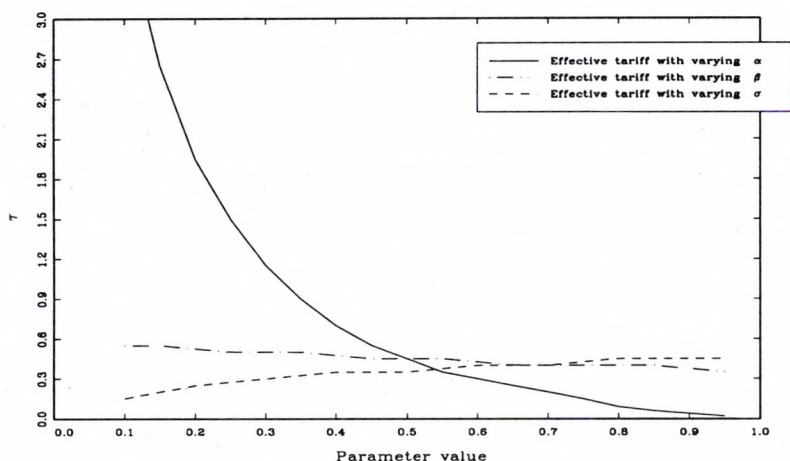


Figure 6: The threshold tariff level for different values of α, β and σ

We have calculated the *threshold* tariff level that is, the minimum tariff level which sustains full coordination dependent on the values for the model parameters. The results of the analysis are illustrated in figure 6 which shows the threshold tariff for different values of the parameters α, β and σ ²⁴. In short, the parameter which influences the threshold tariff level

²⁴We vary only one parameter at a time while the other parameters take their ‘stan-

most, is $(1-\alpha)$ which denotes the productivity of labour. For $\alpha > 0.5$, the highest threshold tariff level is 0.3, that is a thirty percent ad valorem tariff on the price of the imported good. Very low values of α require a tariff of above one or two hundred percent. α affects the size of the threshold tariff level much more than any other parameter because it changes the relative importance of being able to free-ride and of avoiding a tariff punishment. A high α (a low labour productivity, that is) implies that the externalities of foreign monetary policy (κ) are low and the effectiveness of domestic monetary policy (λ) is high. In a situation like this, coordinated and non-coordinated monetary policies are not very different and, hence, gains from being able to free ride are not very high. Since the impact of the tariff does not depend on α , it is much less profitable to bear a tariff punishment in order to simply exploit the gains from free-riding if α is low.

Though the influence of the other parameters is much less significant, the threshold tariff level decreases with increasing β , η_1 and η_2 . A higher propensity to import and higher tariff elasticities of demands, respectively, increase the impact of the tariff punishment Θ_{nc} and, hence, act as if the tariff was higher.

The threshold tariff level increases, however, with the number of the countries n . The reason is, that an increase in n reduces Θ_{nc} , the measure of the damage caused by the tariffs for the outsider and, therefore, a higher tariff is necessary for the punishment to be effective.

dard values', that is $\alpha = \beta = 0.5$ and $\sigma = 1$. The detailed results of this analysis (incl. the results for the parameters η_1 and η_2) and the results of the multivariate analysis can be checked in appendix D.

The threshold tariff increases, too, with σ , the weight of the employment target in the loss function. Since the tariff damages the outsider's economy through inflation the tariff punishment is much more effective when inflation has a relatively high priority, that is for a low σ . Only when priority shifts to the full-employment target that is, σ increases, will the inflationary damage a tariff causes become less important. Then, only a high penalty will create enough inflation so that countries will try to avoid the tariff punishment.

4 Dynamic aspects of the package deal

Up to now, we have focussed on static aspects of the stability of the coalition. The idea being that a given coalition is not sustainable if it is not stable in the sense that it must be individually optimal for a country to be a coalition member. We have assumed that the coalition does not offer coordination in a single field but a package deal.

In the following two sections, we will discuss two different aspects of the 'stable coalition' which are somewhat more of a 'dynamic' nature since they deal with the *formation* of the coalition and the credibility of the package deal.

4.1 The process of coalition formation

We have pointed out that there is always a tariff level high enough that it can sustain full coordination as the stable coalition. However, there may

be a problem of 'getting the coalition off the ground' when we consider some kind of coalition *formation* process.

As can be seen in figures 1 to 5, for a very low coalition size (below four or five members) the coalition is internally not stable but externally stable. That is, no country wants to join the coalition and coalition members want to leave it. This situation changes however, when the coalition has a larger size: outsiders then want to join the coalition and insiders do not want to leave it. If we were now to consider a coalition *formation* process where one country enters after the other we may face problems if the group of 'founding members' is too small since then we wouldn't be able to reach the 'critical size'.

We may indicate two ways out of this dilemma. First, we argue that our model may be more appropriate for a situation of a 'package upgrade' of an already existing customs union than a model for coalition formation starting with two members. The game considered so far is *not* one of an intrinsically dynamic nature. A game which explicitly deals with the formation of the coalition would have to take other dynamic features of monetary policy games, like expectation formation of the private sector over time, into consideration. Most likely, the theory of repeated games which eases the sustainability of coordination outcomes, would have to be applied, as well. All these aspects are neglected here and, therefore, the model is probably less suitable to explain a dynamic process like coalition *formation*.

However, if we start from an already existing trade bloc, we could easily exceed the 'founding size' of five countries. Above this size the increase is

‘automatic’: there are negative gains from leaving the coalition but positive ones from joining it. Hence, the model may serve as a potential application where we have a ‘package upgrade’ from a trade block to a currency block in mind. In this light, we may present an alternative interpretation of the ‘Fortress Europe’ idea. Typically, ‘Fortress Europe’ denotes the establishment or increase of external barriers of an internal European economic policy bloc. This creation of barriers is generally considered to be the result of the efforts of all members to keep their existing national protection. We provide a complementary explanation: threats of outside tariffs could be used to sustain policy cooperation in other economic areas.

Another feature, which is worthwhile noting, could provide a second solution to the ‘starting problem’. In particular for higher tariffs ($\tau \geq 0.5$) and more countries ($n \geq 9$) losses inside the coalition are lower than outside the coalition. This can provide a motivation for countries to go ahead and join the coalition early. They may want to belong to the ‘lucky ones’, the insiders that is, in case the tariff punishments are actually imposed on outsiders. This incentive may help to reach the critical initial size of the coalition.

4.2 The credibility of punishment in an extensive game

We have excluded so far the question of the credibility of the punishment by assuming that the coalition will only have the choice of adopting the package deal, but not either of the two policies separately. This assumption

is justified in that the coalition knows that with monetary policy alone it can not sustain a coalition with more than three countries. Therefore, it would like to be able to commit to the 'package deal', particularly, since it is possible to sustain full coordination and, hence, tariffs are only a threat but not actually imposed. We may ask, however, what happens if the coalition cannot commit credibly for instance on institutional grounds.

A chain store paradox In order to answer this question it may be reasonable to split the game into a two stage game as in Basevi et al. [1]. In the first stage, monetary policy is conducted and the coalition is decided upon. In the second stage, the outsiders are supposed to be punished by tariffs imposed by the coalition.

The extensive game has the structure of the 'chain store paradox' discussed in Selten [19]²⁵. Like the incumbent in Selten's model, the coalition would prefer to credibly commit to the threat of tariff punishments. However, once the coalition is formed it is not optimal to actually carry out the punishment since it would hurt the coalition, as well. If we were to select strictly sub-game perfect equilibria only, the coalition's 'rational' choice

²⁵In Selten's model, a chain store operates in N markets, in each of which there is a prospective entrant. In case of entry of the competitor, the incumbent can either fight or accomodate. The entrant's profit is positive if the incumbent accomodates, and negative if he fights. The incumbent incurs negative profits if he fights, positive profits if he accomodates, and the highest profits if the competitors stay out. Decisions are made sequentially. In the unique sub-game perfect equilibrium, all potential competitors enter and the chain store behaves passively in all markets. However, intuition suggests that the chain store should act aggressively towards early entrants in order to deter later entrants: it should try to acquire a reputation for being aggressive.

would be not to impose any tariff punishments and the outsiders would not join the coalition beyond size three.

Selten argues, however, that sub-game perfection does not select the intuitively most plausible solution for such a game. Intuitively, one would expect that the coalition will be willing to carry out the punishments the first times they become necessary in order to build up a reputation to be ‘tough’ and hence, to avoid the situation where other countries do not join the coalition. Only if the potential gains from maintaining the reputation are lower than the costs of tariff punishments, would the coalition not try to build up a reputation.

We have performed a numerical analysis in order to evaluate whether the costs of punishment exceed the potential gains through reputation. The potential gains are determined by the difference of the losses between the actual coalition size and a coalition of three countries. The results of the analysis are summarized in table 1²⁶. We have determined the (maximum) number of deviators which can be punished with the threshold tariff. This implies a minimum coalition size which is necessary that punishment of deviators pays off. Even though the punishment hurts the coalition countries, they are still better off than without tariff threats (with a coalition of three, that is) in these cases.

The analysis shows that if we have six countries, it pays to fight one or two countries which deviate. If we have seven (or more) countries, even three deviators (or more) can be punished if this leads to a coalition which comprises the remaining countries, that is one more country than the stable

²⁶The details of the analysis can be checked in Appendix D.

<i>Number of countries n =</i>	3	4	5	6	7	8	9	10
<i>Max. number of deviators</i>	0	0	0	2	3	4	5	6
<i>Min. coalition size</i>	(3)	(3)	(3)	4	4	4	4	4

Table 1: Punishment of deviators

coalition when there are no tariffs. Hence, the gains from having one more countries in the coalition outweighs the losses of punishing all the remaining countries²⁷. Each country which would like to leave the coalition is likely to be punished since this may ensure that the ‘necessary’ four or five countries remain in the coalition. Therefore, no country will want to stay out.

This solution, however, is not formal since building up a reputation requires a model of sequential entrance. The following paragraph suggests what such a formal model might look but we leave the analysis for later work.

Solutions to the paradox Kreps and Wilson [12] and Milgrom and Roberts [16] have suggested a resolution to the paradox²⁸, based on a

²⁷These results do not vary with the parameter values, see appendix D. They have been tested only up to a total number of 10 countries, though. For more countries there is probably a limit to the size of the fringe.

²⁸The model they suggest is modified in that the incumbent can now be either weak or strong. If he is strong, he ‘enjoys’ fighting since it is his dominant strategy. If he is weak, fighting is costly and can be worthwhile only if it raises profits in another market through building up a reputation for being ‘strong’. Only the incumbent knows whether he is ‘strong’ or ‘weak’. The sub-game perfect equilibrium of this game has the following features: in the first markets entry does not occur. If a firm would enter by mistake, it would be fought by both types. Because the number of markets shrink over time, concerns about reputation become smaller. This encourages entrants to enter.

model of incomplete information on the outsider's part regarding the 'type' of the coalition. It is assumed that the outsider does not know which 'type' the coalition is, a 'tough' type which punishes or a 'soft' type which accomodate if challenged (the differences are justified through different payoff matrices which could be different preferences in the payoff). The tough type will always punish since it is his dominant strategy, whereas the soft type will only punish in order to build up a reputation of being tough. If the probability that the coalition is tough is high enough, no outsider will initially dare to stay out. Only after several countries have joined the coalition will some countries try to stay outside and accept the risk of being punished.

In order to formalize such a model, however, one has to justify incomplete information and different types of payoff functions for the coalition, one of which has to have a dominant strategy of imposing tariffs on outsiders, for international policy games. An example of the latter is that there may be a different loss function for the coalition resulting from further profits from the imposition of tariffs. One could draw in this context from the trade policy literature where the existence of tariffs is explained either with the existence of increasing returns to scale²⁹ or with lobbying industries which seek protection in models of the political economy of trade policy³⁰. Additionally, it is necessary to introduce some degree of incomplete information on the side of the outsider.

This equilibrium requires that the probability of being strong is not too small.

²⁹See e.g. Krugman [13] for the seminal work in this area or Krugman [14] for a comprehensive survey.

³⁰See Rodrik [18] for a survey on this literature.

Extending the game into a game of sequential entrance that is, giving it a time dimension, opens up different solution concepts based on repeated games. In infinitely repeated games, generally speaking, it is easier to sustain cooperative outcomes following the reasoning of the folk theorem. Then, we would probably get different results even in the pure monetary policy cooperation game. Additionally, adding a time dimension would require an explicitly dynamic model which would deal with such issues as those of credibility of the monetary authority towards the private sector. We leave this for further work in the future.

5 Conclusion

In the real world so-called 'package deals' can be more often observed than simple coordination in specific policy fields. This paper provides a formal model which tries to explain why this comes about and what the advantages of a package deal vis-à-vis single policy coordination are.

As opposed to the model used in Basevi et al. [1] in order to evaluate 'package deal' questions, we have extended our model to more than two countries and can therefore cover the issue of a customs union which wants to extend coordination to the monetary field. The customs union can be exploited strategically to influence the formation of a currency bloc.

Monetary policy coordination alone provides small incentives to form larger blocs since the free-riding incentive dominates the gains from cooperation in this case. Tariff policy threats, however, add an incentive which can make full coordination sustainable if the tariff level is high enough. The

most important difference of the two policy instruments is that monetary policy does not allow the policy maker to apply a different policy to co-operators and to defectors while tariff policy allows to distinguish between them.

Our model does not claim to be able to explain the existence of trade policy but it should be seen rather as complementary to classical trade policy models. We aim at formalizing some strategic aspects of using trade policy outside of 'genuine' trade policy areas. This is why we choose as a starting point a model used to explain monetary policy coordination, focussing on demand structures – in contrast to many trade and customs union models which explain coalition formation with production structures.

This paper, however, has also shown the limits of applying trade policy in models which are mainly used to explain monetary policy coordination. In these models, trade policy will generally not be profitable for either economy. Consequently, the tariff punishment may face problems of credibility, particularly, if the threshold tariff is high. Then, we have either to lower the 'damage' and risk that full coordination cannot be sustained or we have to modify the model in line with the reputation models of Kreps and Wilson [12] and Milgrom and Roberts [16]. In this case, too, full cooperation may not be sustainable.

Appendix A: Deriving the demand equation

A.1 Linear approximation of the demand function

The real aggregate demand function for good i is derived from a combination of loglinearization and linear approximation of the expenditure functions following the procedure proposed by Canzoneri and Henderson [4], p.100.

Aggregate demand for good i is the sum of domestic private demand, foreign private demand and domestic public demand. The latter is equal to the domestic tariff revenues which the government spends exclusively on the domestic good.

f^{ij} denotes the expenditure function of country i on good j . All capital letter variables denote the respective variables in levels. Nominal expenditure is dependent on income (which equals nominal output in our model if money markets are in equilibrium) and the respective domestic prices of all goods. Hence, nominal expenditures (in domestic currency) are:

$$\begin{aligned} f^{ii}[P_i Y_i, \{E_{ih} P_h (1 + \tau_{ih})\}_{h=1 \dots n}] & \quad \text{domestic private outlays for good } i \\ f^{ij}[P_i Y_i, \{E_{ih} P_h (1 + \tau_{ih})\}_{h=1 \dots n}] & \quad \text{domestic private outlays for good } j \\ f^{ji}[P_j Y_j, \{E_{jh} P_h (1 + \tau_{jh})\}_{h=1 \dots n}] & \quad \text{foreign private outlays for good } i \end{aligned}$$

All real expenses are in terms of units of good i . The price of the domestic good abroad is $E_{ji} P_i (1 + \tau_{ji}) = \frac{P_i (1 + \tau_{ji})}{E_{ij}}$; hence, the foreign demands for good i have to be multiplied by $\frac{E_{ij}}{P_i (1 + \tau_{ji})}$. Bearing in mind that expenditure functions are linearhomogenous in prices (and hence, in real exchange rates

and in ad valorem tariffs $(1 + \tau)$), the real aggregate demand for good i in levels is:

$$Y_i = f^{ii}[Y_i, \{Z_{ih}(1 + \tau_{ih})\}_h] + \sum_{\substack{j=1 \\ j \neq i}}^n \frac{\tau_{ij}}{1 + \tau_{ij}} f^{ij}[\cdot] + \sum_{\substack{j=1 \\ j \neq i}}^n \frac{1}{1 + \tau_{ji}} f^{ji}[Z_{ij}Y_j, \{Z_{ih}(1 + \tau_{jh})\}_h] \quad (14)$$

where $Z_{ij} = E_{ij} \frac{P_j}{P_i}$ denotes the real exchange rate between good i and good j .

Like in Canzoneri and Henderson [4], taking logarithms, linearizing around the disturbance-free equilibrium values $\ln \bar{Y}_i$, etc. and replacing $y = (\ln Y_i - \ln \bar{Y}_i)$, $z_{ij} = (\ln Z_{ij} - \ln \bar{Z}_{ij})$ and $\theta_{ij} = (\ln(1 + \tau_{ij}) - \ln(1 + \bar{\tau}_{ij}))$ gives:

$$\begin{aligned} y_i = & \left[f_0^{ii} + \sum_{\substack{j=1 \\ j \neq i}}^n \frac{\bar{\tau}_{ij}}{1 + \bar{\tau}_{ij}} f_0^{ij} \right] y_i + \sum_{\substack{j=1 \\ j \neq i}}^n \left[\frac{1}{1 + \bar{\tau}_{ji}} f_0^{ji} \right] y_j + \\ & \underbrace{\sum_{\substack{j=1 \\ j \neq i}}^n \left[f_j^{ii(1 + \bar{\tau}_{ij})} + \frac{1}{1 + \bar{\tau}_{ji}} f_0^{ji} \bar{Y}_j + \sum_{\substack{h=1 \\ h \neq i}}^n \frac{\bar{\tau}_{ih}}{1 + \bar{\tau}_{ih}} f_j^{ih(1 + \bar{\tau}_{ij})} + \sum_{\substack{h=1 \\ h \neq i}}^n \frac{1}{1 + \bar{\tau}_{hj}} f_j^{hi(1 + \bar{\tau}_{hj})} \right] \frac{\bar{Z}_{ij}}{\bar{Y}_i} z_{ij}}_{\delta^{ij}} + \\ & \underbrace{\sum_{\substack{j=1 \\ j \neq i}}^n \left[f_j^{ii} \bar{Z}_{ij} + \sum_{\substack{h=1 \\ h \neq i}}^n \frac{\bar{\tau}_{ih}}{1 + \bar{\tau}_{ih}} f_j^{ih} \bar{Z}_{ij} + \frac{1}{(1 + \bar{\tau}_{ij})^2} \bar{f}^{ij} \right] \frac{1 + \bar{\tau}_{ij}}{\bar{Y}_i} \theta_{ij}}_{\eta_1^{ij}} - \\ & \underbrace{\sum_{\substack{j=1 \\ j \neq i}}^n \left[\frac{1}{(1 + \bar{\tau}_{ji})^2} \bar{f}^{ji} - \frac{1}{1 + \bar{\tau}_{ji}} f_{ji}^{ji} \bar{Z}_{ii} \right] \frac{1 + \bar{\tau}_{ji}}{\bar{Y}_i} \theta_{ji}}_{\eta_2^{ji}} + \sum_{\substack{j=1 \\ j \neq i}}^n \sum_{\substack{h=1 \\ h \neq i}}^n \underbrace{\left[\frac{1}{1 + \bar{\tau}_{ji}} f_h^{ji} \bar{Z}_{ih} \right] \frac{1 + \bar{\tau}_{jh}}{\bar{Y}_i}}_{\eta_3^{jh}} \theta_{jh} \end{aligned}$$

where the subscripts denote partial derivatives with respect to the $(h+1)$ th argument, that is e.g. f_0^{ji} denotes the derivative of f^{ji} with respect to the real income of country j whereas f_h^{ji} denotes the derivative of f^{ji} with respect to the domestic (in country j that is) real price of good h .

We can rewrite the demand for good i taking into account that the budget

constraint requires that $f_0^{ii} + \sum_{j=1, j \neq i}^n f_0^{ij} = 1$ and $f_h^{ii} + \sum_{j=1, j \neq i}^n f_h^{ij} = 0$:

$$y_i = \left[1 - \sum_{j=1, j \neq i}^n \frac{1}{1+\bar{\tau}_{ij}} f_0^{ij} \right] y_i + \sum_{j=1, j \neq i}^n \left[\frac{1}{1+\bar{\tau}_{ji}} f_1^{ji} \right] y_j + \sum_{j=1, j \neq i}^n \delta^{ij} z_{ij} + \sum_{j=1, j \neq i}^n \eta_1^{ij} \theta_{ij} - \sum_{j=1, j \neq i}^n \eta_2^{ji} \theta_{ji} + \sum_{j=1, j \neq i}^n \sum_{h=1, h \neq i}^n \eta_3^{jh} \theta_{jh}$$

Similarly, the real demand for good k while i is the numéraire good can be derived:

$$y_k = \left[1 - \sum_{j=1, j \neq k}^n \frac{1}{1+\bar{\tau}_{kj}} f_0^{kj} \right] y_k + \sum_{j=1, j \neq k}^n \left[\frac{1}{1+\bar{\tau}_{jk}} f_0^{jk} \right] y_j + \sum_{j=1, j \neq k}^n \delta^{kj} z_{ij} + \left[\delta^{ik} - \sum_{j=1, j \neq k}^n \frac{1}{1+\bar{\tau}_{kj}} f_0^{kj} \right] z_{ik} + \sum_{j=1, j \neq k}^n \eta_1^{kj} \theta_{kj} - \sum_{j=1, j \neq k}^n \eta_2^{jk} \theta_{jk} + \sum_{j=1, j \neq k}^n \sum_{h=1, h \neq k}^n \eta_3^{jh} \theta_{jh}$$

A.2 Restrictions on the elasticities

In this paragraph we derive the restrictions several model features impose on the expenditure functions and, hence, on the parameters of the demand functions.

- Walras' law
- Trade balance
- Symmetric countries

Whereas the first two conditions must hold since we are in a general equilibrium framework, the latter is an assumption. Walras' law must hold with equality when the budget constraints hold with equality and trade must always be balanced since we have no capital markets. This imposes

restrictions on the properties of the expenditure functions and, hence, on the elasticities η_1, η_2, η_3 and δ .

Walras' law requires that the n goods demands are linear dependent. Summing up all demand equations yields only an identity for all variable values if

$$\eta_2^{ij} = \eta_1^{ij} + (n-2)\eta_3^{ij}$$

This condition describes the redistribution of domestic outlay following a decrease in demand for good j due to a tariff imposed on this good. The outlay reduction for good j is distributed to good i according to the elasticity η_1 and, in equal parts since we have symmetric expenditure functions, to the remaining $n-2$ goods.

Trade balance Trade must be always balanced since we have no capital markets. Substituting the budget constraint $Y_i = f^{ii}[\cdot] + \sum_{j \neq i}^n f^{ij}[\cdot]$ into the goods demand (14) gives the trade balance:

$$\sum_{\substack{j=1 \\ j \neq i}}^n \frac{1}{1+\tau_{ij}} f^{ij}[\cdot] = \sum_{\substack{j=1 \\ j \neq i}}^n \frac{1}{1+\tau_{ji}} f^{ji}[\cdot]$$

Hence, the trade balance restriction is ensured when the budget constraints are fulfilled and goods markets are cleared.

In the long run equilibrium – with natural rates of output being the same in all countries and an equilibrium real exchange rate of unity – bilateral tariffs must be equal. Either, monetary or tariff policy, would shift the economy away from the disturbance-free equilibrium where the loss function

takes its minimum value. Consequently, the pareto-efficient tariff structure in the long-run equilibrium are **zero** tariffs, since tariffs would only increase the CPI but not affect the real exchange rate because all bilateral tariffs have to be equal. That is,

$$\bar{\tau}_{ij} = \bar{\tau}_{ji} \quad \forall j, i$$

Using zero-equilibrium tariffs and the budget constraints while equilibrium real exchange rates are unity and natural rates of output are \bar{Y} we can write:

$$\begin{aligned} \eta_1^{ij} &= [f_j^{ii} + \bar{f}^{ij}]^{\frac{1}{\bar{Y}}} \\ \eta_2^{ji} &= [\bar{f}^{ji} - f_i^{ji}]^{\frac{1}{\bar{Y}}} = [f_0^{ji}\bar{Y} + \sum_{\substack{h=1 \\ h \neq i}}^n f_h^{ji}]^{\frac{1}{\bar{Y}}} \\ \eta_3^{jh} &= [f_h^{ji}]^{\frac{1}{\bar{Y}}} \\ \delta^{ij} &= \left[\sum_{\substack{h=1 \\ h \neq i}}^n f_j^{hi} - \sum_{\substack{h=1 \\ h \neq i}}^n f_h^{ih} + \bar{f}^{ji}\bar{Y} \right]^{\frac{1}{\bar{Y}}} = \eta_1^{ij} + \sum_{\substack{h=1 \\ h \neq i}}^n f_j^{hi} \frac{1}{\bar{Y}} \end{aligned} \quad 31$$

Model symmetry requires that the partial derivatives of the expenditure functions across countries and across goods are symmetric, this includes:

³¹Expenditure functions are always linear homogenous in prices and in our model they are linear homogenous in the income, as well. Then the Euler theorem is applicable:

$$f^{ji} = f_0^{ji}\bar{Z}_{ij}\bar{Y}_j + \sum_{h=1}^n f_h^{ji}\bar{Z}_{ih}$$

which gives the alternative expression for η_2^{ji} .

- The shares of additional income which are spent on domestic (foreign) goods are equal across countries: $\mathcal{F}_0^i := f_0^{ii} = f_0^{jj}$ and $\mathcal{F}_0^j := f_0^{ij} = f_0^{ji} \quad \forall j \neq i$
- The own (real) price effects of domestic (foreign) goods are equal across countries: $\mathcal{F}_i^i := f_i^{ii} = f_j^{jj}$ and $\mathcal{F}_j^j := f_i^{ji} = f_j^{ij} \quad \forall j \neq i$
- The cross (real) price effects of domestic (foreign) goods are equal across countries and goods: $\mathcal{F}_j^i := f_j^{ii} = f_i^{jj} = {}^{32}f_i^{ij} = f_j^{ji}$ and $\mathcal{F}_h^j := f_h^{ij} = f_j^{ih} = f_h^{ji} \quad \forall j \neq i$

With these conditions, elasticities do not differ across goods and, hence, we can drop the superscripts of δ, η_1, η_2 and η_3 . Furthermore, we can now express δ as a function of η_1 and η_2 that is, $\delta = \eta_1 + \eta_2 - \frac{\beta}{n-1}$.

With the model symmetry we can rewrite the elasticities.

$$\begin{aligned}
 \eta_1 &= [\mathcal{F}_j^i + \bar{f}^{ij}] \frac{1}{\bar{Y}} = [-(n-2)\mathcal{F}_h^j - \mathcal{F}_j^j + \bar{f}^{ij}] \frac{1}{\bar{Y}} \\
 \eta_2 &= [-\mathcal{F}_j^j + \bar{f}^{ji}] \frac{1}{\bar{Y}} = [(n-2)\mathcal{F}_h^j + \mathcal{F}_j^j] \frac{1}{\bar{Y}} + \mathcal{F}_0^j \\
 \eta_3 &= \mathcal{F}_h^j \frac{1}{\bar{Y}} \\
 \delta &= [2\mathcal{F}_j^i + (n-2)\mathcal{F}_h^j] \frac{1}{\bar{Y}} + \mathcal{F}_0^j = \eta_1 + [\mathcal{F}_j^i + (n-2)\mathcal{F}_h^j] \frac{1}{\bar{Y}} \quad (15)
 \end{aligned}$$

An intuitive explanation of the last expression for δ goes as follows. A tariff on good j (imposed by country i) changes the demand for good i as if the price of good j had increased (δ) minus the substitution effects abroad, since only domestic demand shifts whereas foreign demand remains unaltered in the first place. The cross price effects are equal across countries due to the symmetry.

³²This equality can easily be proved by comparing the expressions for η_1 and η_2 .

If η_1 is positive, then $\frac{\eta}{\delta}$ is only larger than one if the cross price effects are negative. Then, however, δ might become negative. If η_1 is negative, $\frac{\eta}{\delta}$ is always smaller than one since this case can only occur when the cross price effects are negative.

A.3 Signs of the elasticities

The signs of the elasticities of the demand function depend on the properties of the underlying utility function.

- $\mathcal{F}_0^i(\mathcal{F}_0^j)$ denotes the change of a country's demand for the domestic (foreign) good with respect to its income. If the good is a normal (inferior) good this term is positive (negative). We have assumed that each country spends a positive fraction of its income on all goods. If we assume that this holds as well for an additional unit of income, all goods are normal goods. $\Rightarrow \mathcal{F}_0^i(\mathcal{F}_0^j) > 0$
- $\mathcal{F}_i^i(\mathcal{F}_j^j)$ denotes the own price effect of a domestic (foreign) good. This effect is negative for normal goods and positive for Giffen goods. If we assume that all goods are normal with respect to changes in income, we have no Giffen goods³³ and, hence, the demand for a good will always decrease when its price increases. $\Rightarrow \mathcal{F}_i^i(\mathcal{F}_j^j) < 0$
- $\mathcal{F}_j^i, j \neq i$ is the cross price effect of the demand for good i with respect to the price of good j . If i and j are substitutes (complements) the cross price effect is positive (negative), assuming that good j is a

³³The Slutsky equation requires that Giffen goods are strongly inferior goods.

normal good. In other words, if the demand for j falls when it becomes more expensive, the demand for i falls, as well, if it is a complement and it rises if i is a substitute for j . If j is a Giffen good it is the other way around. However, since the case of *Giffen goods* is of rather theoretical nature, we will neglect it. $\Rightarrow \mathcal{F}_j^i > 0 (< 0)$ if i, j are substitutes (complements) and normal goods.

We summarize the possible combinations of the features of the expenditure function and how they affect the signs of the elasticities of tariffs and of the (real) prices in table 2.

<i>Own price effect</i>	<i>normal</i>	<i>Giffen</i>	<i>normal</i>	<i>Giffen</i>
<i>Cross price effect</i>	<i>Substitutes</i>		<i>Complements</i>	
	$\mathcal{F}_i^i < 0, \mathcal{F}_j^i > 0$	$\mathcal{F}_i^i > 0, \mathcal{F}_j^i < 0, \mathcal{F}_0^j < 0$	$\mathcal{F}_i^i < 0, \mathcal{F}_j^i < 0$	$\mathcal{F}_i^i > 0, \mathcal{F}_j^i > 0, \mathcal{F}_0^j < 0$
η_1	positive	?	positive	positive
η_2	positive	negative	positive	?
η_3	positive	negative	negative	positive
δ	positive	negative	?	positive

Table 2: The sign of the tariff and real price elasticity of demand

If not noted otherwise, we will assume that all goods are normal and substitutes and, hence, η_1, η_2, η_3 and δ are positive and, according to eqn. (15), δ is larger than η_1 .

Appendix B: Deriving the reduced form

We will reduce the economy's model, eqn. (1) to eqn. (7), to two equations which express the equilibrium values of employment and CPI in terms of the policy instruments, money supplies and tariffs, and of the model parameters.

We assume that the expected money supply (more precisely, its deviation) for wagesetters is zero. Substituting equation (3) into (2) gives:

$$p_i = \alpha l_i + x \quad (16)$$

Substituting (16) and (1) into (4) yields the reduced form for employment:

$$l_i = m_i - m_i^e = m_i \quad (17)$$

Thus, employment changes one for one with the domestic money supply and is not affected by the other policy variables that is, foreign money supply or tariffs.

Substituting (9) into (16) and (1) gives the equilibrium values of the output and its price level:

$$p_i = \alpha m_i + x \quad (18)$$

$$y_i = (1 - \alpha)m_i - x \quad (19)$$

We substitute eqn. (19) into equation (6) and solve for $\delta \sum_{j=1, j \neq i}^n z_{ij}$. Substituting this expression and eqn. (18) into equation (7) gives the reduced form for the CPI:

$$q_i = \underbrace{\left(\alpha + \frac{\beta^2(1-\alpha)}{\delta(n-1)}\right)}_{\lambda} m_i - \underbrace{\frac{\beta^2(1-\alpha)}{\delta(n-1)^2}}_{\kappa} \sum_{j=1, j \neq i}^n m_j + \frac{\beta}{n-1} \left(1 - \frac{\eta_1}{\delta}\right) \sum_{j=1, j \neq i}^n \theta_{ij} + \frac{\beta}{n-1} \frac{\eta_2}{\delta} \sum_{j=1, j \neq i}^n \theta_{ji} - \frac{\beta}{n-1} \frac{\eta_3}{\delta} \sum_{j=1, j \neq i}^n \sum_{h=1, h \neq i}^n \theta_{jh} + x$$

Setting the first coefficient to λ and the second to κ , the reduced form for q_i can be rewritten as:

$$q_i = \lambda m_i - \kappa \sum_{j=1, j \neq i}^n m_j + \frac{\beta}{n-1} \underbrace{\left[\left(1 - \frac{\eta_1}{\delta}\right) \sum_{j=1, j \neq i}^n \theta_{ij} + \frac{\eta_2}{\delta} \sum_{j=1, j \neq i}^n \theta_{ji} - \frac{\eta_3}{\delta} \sum_{j=1, j \neq i}^n \sum_{h=1, h \neq i}^n \theta_{jh} \right]}_{\Theta} + x$$

The coefficients λ and κ are positive since $0 < \alpha < 1$ and $n \geq 3$.

Appendix C: Solving the equilibrium with a coalition

We will keep this analysis very short, since the main steps can be checked in the appendix of Kohler [11].

The countries $j = 1, \dots, k$ are members of the coalition C , the countries $i = k + 1, \dots, n$ are not in the coalition. The optimization problem which has to be solved by the monetary authority of a country can be summarized as follows. Outside the coalition L_i is minimized with respect to the own money supply; in the coalition L_i is minimized with respect to the money supplies of all coalition members.

$$\min_{m_i, m_j} L_i = \frac{1}{2} \left(\sigma m_i^2 + (\lambda m_i - \kappa \sum_{\substack{j=1 \\ j \neq i}}^n m_j + \Theta + x)^2 \right)$$

The reaction function of a country outside the coalition A country which is not in the coalition sets its own money supply so as to minimize its losses. It takes the other's money supplies as given (Nash conjectures).

$$\min_{m_i} L_i \quad \text{s.t. } m_j = \bar{m}_j \quad \forall j \neq i$$

The first order condition and the symmetry assumption for outsiders give the money supply of a non-member as a function of the coalition's money supply:

$$m_{nc}^* = \underbrace{\frac{\lambda \kappa}{\sigma + \lambda^2 - \lambda \kappa (n - k - 1)}}_{\kappa \vartheta} \sum_{j=1}^k \bar{m}_{j,c} - \underbrace{\frac{\lambda}{\sigma + \lambda^2 - \lambda \kappa (n - k - 1)}}_{\vartheta} [\Theta_{nc} + x] \quad (20)$$

The reaction function of a coalition member The coalition solves its optimization problem subject to a given money supply of the non-members:

$$\min_{m_i \in C} \mathcal{L} = \sum_{j=1}^k \frac{1}{k} L_j \quad \text{s.t. } m_i = \bar{m}_{i,nc} \quad \forall i = k+1, \dots, n$$

The first order condition together with the symmetry assumption for the coalition money supplies give the coalition member's reaction function dependent on the non-members' money supplies.

$$m_c^* = \frac{\lambda - \kappa(k-1)}{\sigma + (\lambda - \kappa(k-1))^2} \left[\kappa \sum_{i=k+1}^n \bar{m}_{i,nc} - (\Theta_c + x) \right] \quad (21)$$

The equilibrium Replacing the non-members' money supply in equation (21) with equation (20) gives the equilibrium money supply of a coalition member:

$$m_c^* = - \underbrace{\frac{(\lambda - \kappa(k-1))}{\sigma + (\lambda - \kappa(k-1)) [\lambda - \kappa(k-1) - \kappa^2(n-k)\vartheta k]}}_{\rho} \left[\kappa(n-k)\vartheta \Theta_{nc} + \Theta_c \right] - \rho [\kappa(n-k)\vartheta + 1] x$$

and the equilibrium money supply of a non-member:

$$m_{nc}^* = - \underbrace{[\kappa^2 \vartheta^2 k \rho (n-k) + \vartheta]}_{\omega} \Theta_{nc} - \kappa \vartheta k \rho \Theta_c - [\omega + \kappa \vartheta k \rho] x$$

The sign of the coefficients

- ϑ is positive since it can be rewritten as $\vartheta = \frac{\lambda \kappa}{\sigma + \lambda(\lambda - \kappa(n-k-1))}$ and $\lambda - \kappa(n-k-1) = \lambda \frac{k}{n-1} + \alpha \frac{n-k-1}{n-1} > 0$.
- ρ can be rewritten as $\rho = \tilde{\rho} \frac{\sigma + \lambda(\lambda - \kappa(n-k-1))}{\sigma + \lambda + \lambda \kappa}$. ρ is positive since $\tilde{\rho}$ is positive, for the proof, see Kohler [11], Appendix B.1 ($\tilde{\rho}$ is equal to the coefficient ρ discussed on pp. 28ff.).

Appendix D: The simulation results

In the following, we will present the results of the simulation analysis. There is no a-priori reason for a specific value for any of the parameter, hence, we chose values in the middle of the defined ranges for each parameters. Consequently, a robustness analysis was performed whose results are presented subsequently. The ‘standard values’, that is the values if not noted otherwise, are:

$$\alpha = \beta = \tau = 0.5, \sigma = 1, \mathcal{F}_j^j = -0.5, \mathcal{F}_j^i = 0.45$$

The elasticities are calculated according to:

$$\begin{aligned} \eta_1 &= \frac{\beta}{n-1}(1 + \mathcal{F}_j^i) \quad \text{and} \quad \eta_2 = \frac{\beta}{n-1}(1 - \mathcal{F}_j^j) \\ \eta_3 &= \frac{1}{n-2}(\eta_2 - \eta_1) \quad \text{and} \quad \delta = \eta_1 + \eta_2 - \frac{\beta}{n-1} \end{aligned}$$

This ensures that η_1 and η_2 remain within the limits $\frac{\beta}{n-1}$ and $2\frac{\beta}{n-1}$, and η_3 remains between zero and $\frac{\beta}{n-1}$. In addition, $(-\mathcal{F}_j^j)$ must always be higher than \mathcal{F}_j^i if η_3 has to be positive.

D.1 Threshold tariffs

For each set of parameter values we calculate the minimum tariff level τ which can sustain full coordination. In table 3, we present the results of the **univariate analysis**.

In short, the threshold tariff decreases in $\alpha, \beta, (-\mathcal{F}_j^j)$ and \mathcal{F}_j^i ; it increases in σ and n .

α	0.1	0.2	0.3	0.4	0.45	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9
τ^*	3.7	1.95	0.15	0.7	0.55	0.45	0.35	0.3	0.25	0.2	0.15	0.1	0.06	0.04
β	0.1 - 0.2		0.25 - 0.4		0.45	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9
τ^*	0.55		0.5		0.45	0.45	0.45	0.45	0.4	0.4	0.4	0.4	0.4	0.4
σ	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.80-1.2		1.3-2.3		2.4-2.9		3-5
τ	0.15	0.25	0.3	0.35	0.35	0.4	0.4	0.45		0.5		0.55		0.6
n	3	4	5	6	7	8	9	10	11	12	13	14	...	22
τ	0.0	0.3	0.3	0.4	0.4	0.4	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
\mathcal{F}_j^i	0.1									0.2				
$-\mathcal{F}_j^j$	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	0.2	0.3	0.4	0.5	0.6
τ	0.6	0.6	0.5	0.5	0.5	0.5	0.4	0.4	0.4	0.6	0.5	0.5	0.5	0.4
\mathcal{F}_j^i	0.2			0.3						0.4				
$-\mathcal{F}_j^j$	0.7	0.8	0.9	0.3	0.4	0.5	0.6	0.7	0.8	0.9	0.4	0.5	0.6	0.7
τ	0.4	0.4	0.4	0.5	0.5	0.5	0.4	0.4	0.4	0.4	0.5	0.5	0.5	0.4
\mathcal{F}_j^i	0.4		0.5					0.6				0.7		
$-\mathcal{F}_j^j$	0.8	0.9	0.5	0.6	0.7	0.8	0.9	0.6	0.7	0.8	0.9	0.7	0.8	0.9
τ	0.5	0.4	0.5	0.5	0.4	0.4	0.4	0.5	0.4	0.4	0.4	0.4	0.4	0.4
\mathcal{F}_j^i	0.8		0.9											
$-\mathcal{F}_j^j$	0.8	0.9	0.9											
τ	0.4	0.4	0.4											

Table 3: The threshold tariff: univariate analysis

The damage of the tariff Θ_{nc} increases with the propensity to import β and the tariff elasticities of the demand, η_1 and η_2 (which increase in \mathcal{F}_j^i and \mathcal{F}_j^j , respectively). Consequently, the threshold tariff level is lower when

these parameters take higher values.

The inverse is true for the number of countries n ; the higher n , the fewer the damage caused by the tariff since the trade volume with one country is decreases with the number of trading partners ($n - 1$). Since the damage caused by tariffs decreases with n , the threshold tariff level must increase with n .

σ represents the weight of the employment target in the policy maker's objective function. A low σ means that inflation is relatively more important and, hence, the tariff punishment which creates inflation has more impact, too. Therefore, for low σ a lower tariff level will be sufficient to sustain full cooperation.

Changes of α show the largest impact on the threshold tariff level. The reason is that α influences the relative importance of being able to free-ride and avoiding the tariff punishment. A high α implies κ , which represents the impact of foreign monetary policy on the domestic economy, is low. Therefore, coordinated and uncoordinated monetary policies do not differ very much and gains from free-riding are relatively small for high α . It does then not pay off to undergo a tariff punishment which does not change with α . Hence, the threshold tariff level is lower when α is higher.

The **multivariate analysis** does not give results much different from the univariate analysis. Hence, in table 4 we summarize only the results for the most influential parameter, α ³⁴. We report the threshold tariff level which supports full coordination for all possible values of all parameters

³⁴We report here only a summary of the multivariate analysis. The detailed results can be obtained on request from the author.

except for α , which is quoted explicitly. Again, α is the most influential parameter and affects the threshold tariff level inversely.

$\alpha=1.0$	$\tau \geq 0.1$	<i>sustains all</i>
$\alpha=0.9$	$\tau \geq 0.1$	<i>sustains all</i>
$\alpha=0.8$	$\tau \geq 0.3$	<i>sustains all</i>
$\alpha=0.7$	$\tau \geq 0.3$	<i>sustains most</i>
$\alpha=0.6$	$\tau \geq 0.5$	<i>sustains most</i>
$\alpha=0.5$	$\tau \geq 0.9/0.7$	<i>sustains all/most</i>
$\alpha=0.4$	$\tau \geq 0.9/0.7$	<i>sustains all/most</i>
$\alpha=0.3$	τ	<i>between 0.5 and 1.7</i>
$\alpha=0.2$	τ	<i>mostly above 2, only for very high $\beta(\geq 0.8)$ around 1</i>

Table 4: The threshold tariff: multivariate analysis

D.2 Punishment of deviators

If the coalition cannot commit credibly to the tariff threat on e.g. institutional grounds, it may pay off for the coalition to actually punish in order to build up a reputation. Punishment of deviators pays off if the gains from the ‘additional’ coordination gained through reputation (that is, coordination beyond three countries) exceeds the costs of punishment. We calculated the costs of punishment and balanced it against the gains, assuming that all countries except for the ‘deviators’ join the punishment scheme. The punishment tariff is equal to the threshold tariff level for each parameter constellation. We have determined the (maximum) number of

deviators which may be punished. This implies a minimum coalition size which is necessary that punishment of deviators pays off.

If we have six countries, it pays always to punish up to two deviators; if we have seven countries it pays still to punish up to three deviators; if we have eight countries it pays to punish up to four deviators. Since there are always three countries in the coalition when there are no tariff threats, this means that punishment of deviators is always worthwhile for the coalition if this ensures that at least one more member joins the coalition.

<i>Parameter</i>		<i>Threshold tariff</i>	<i>Number of countries n =</i>									
		τ^*	3	4	5	6	7	8	9	10		
α	0.1	3.7	0	0	0	2	3	4	5	6		
	0.2	1.95	0	0	0	2	3	4	5	6		
	0.3	1.1	0	0	0	2	3	4	5	6		
	0.4	0.7	0	0	0	2	3	4	5	6		
	0.5	0.45	0	0	0	2	3	4	5	6		
	0.6	0.3	0	0	0	2	3	4	5	6		
	0.7	0.2	0	0	0	2	3	4	5	6		
	0.8	0.09	0	0	0	2	3	4	5	6		
	0.9	0.04	0	0	0	2	3	4	5	6		

Table 5: Minimum number of countries where punishment of deviators pays (1)

We present the results of the univariate sensitivity analysis in table 5. The result described above (if the coalition gains only one more member the

<i>Parameter</i>		<i>Threshold tariff</i>	<i>Number of countries n =</i>									
		τ^*	3	4	5	6	7	8	9	10		
β	0.1-0.2	0.55	0	0	0	2	3	4	5	6		
	0.3-0.4	0.5	0	0	0	2	3	4	5	6		
	0.5-0.6	0.45	0	0	0	2	3	4	5	6		
	0.7-0.9	0.4	0	0	0	2	3	4	5	6		
σ	0.1	0.15	0	0	0	2	3	4	5	6		
	0.2	0.25	0	0	0	2	3	4	5	6		
	0.3	0.3	0	0	0	2	3	4	5	6		
	0.4-0.5	0.35	0	0	0	2	3	4	5	6		
	0.6-0.7	0.4	0	0	0	2	3	4	5	6		
	0.8-1.2	0.45	0	0	0	2	3	4	5	6		
	1.3-2.3	0.5	0	0	0	2	3	4	5	6		
	2.4-2.9	0.55	0	0	0	2	3	4	5	6		

Table 6: Minimum number of countries where punishment of deviators pays (2)

tariff punishment scheme pays) holds for all parameter values³⁵.

³⁵ \mathcal{F}_j^i and \mathcal{F}_j^j , though here not reported, do not change the results, too.

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