Why do sanctions need time to work?

Adjustment, learning and anticipation

Peter A G van Bergeijk and Charles van Marrewijk

Economists disagree on the influence of time on the probability of success of economic sanctions. Some argue that it takes time to convince the sanction target. Others stress that economic adjustment will reduce incentives to comply. We seek to reconcile these different literatures, modelling the target's decision to comply as a function of both (anticipatory) economic adjustment and Bayesian learning. We show that sanctions which do not work instantaneously (ie there is neither political compliance nor economic adjustment) can work in the long run, but only if the learning effect dominates the adjustment effect. A sufficient condition for ultimate compliance is that (potential) sanction damage that cannot be avoided by adjustment in the long run exceeds the yield of misconduct.

Keywords: Sanctions; Adjustment; Learning

Economic disincentives are increasingly being used in all kinds of policy fields. Fines, denial of economic benefits, exclusion and the like become more and more important in, for example, employment schemes, environmental policy and law enforcement. Such economic disincentives aim to change the behaviour of the target, ie the economic subject on which the economic sanction is to be imposed. Practical experience with such economic sanctions shows that it can take quite some time before the target complies – even if the target is repeatedly punished. This is so because the target rightly considers actual punishment as an uncertain outcome: detection of misdemeanour often is less than 100% (and likewise for conviction). Obviously, the subjective probability that punishment will actually follow upon misconduct increases if the target in the

course of time is repeatedly punished. An important countervailing force, however, is that the target at the same time seeks to reduce the costs or welfare loss of punishment.

This paper investigates the case of economic sanctions as an instrument of foreign policy. This is an interesting subject because policy oriented literature and economic trade theory seem contradictory on the question of whether the passage of time increases or decreases the probability of compliance. On the one hand, traditional neoclassical theory stresses that reallocation of production factors (both during and in anticipation of sanction episodes) will reduce the welfare loss of a sanction for a given time interval. On the other hand, the target may need some time to learn that the sanction threat is real. This paper analyses this trade off between learning and adjustment for the case of international political sanctions that aim at changing the political behaviour of other countries, but our findings have a wider application to other economic disincentives.

The relevance of our approach is shown by the curiosity that a majority of those foreign policy sanctions that have been successfully implemented in the past, have taken longer than one year to succeed. If the intentions of the imposing countries and the perceptions of the target country are known with certainty, the sanctions should either work directly

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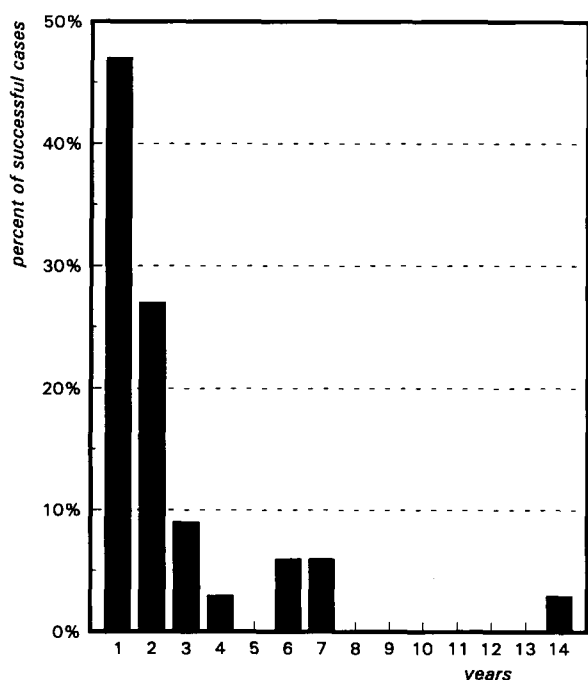
Figure 1. Successful sanctions by duration (years).

Source: Hufbauer *et al* [26].

Figure 2. Unsuccessful sanctions by number of years.[9]

[a] Note that 'other' includes all sanctions that were still continuing in 1989 (the last year in the Hufbauer *et al* [26] database).

or never at all. The history of the economic sanction instrument illustrates both sanctions that work directly and sanctions that never seem to work. Sanctions that worked more or less instantly are the League of Nations' sanctions against Yugoslavia in 1921 and against Greece in 1925 and the US sanctions against the Netherlands in 1948, against South Korea in 1975 and against El Salvador in 1987. Notable protracted failures are the 1954 Spanish sanction episode targeted against the British rule of Gibraltar (which lasted more than 30 years) and the 1960 US sanctions against Cuba which are still in force. These border cases can be explained with reference to traditional economic theory. However, according to the Hufbauer *et al* [26] database, many successful sanctions appear to take some time to work. Indeed, more than half the successful sanctions requires two years or more to achieve compliance (see Figure 1). In order to explain the pattern evident in Figure 1 a new theory is needed.

Another peculiarity of economic sanctions is that the implementation of a sanction today does not necessarily imply that this sanction will be implemented in the next period as well. Indeed, according to the Hufbauer *et al* [26] database, about one out of three ineffective economic sanctions lasted one year or less (Figure 2). As the target of the sanction did not change its behaviour, the reason for implementing the sanction in the first place continued in these cases.
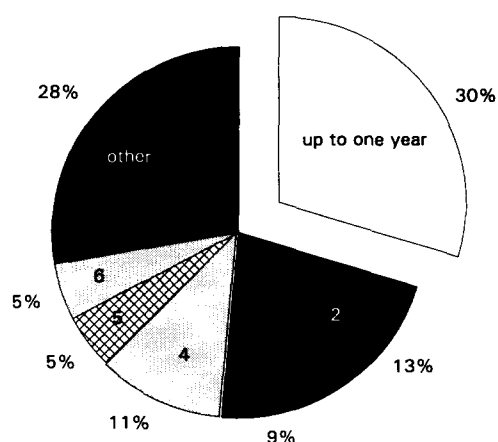
Evidently then, continuation of a sanction is uncertain. This is why any theory of economic sanctions should not start from a deterministic setting. First, it has to deal with the stochastic outcome of situations in which economic sanctions have been applied. Second, it has to acknowledge the impact of (subjective) expectations and probabilities in the decision process.

The next section clarifies the basic concepts of our analysis. The third section introduces adjustment when probabilities are exogenous. It would, however, be quite inconsistent to allow for adaptations in the production structure in reaction to (the possibility of) future sanction damage while the expectations about the future (ie about the probabilities of sanction damage in the next period) are kept constant. So in the section following we model expectations formation as a process of Bayesian learning. We show that sanctions which do not work instantaneously can still work in the long run, but only if the learning effect dominates the adjustment effect. A sufficient condition for ultimate compliance is that the unavoidable part of potential sanction damage exceeds the yield of misconduct. We then introduce the possibility that the target anticipates the imposition of economic sanctions at some point in the future and develop an expression for the optimal length of the process of anticipatory adjustment. The final section summarizes the main conclusions.

Settings

Many authors have argued that the duration of economic warfare is essentially positively related to the probability of its success. Daoudi and Dajani ([13], pp 168–169), for example, expect that sanctions

increasingly hurt when they last longer. Sanctions resemble a slow poison: the consequences are revealed only in the course of time, weakening the target's integrity, and this eventually causes the target's collapse.[1] The economics textbook treatment of foreign policy sanctions, however, suggests a negative relationship between success and duration. The questions of how much damage can be inflicted on the target depends to a large degree on the target's (in)flexibility as it reacts to the sanction. Rigidity of economic structures being basically a short-term phenomenon, it appears probable that the passage of time erodes the economic impact of sanctions.[2]

At the start of the 1980s it appeared difficult to reconcile these different views with respect to the relationship between time and success. This was especially so since empirical evidence at that time, if available at all, was inconclusive (Bull [10], p 122). Consequently, many authors stressed that the theory of economic sanctions was characterized by both a wide variety of definitions and the fact that the mechanism by which sanctions were supposed to be effective often was obscure.[3] Typically, the study of international economic penalties was of a (comparative) static macroeconomic nature and where dynamics was part of the analysis this was only in the sense that the target economy was allowed to react by stockpiling or by other policies aimed at reducing its vulnerability to foreign pressure.

In the mid-1980s a new strand of literature recognized that not only the implementation of economic sanctions but also the mere threat to use them can be an adequate policy instrument.[4] In the models of, for example, Hughes Hallett and Brandsma [27], Kaempfer and Lowenberg [28,29] and Schultz [43] the sender countries utter a strategic threat consisting of the announcement that economic sanction measures will be applied. If behaviour is altered the game ends and the sender attains its objective in the most efficient way, as it does not have to bear the costs of the sanction. If, however, a threat is not sufficiently credible to change behaviour, punitive action has to be carried out. This is painful and costly for both the sender and the target since both parties will be unable to reap the full benefits of free and undisturbed trade. Consequently, a sanction might be too costly to be carried out and the threat may appear false.[5] This implies that the passage of time may also become a positive determinant of success. Actual implementation of sanction measures increases the value of the threat as even partial implementation increases the probability of (possibly full) application in the next period (Van Bergeijk and Van Marrewijk [3]).

The econometric identification, however, of the relationship between compliance and duration is problematic as the duration of a sanction should be considered endogenous (Lam [31]).[6] Dehejia and Wood ([14], p 76) introduce duration in both linear and non-linear form in order to allow for a more complex relationship with the likelihood that a sanction succeeds; but the empirical evidence for their preferred specification is not impressive. It should, moreover, be noted that this variable is particularly inaccurately measured. For example, arbitrary rounding in nearly 10% of the cases results in overstatement of the duration of the episode by a factor four or more (Bonetti [6]). Hence if a trade off exists between the credibility of a threat and the reallocation of factors of production then this can only be investigated if both expectations and the adjustment process are explicitly modelled.

Moreover, this relationship is complicated by the fact that a potential target may anticipate the sanction measures and adjusts its economy in advance. Seeler [44], for example, points out that in Europe quite some time passes between the decision that sanctions will be implemented and the moment of their actual legal implementation. The UN Security Council sanctions provide other examples.[7] Schrijvers [42] clarifies that in the diplomatic upswing to the actual imposition of UN sanctions a prior determination under Article 39 of the UN Charter is necessary in

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[1] Brady ([9], p 299) claims that sanctions with time become extremely efficient, because agreement on the international unacceptability of the target's conduct causes more and more countries to join the embargo. Hanlon and Omond ([23], p 12) argue that even tight sanctions will require several years to have an impact. In addition, arguing that ineffective sanctions have a tendency to last, Dekker ([15], p 396), Lindsay ([34], p 165) and Leyton-Brown ([33], p 308) stress economic-psychological factors such as loss of face or the fact that the welfare loss should be sudden in order to prevent the target population from getting used to the sacrifices.

[2] See for examples Kemp [31], pp 208–217), Frey ([19], pp 103–121) and Carbaugh ([11], pp 144–147).

[3] See Van Bergeijk ([2], pp 27–43) for a review of economic and non-economic theories of sanctions.

[4] A theory of policy intervention as a defence against possible trade disruption by other governments developed following the seminal article by Bhagwati and Srinivasan [5]. See, for example, Mayer [36], Tolley and Wilman [47], Bergström *et al* [4], Srinivasan [48], Van Marrewijk and Van Bergeijk [3] and Van Bergeijk ([2], pp 107–110). This strand of the literature deals both with adjustment in reaction to a perceived external threat and with endogenizing the probability of trade disruption (as a function of the volume of trade). It does not, however, deal with the problems of political behaviour and learning that are the topics of the present paper.

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[5] Actually, this fits in with the economic theory of strategic threats and reputation pioneered by Schelling [41] and Boulding [8].

[6] Lam ([32], p 241), however, in his investigation excludes those cases where economic sanctions were only threatened but not actually imposed which begs all the interesting questions.

[7] The UN Security Council took sanctions against Rhodesia (1966–79), South Africa (1977–94), Iraq (1990–), Former Yugoslavia (1991–), Somalia (1992–), Libya (1992–), Liberia (1992–), Haiti (1993–) and Angola (1993–).
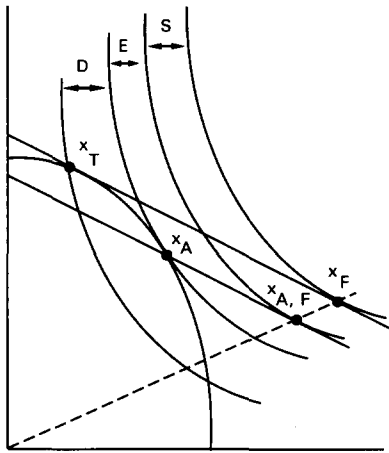
Figure 3. The impact of an economic sanction: production, consumption and utility.

order to determine the existence of the 'threat to peace, a breach of the peace or an act of aggression' that is a precondition for invoking Articles 41 (the 'sanction article') and 42 (the 'enforcement article') of the UN Charter. Actually, premandatory Security Council resolutions contain phrases that mimic the Article 39 requirements. Such resolutions are to be interpreted as diplomatic hints that the Security Council is on the brink of implementing sanctions. On the one hand, this offers the target a face saving way out and may thus be helpful in achieving the sender's goal. On the other hand, this may act as an important incentive for the target to build stockpiles and adjust its economic structure in advance.

The neoclassical model

Consider Figure 3 which illustrates the neoclassical model of a complete embargo which is implemented at moment t_0.[8] Figure 3 shows four consumption points: x_F, the free trade consumption point, x_T, the free trade production point which becomes the consumption point at t_0 if the economy did not anticipate the sanction, x_A, the autarky consumption point which will ultimately be reached if the sanction blocks all international exchange and, finally, $x_{A,F}$, the free trade consumption point if the economy does not specialize at all (for example, when an autarkic economy is just opening up to international trade or if a trading economy expects very severe sanctions in the near future).[9] Movements between x_T and x_A are

costly and take time since the factors of production need to be reallocated. Sanction damage decreases over time and consists of a transitory part $D = u(x_A) - u(x_T)$ and a permanent loss $P = u(x_F) - u(x_A)$, the well-known gains from trade. This permanent loss can analytically be subdivided into a part $E = u(x_{A,F}) - u(x_A)$, the gains from exchange, that relates to the fact that the sanction prohibits all international exchange and a part $S = u(x_F) - u(x_{A,F})$ that represents the gains from specialization in production due to international trade. Note that a limit exists to the extent of anticipation as it will in general not be advantageous for the target to change its production structure to the right of the autarky production point.[10]

Expected utility

Our theory combines the insights of the two approaches to the relationship between the time variable and the probability of success of economic sanctions.[11] We study the target's options and alternative economic trajectories in a model that analyses an economic decision unit (the target) which is confronted by (the threat of) an economic sanction, possibly in a super game setting of which we only model the target's decision process. We assume that the target country is risk neutral, which enables us to normalize such that $u(y) = y$.[12] We distinguish between three different yields that influence the target's behaviour ($y_H > y_N > y_L > 0$):

(i) y_N = yield of neutral activities which the sender does not oppose.

(ii) y_H = the sanction threat is false: the target does not comply and no sanction is imposed.

(iii) y_L = the sanction threat is real: the target does not comply and the sanction is imposed.

We assume that the target derives some benefit from the 'misconduct' that induced the sanction threat, so that the premium of non-compliance ($y_F - y_N$) is positive.
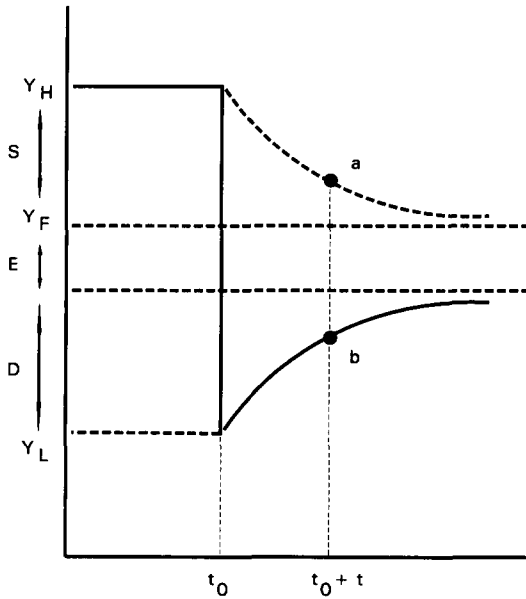
Figure 4 translates Figure 3 into a time path for

Figure 4. The impact of an economic sanction: time path of utility.

national welfare for the case of a complete embargo.[13] In the limit, as $t \to \infty$, utility will settle at the autarky level $u(x_A)$. The immediate effect of an embargo at time t_0 is a fall from the free trade, full specialization welfare level y_H to y_L, the no trade, full specialization welfare level. So the total sanction damage that can be imposed in any given period consists of a permanent part and a transitory part so that $y_L = y_F - D - E$. Once the sanction is issued, both y_H and y_L are influenced by the target's adjustment while it moves the factors of production and we assume that t periods after the issuing of the sanction the transitory part of the sanction damage and the gains from exchange have reduced to $\delta^t D$ and $\delta^t E$, respectively. Naturally, we have $0 < \delta < 1$; and the smaller δ, the larger the speed of adjustment.

Finally, we have the target's subjective probability π that the sanction will actually be imposed in the next period by the sender, given that the target does not comply.[14] This probability determines the target's expected utility of non-compliance. Consider Figure 4

where at $t_0 + t$ the target weighs a and b with $(1 - \pi)$ and π, respectively. The target country does not know this probability π with which the sanction is imposed. So it will have to make an educated guess about the parameter π, which can be represented by an *a priori* distribution function of π. Indeed, this is a case par excellence where good judgement and subjective weights of evidence and learning are essential features of rational decision making.[15]

Two crucial hypotheses are the unitary actor assumption and our treatment of the yields and discount rates as exogenous parameters in time. Indeed, there is more to economic sanctions than the processes that are studied in our model. Often government actions are the result of group decisions, but laboratory tests by Haney *et al* [24] of the differences between unitary actors and advisory models shows that 'the unitary actor model is on the right track. Such a model does not do great harm to model the larger questions' (Haney *et al* [24], p 632). Likewise the valuation of the yields may fluctuate quite substantially (depending, for example, on who runs the target country), and the rate of time preference for a despotic ruler might swing to the current period when faced by sanctions that might cost him his job. Indeed, even costs that can be objectively determined using standard economic techniques may be valued very differently by different rulers. Our model does not address these issues, but at the cost of reduced transparency these issues could be incorporated.

Exogenous *a priori* probabilities

Since we study the response of a target country to sanctions over time, we have to discount the (expected) future outcomes (or yields) that are the possible result of present decisions. The present discounted value of complying $PDV(C)$ consists of the discounted future stream of normal pay offs y_N, which at the rate of time preference ρ yields $(0 < \rho < 1)$:

$$PDV(c) = \sum_{j=0}^{\infty} \rho^j y_N = \frac{y_N}{(1 - \rho)} \qquad (1)$$

Given the subjective *a priori* probability π that a sanction will be imposed, the net expected value of not complying in period 0 is

$$(1 - \pi)(y_F + S) + \pi(y_F - E - D) \qquad (2)$$

We describe the development of damage over time in accordance with the traditional neoclassical trade

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[13] Note that we do not define the exact unit in which t is measured. This unit may be interpreted as years, months, weeks or days with only the logical implication that the other variables such as the yields and the discount rates are also defined for the same time unit.
[14] Note that this probability cannot be expected to be established on the basis of a physical probability distribution as Hufbauer *et al* [26] only describe 116 economic sanctions in their *Economic Sanctions Reconsidered* which is the standard reference on this subject. See Bull [10] and Bonetti [6] for a critical evaluation of the Hufbauer and Schott study. Moreover, the number of cases in which economic sanctions were expected or contemplated is unknown (see Tsebelis ([49], pp 26–27).

[15] See Good [20] and Epstein and Le Breton [16] on subjective probability and Bayesian learning.

model illustrated in Figures 3 and 4. Calculating the expected present discounted value of not complying *PDV(NC)* requires that we take both the sanction damage and the speed of adjustment into account. After *t* periods of adjustment, the gains from specialization have reduced to $\delta^t S$ and the transitory damage to $\delta^t D$. The discounted expected yield at t_0 of not complying is therefore:

$$\rho^t[(1-\pi)(y_F+\delta^t S)+\pi(y_F-E-\delta^t D)] \qquad (3)$$

So provided $\pi D \geqslant (1-\pi)S$ (otherwise there is no expected gain in adjusting the economy), we may write:[16]

$$PDV(NC)=\frac{y_F-\pi E}{1-\rho}-\frac{\pi D-(1-\pi)S}{1-\rho\delta} \qquad (4)$$

The target will decide to comply if the present discounted value of compliance is larger than or equal to the present discounted value of non-compliance: $PDV(C) \geqslant PDV(NC)$. Let for notational convenience $\eta \equiv (1-\rho)/(1-\rho\delta) \in (1-\rho, 1)$ be the appropriate discount rate for adjustable items (*D* and *S*) in order to rewrite the condition for compliance as

$$\pi(\eta D+E) \geqslant (y_F-y_N)+(1-\pi)\eta S \qquad (5)$$

So the expected temporary damage and the forgone gains of exchange must be larger than or equal to the sum of the premium of non-compliance (y_F-y_N) and the expected gains from international specialization. So the premium of non-compliance has to be balanced against the expected disutility of the sanction, taking adjustment into account. This requires that sanction damage is weighted by the subjective probability that a sanction will be actually implemented in the next period and that the transitory components are corrected for the speed of adjustment and the rate of time preference, respectively, as these terms are changing over time. The condition of Equation (5) which describes the case of exogenous subjective probabilities is more likely to hold (and therefore the target is more likely to comply) if, other things equal, the premium of non-compliance decreases (either by a decrease of y_F or an increase of y_N), the rate of time preference increases (ρ decreases), the speed of adjustment decreases (δ increases), or sanction damage (*D*, *E*, and/or *S*) increases.

Although instructive, the model in this section is unable to explain why economic sanctions take some

time to work. Allowing for learning, the next sections will show that some sanctions work *a priori* while others will not work at all.

Learning: endogenous *ex post* probabilities

If the sanction instantaneously succeeds, time does not have a role to play, because the target complies and hence the sanction episode ends. In the two other cases (sanctions that continue forever and sanctions that take some time to work) both learning and adjustment are important: the target will update its belief that the sanction will be implemented in the next period while it also adjusts the allocation of the factors of production.[17] Learning influences the *a priori* probability that the sanction will be implemented if behaviour does not conform to the standards set by the sender country or group of countries.

All that we conjecture at this point is that the target makes an educated guess about the parameter π, which can be represented by an *a priori* distribution function of π. We propose a learning rule that is a simple example of adaptive learning, in which agents use an intuitive procedure. In our model the target's procedure for making and changing its choices on the basis of past outcome is the statistical rule of Bayesian updating.[18] Epstein and Le Breton [16] show axiomatically that the existence of a Bayesian prior is implied if preferences are based on beliefs and admit dynamically consistent updating in response to new information. In this sense our learning rule is 'simple but adequate'. Let π_0 be the Bayesian (subjective) *a priori* probability that a sanction will be imposed. This *a priori* probability is based on information such as the success rate of sanctions in general or the sender's track record with respect to sanction implementation. Let $\pi_t, t \geqslant 1$, be the Bayesian update of this probability if a sanction has been imposed for *t* periods with $\pi_0 \leqslant \pi_1 \leqslant \pi_2 \leqslant \ldots \leqslant \pi_t \leqslant \pi_{t+1} \leqslant \ldots$ and strict inequality if actual learning takes place and that $\lim_{t\to\infty}\pi_t=1$.

An important difference between learning and adjustment is that the learning process starts immediately, whereas adjustment only happens if the perceived benefits of adjustment exceed the perceived costs of adjustment (ie the reallocation of the factors of production). So we will distinguish two situations: immediate adjustment and postponed adjustment.

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[16] Note that the economy will never adjust if a sanction is implemented as long as $\pi D<(1-\pi)S$ and will only comply if $\pi(P-D) \geqslant (y_F-y_N)+(1-\pi)S$.

[17] In addition to the question that we investigate in this paper, learning could be applied to the other parameters of the model as perceived by decision makers, and to their preferences.

[18] See, for example, Honkapohja [25] or Evans and Hokapohja [17]. One important feature of this rule in contradistinction to Guesnerie and Woodford [22] is that the weight attached to the forecast errors decreases to zero.

Immediate adjustment $(\pi_0 D \geqslant (1 - \pi_0)S)$

When the target adjusts its economic structure immediately if it is hit by a sanction, we find *ex ante* compliance if:

$$\pi_0(\eta D + E) \geqslant (y_F - y_N) + (1 - \pi_0)\eta S \qquad (6)$$

If the condition of Equation (6) does not hold the target does not comply and we assume that a sanction will be imposed (if the sanction is not imposed, the target for obvious reasons will never comply). In period 1 the target again has to decide whether or not to comply. Two things have changed since period 0:

(i) First, the target received information that the sanction was not false and so it updates its belief about the probability that the sanction will be imposed in the next period. Learning has taken place (so $\pi_0 \rightarrow \pi_1$).

(ii) Second, the target has partly adjusted its economy to reduce the economic impact of the imposed sanction, ie the transitory components have reduced to δD and δS in period 1.

So, as time passes by, the target evaluates both the sanction history of inflicted (but insufficient) damage and the prospects of adjustment leading to reduced (but more probable) damage. The target will comply after period one if:

$$\pi_1(\eta \delta D + E) \geqslant (y_F - y_N) + (1 - \pi_1)\eta \delta S \qquad (7)$$

If, however, the condition of Equation (7) does not hold, then the sanction continues and so will the learning and adjustment processes. The target will comply after period t if:

$$\pi_t(\eta \delta^t D + E) \geqslant (y_F - y_N) + (1 - \pi_T)\eta \delta^t S \qquad (8)$$

Note that as $t \rightarrow \infty$, the condition of Equation (8) reduces to $E \geqslant (y_F - y_N)$. Hence as long as the gains from international exchange exceed the premium of non-compliance, the target can ultimately be forced to comply. This may account for the long duration of sanctions when clearly visible results do not materialize. The Western strategic embargo against the Eastern bloc might be an example as this sanction is generally thought to have been ultimately quite successful (Roodbeen [39]).

It is more likely that the target will comply if $PDV(NC)$ falls from period t to period $t+1$, ie if:

The direct learning effect, the cross-cost effect and the cross-gain effect involve Δ_t (which goes to zero as $t \rightarrow \infty$) and fall rapidly over time. This means that the direct adjustment effect tends to dominate the other effects after a while, so that compliance becomes less likely.[19] From a policy perspective this suggests that unsuccessful sanctions that are continued for a long period of time are most probably unnecessarily costly.

Postponed adjustment $(\pi_0 D < (1 - \pi_0)S)$

If the condition of Equation (6) holds then we have *ex ante* compliance and hence there is no adjustment. In the other case sanctions will be imposed. The target starts to learn, but it will not adjust its economy at time t unless

$$\pi_t D \geqslant (1 - \pi_t)S \qquad (10)$$

Now as $t \rightarrow \infty$ it follows that $\pi_t \rightarrow 1$ so that Equation (10) in the long run requires $D \geqslant 0$. Hence for positive adjustable damage the target will ultimately always adjust its economic structure either until all possibilities are exhausted or until compliance follows.

Let T be the first period in which the target perceives adjustment to be beneficial, ie $\pi_T D \geqslant (1 - \pi_T)S$. Then the target will comply if:

$$\pi_t(D + E) \geqslant y_F - y_N + (1 - \pi_t)S$$
$$\text{for} \quad t < T \quad \text{(no adjustment)}$$

$$\pi_t[\eta \delta^{T-t} D + E] \geqslant y_F - y_N + (1 - \pi_t)\eta \delta^{T-t} S \qquad (11)$$
$$\text{for} \quad t \geqslant T \quad \text{(adjustment)}$$

Numerical example

So far our model has distinguished between the following five possibilities:

(i) *ex ante* compliance;

(ii) sanctions, economic adjustment only after period T until the target complies;

(iii) sanctions, economic adjustment only after period T, no compliance;

(iv) sanctions, no economic adjustment until the target complies $(T = 0)$;

(v) sanctions, economic adjustment until the target complies $(T = 0)$.

These results hold for general Bayesian rules for updating. Our example uses the so-called beta distri-

Total learning effect	$\geqslant$	total adjustment effect		
$\Delta_t E$ + $\eta \delta^{t+1} \Delta_t D$	$\geqslant$	$\eta \delta^t(1-\delta)[\pi_t D - (1-\pi_t)S]$ +	$\eta \delta^{t+1} \Delta_t S$	(9)
direct	cross-	direct	cross-	
learning	cost	adjustment	gain	
effect	effect	effect	effect	
	with $\Delta_t \equiv \pi_{t+1} - \pi_t \geqslant 0$			

[19] For example for Δ_t the beta distribution is

$$\Delta_t = \frac{\beta + 1}{(\alpha + \beta + 3 + t)(\alpha + \beta + 2 + t)} \sim \frac{1}{t^2}$$

which approaches zero much more quickly than δ^t.

Table 1. Numerical example.[a]

α	t*	β	t*	ρ	t*	δ	t*	y_F	t*	y_N	t*	E	t*	D	t*	S	t*
	P	3	A	0.6	1	0.6	7	2.7	A	1.4	∞	0.9	∞		P	0.1	A
4	8	4	A	0.7	2	0.7	7	2.8	A	1.6	91	1.1	63		P	0.3	2
5	6	5	2	0.8	3	0.75	6	2.9	2	1.8	21	1.3	16	1.2	6	0.8	4
6 (Base case)	5	6	5	0.9	5	0.8	5	3.0	5	2.0	5	1.5	5	1.5	5	1.0	5
7	3	7	8	0.95	6	0.85	3	3.2	21	2.1	2	1.6	3	1.8	3	1.1	5
8	1	8	10	0.97	7	0.9	2	3.4	91	2.2	A	1.7	1	2.2	1	1.3	6
9	A	9	13	0.99	7	0.95	1	3.6	∞	2.3	A	1.9	A	2.4	A		P

[a] (A = *ex ante* (instantaneous) compliance, P = postponed adjustment; ∞ = adjustment exceeds learning; sanction will never work).

bution function as a tool to explicitly model a specific Bayesian expectations formation process. Consequently, the numerical example is a special case of the general model that was analysed in the previous sections. This beta function is characterized by the parameters α and β and is a versatile distribution function that has the great analytic advantage that Bayesian updating again leads to a beta posterior probability density function. The probability density function for $\alpha > -1$ and $\beta > -1$ is (Fisz [18]):

$$g(\pi) = \frac{(\alpha+\beta)!}{\alpha!\,\beta!}\,\pi^{\alpha}(1-\pi)^{\beta} \quad (12)$$

The expected value and variance are:

$$E(\pi) = \frac{\alpha+1}{\alpha+\beta+2} \quad (13)$$

$$\mathrm{Var}(\pi) = \frac{(\alpha+1)(\beta+1)}{(\alpha+\beta+3)(\alpha+\beta+2)^2} \quad (14)$$

The target country will have some *a priori* ideas about the probability $E(\pi)$ that a sanction will be executed upon (continued) non-compliance and about its variance $\mathrm{Var}(\pi)$ which represents its confidence about the estimate $E(\pi)$. This is sufficient to determine the *a priori* parameters α and β. For example, if the target thinks all π's are equally likely ('extreme ignorance') then $\alpha = \beta = 0$ and $g(\pi) = 1$. Alternatively, if the target thinks $\pi > \frac{1}{2}$ to be less likely, then it implicitly assumes $\alpha < \beta$.[20] Suppose then, that the target decides not to comply and that a sanction is imposed. If the target is a Bayesian learner, the updated values for α and β, α^* and β^* say, after a sample of size n with r 'events' are $\alpha^* = \alpha + r$ and $\beta^* = \beta + n - r$, respectively. Now if the target does not comply and a sanction is imposed the sample size is one ($n = 1$) and the number of 'events'

is also one ($r = 1$), which implies $\alpha^* = \alpha + 1$, $\beta^* = \beta$ and

$$E(\pi | n = r = 1) = \frac{(\alpha+2)}{(\alpha+\beta+3)} = \pi_1 \quad (15)$$

In general:

$$E(\pi | n = r = t) = \frac{(\alpha+1+t)}{(\alpha+\beta+2+t)} = \pi_t \quad (16)$$

We illustrate the model by presenting a numerical example in Table 1. Let t^* be the first non-negative integer t so that Equation (11) holds.[21] The following four possibilities are illustrated in Table 1:

(i) *Ex ante* threat: $t^* = 0$; the target complies immediately.

(ii) Immediate adjustment; learning effect dominates adjustment effect ($T = 0$): $0 < t^* < \infty$; the sanction has to be imposed for t^* periods during which the target is learning about the seriousness of the sender. The target economy adjusts to avoid part of the sanction costs, but adjustment is limited in scope and speed. After t^* periods the target complies.

(iii) Immediate adjustment; adjustment effects dominates learning effect ($T = 0$): $t^* = \infty$; even if the sanction is imposed forever, which is very costly for both the sender and the target, the target will never comply. This requires $E < (y_F - y_N)$.

(iv) Postponed adjustment ($T > 0$): large values of β and S or small values of α and D imply that $(\pi_0 D < (1 - \pi_0)S)$, in which case adjustment is no longer immediate. Three situations can be distinguished. (1) Postponed adjustment before compliance. For the base case this occurs, for example, if *ceteris paribus* $S = 2$. Then the target starts to adjust in period 3 and complies in period 6. (2) Postponed compliance without adjustment. For the base case this occurs, for example, if *ceteris*

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[20] Since the target country is risk neutral, we may use $E(\pi)$ in the *a priori* sense to determine whether or not the country will cooperate in period 0.

[21] Note that Equation (11) covers all cases because $T = 0$ is possible.

paribus $S = 4$. Then the target complies in period 11 (before it starts to adjust the economy which would have taken place in period 12). (3) Postponed adjustment without compliance. For the base case this requires a change in, on the one hand, the adjustable sanction damage and its probability and, on the other hand, the yields E, y_F or y_N.

We define our base case as a hypothetical sanction for which $\alpha = 6$ and $\beta = 6$ (implying $E(\pi_0) = 0.5$), $E = 1.5$, $D = 1.5$, $S = 1$, $y_F = 3$, $y_N = 2$, $\rho = 0.9$ and $\delta = 0.8$. In this case it takes $t^* = 5$ periods before the target complies. Next we investigate how a change in the explanatory variables *ceteris paribus* changes the value of t^*. If, for example, α increases we find that for $\alpha = 9$ (π increases to 0.59) the sanction threat will *ex ante* enforce compliance and so the sanction does not have to be implemented.[22] In contrast, when the gains from exchange decrease to $E = 0.9$ we find that the sanction will never work.

Extensive simulations as illustrated in Table 1 suggest that a sanction will take longer to succeed when α decreases or β increases ($E(\pi)$ decreases), when sanction damage decreases (either E, S or D decreases), when the yield of misconduct increases (either y_F increases or y_N decreases) and when the rate of time preference decreases (ρ increases) or the speed of economic adjustment increases (δ decreases).

Anticipation, learning and adjustment

Now suppose that the target anticipates the imposition of economic sanctions after τ periods, for example because a sanction threat has been expressed and the target knows the time period that in general passes between the decision that sanctions will be implemented and the moment of their actual legal implementation. Figure 5 illustrates what anticipation implies in terms of the trajectories that were introduced in Figure 4.

We can discern several trajectories in Figure 5. A rather uninteresting trajectory is the horizontal line through point e that represents the truly autarkic economy. Such an economy cannot be hit by economic sanctions.[23] The trajectory of the trading economy that does not anticipate a sanction can be represented
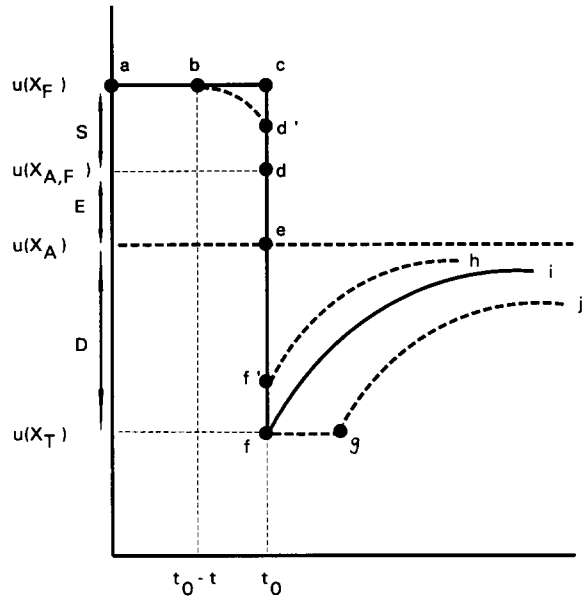

Figure 5. Anticipation of an economic sanction: time path of utility.

by *acfi*, assuming that the economy starts to adjust at time t_0 or by *acfgj*, when it takes some time before economic adjustment to the sanction can start. If the sanction is anticipated by the target then a trajectory *abd'f'h* becomes possible and the target has to balance the costs of anticipation (the area *bcd'*) against the benefit of a reduction of the sanction damage after time t_0 (namely the area befreen *f'h* and *fi*). Note the limit to anticipation as there is no incentive to reduce consumption below $x_{A,F}$ (point d in Figure 5). Note that since actually no sanction is imposed before $t_0 = \tau$, learning does not take place and π is fixed up till the moment of implementation.

We have two situations. The first situation is when $\pi D < (1 - \pi)S$ so that adjustment is not deemed beneficial. This essentially boils down to the situation that was analysed above. The second situation deals with $\pi D \geqslant (1 - \pi)S$. Even if the target *a priori* decides that it will comply, we have a period in which the target persists in its objectionable, but presumably profitable, behaviour. If it maximizes utility it will only comply once the sanctions are actually implemented:

$$PDV(C) = \left\{ \sum_{j=0}^{\tau} \rho^j(y_F + S) \right\} + \left\{ \sum_{j=\tau+1}^{\infty} \rho^j y_N \right\}$$

$$= \frac{(1 - \rho^{\tau+1})(y_F + S) + \rho^{\tau+1} y_N}{1 - \rho} \tag{17}$$

The target always starts adjustment at τ (as this is profitable since $\pi D \geqslant (1 - \pi)S$), but it may start anticipatory adjustment τ^* periods earlier. The delay in

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[22] Note that any π_0 can be obtained with many combinations of α and β. Lower α's and β's imply by Equation (14) large variance and hence more uncertainty. So in our model the learning effect is stronger and sanctions will take longer the less reliable the target considers the information on which it builds its *a priori* beliefs about π.

[23] This does not exclude the possibility that the economy may become the target of an economic sanction. This assumption merely states that the autarkic economy will not change its behaviour if a sanction is imposed. Such sanctions are a curiosity. Tony Lowenberg once pointed out that Canada withdrew South Africa's landing rights although there were no direct flights from South Africa to Canada.

implementation of the sanction gives the target a first mover advantage. Naturally, $\tau^* \leqslant \tau$. The present discounted value of non-compliance at τ^* now becomes:

$$PDV(NC|\tau^*) = \sum_{j=0}^{t-\tau^*} \rho^j(y_F + S)$$

$$+ \sum_{j=\tau-\tau^*+1}^{\tau} \rho^j(y_F \delta^{j-\tau+\tau^*}S)$$

$$+ \sum_{j=\tau+1}^{\infty} \rho^j[y_F - \pi E - \delta^{j-\tau+\tau^*}$$

$$\times [\pi D - (1-\pi)S]] \qquad (18)$$

The first term states that the target does nothing until it anticipates that adjustment becomes beneficial. The period of anticipatory adjustment starts τ^* periods before the actual implementation of the sanctions, as indicated by the second term. Finally, the third term describes adjustment while the sanctions are actually in force. The target's problem in anticipating the sanctions is to choose a value of τ^* that maximizes $PDV(NC|\tau^*)$, ie

$$PDV(NC) = \max(PDV(NC|\tau^*)|\tau^* \in \{0, 1, \ldots, \tau\}) \qquad (19)$$

Rewrite Equation (18) as:

$$PDV(NC|\tau^*) = h_1(y_F, S, E, \rho, \tau, \pi)$$

$$+ \frac{\rho^{\tau+1}}{(1-\rho\delta)} h_2(\tau^*, D, S, \rho, \delta, \pi)$$

with

$$h_1(\bullet) \equiv \frac{y_F + S - \rho^{\tau+1}\pi E}{1-\rho} \qquad (20)$$

$$h_2(\bullet) \equiv \rho^{-\tau^*}\{\delta S[1 - (\rho\delta)^{\tau^*}] - S/\eta\}$$
$$- \delta^{\tau^*+1}[\pi D - (1-\pi)S]$$

Combining Equations (19) and (20), it follows that maximization of $PDV(NC|\tau^*)$ is equivalent to maximization of $h_2(\bullet)$ and independent of y_F, y_N, E and τ (provided the constraint $\tau^* \leqslant \tau$ is not binding). The gains from exchange E can always be reaped as long as the sanctions are not yet imposed so that these gains do not influence the target's decision concerning the moment when it starts its adjustment process. Likewise the yield of misconduct does not influence the questions of why and when to adjust (it does of course influence the decision whether or not to comply). Once the sanction is actually imposed, the analysis proceeds along the lines discussed above.

Table 2. Numerical example of the optimal period of anticipatory adjustment.

	S	r*	ρ	r*	δ	r*	π	r*	D	r*
	2.5	0	0.5	0	0.5	0	0.4	0	0.5	0
	1.5	1	0.8	1	0.7	1	0.5	1	1	1
Base case	1.0	2	0.9	2	0.8	2	0.7	2	2	2
	0.5	3	0.95	2	0.9	3	0.8	2	3	3
	0.4	4	0.97	2	0.95	4	0.9	3	5	4
	0.3	5	0.99	3	0.97	5	0.95	3	7	5

Table 2 illustrates our model numerically. We define a base case for $S = 1$, $\rho = 0.9$, $\delta = 0.8$, $\pi = 0.7$ and $D = 2$. Our model implies that adjustment is optimal if the adjustment process starts two periods before the actual implementation of sanctions. So if the actual implementation is anticipated to be in period 10, the target will not adjust its economy before period 8. If, however, at $t = 0$ the sanctions are anticipated to be implemented in period 1, adjustment is immediate. Next we investigate how changes in the exogenous variables influence the optimal adjustment period. For example, if the gains from specialization increase beyond 2.5 adjustment is immediate, while it is postponed until period 5 if S is set equal to 0.3. The simulations reported in Table 2 show that anticipation is *ceteris paribus* more relevant the slower the speed of adjustment $(1 - \delta)$, the higher the rate of time preference $(1 - \rho)$, the larger the *a priori* probability π, the larger the transitory damage D and the smaller the gains from specialization S. Taking anticipation into account therefore does not alter our results in a substantial way. Obviously, the adjustment effect is more likely to exceed the learning effect so that compliance becomes less likely if sanctions are announced some periods before they are implemented. Sanctions will not achieve compliance more quickly if they are announced earlier. If the time frame is such that the target gets more time than it needs to adjust in an optimal way, no effect will be discernible until the optimal process of adjustment starts.

Summary and conclusions

The generalized history of economic sanctions as an instrument of foreign policy shows that most sanctions take some years to become a success, although in fact some instances of *ex ante* compliance and quite a number of long-lived unsuccessful sanctions exist. Traditional economic analysis of sanctions can only discern sanctions that work *a priori* or that will not work at all. A second feature of the sanction instrument is the uncertainty about its actual imple-

mentation in the (near) future. Hence we argue that theory should take into account the stochastic outcome of situations in which sanctions are threatened or applied. This implies that targets, on the one hand, may need some time to arrive at 'better' (more realistic) estimates of the probability that sanction damage will be delivered in the near future if behaviour persists in misconduct, ie does not conform to the standards set by the sanction sender. On the other hand, a target may anticipate the imposition of a sanction so as to reduce the costs of non-compliance.

We model the decision by the sanction target to comply or to persist as a function of both economic adjustment and Bayesian learning. Our model distinguishes between sanctions that (i) work directly (*ex ante* compliance), (ii) take some time to work and (iii) will never work.[24] Moreover we distinguish between economic adjustment and political compliance. We show that sanctions that do not achieve *ex ante* compliance may still work in the future provided that permanent (unadjustable) sanction damage exceeds the yield of misconduct. Delivering permanent damage increases the probability that the target will comply as the target learns to better understand the sender's determinedness. Taking anticipation into account does not alter our results in a substantial way. Obviously, the adjustment effect is more likely to exceed the learning effect so that compliance becomes less likely if sanctions are announced some periods before they are implemented. Sanctions will not achieve compliance more quickly if they are announced earlier. If the time frame is such that the target gets more time than it needs to adjust in an optimal way, no effect will be discernible until the optimal process of adjustment starts.

An implication of our model is that the actual development of observable variables (such as changes of the economic structure) does not give much information about whether or not the target will actually comply. This result may be of interest to analysts of specific sanctions that are in force. Sanctions which do not work instantaneously (ie there is neither economic adjustment nor political compliance) can work in the long run, but only if learning dominates adjustment. Imposing sanctions for too long may only bring about unnecessary costs for both the sender and the target without increasing the probability of compliance. In general long-lived sanctions can only have some positive utility if (i) the target is very stubborn, dull or disbelieving and (ii) perma-

nent sanction damage is sufficiently large. Otherwise, sanctions should only be implemented for a limited number of years.

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[24] Bonetti [7] recently arrived at similar results on the duration of economic sanctions in a model which studies economic sanctions as an iterated discrete-time war of attrition and uses sunk cost accounting to explain the persistence of sanction episodes.

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