# Hormone beef, chlorinated chicken and international trade*

Giacomo Calzolari† Giovanni Immordino‡

December 11, 2002

**Abstract**

We study international trade in innovative goods subject to uncertain consumer health effects. Such goods are often at the center of international trade disputes. We show that an interesting form of protectionism may arise because of scientific uncertainty. A free-riding effect is identified, implying more conservative behavior by countries. We also study the role of producers (lobbies) in providing valuable information, finding that the innovative lobby has an advantage in providing information as compared with the lobby producing the 'traditional' good. Moreover, lobbies disclose more information when the health effects are long-lasting.

J.E.L. numbers: D8, F1, L1.

Keywords: international trade, lobbies, informational externality, scientific uncertainty, labeling, firm liability.

*The authors gratefully acknowledge the "2000 Young Economist Award" assigned to this paper by the European Economic Association and the numerous suggestions offered by R. Blundell, H. Cremer, J.P. Danthine, H.K. van Dijk, L. Lambertini, M. LiCalzi, A. Lizzeri, T. Persson, P. Picard, R. Repullo, J.C. Rochet, C. Scarpa, J. Tirole, L. White, three anonymous referees and seminar participants at the University of Toulouse, Salerno, Cattolica, Trento, CNR Alghero, Ente L. Einaudi, EEA 2000, EARIE 2000 and 2001 European Winter Meeting of the Econometric Society. The usual disclaimer applies.

†Corresponding Author, University of Bologna, Department of Economics, Piazza Scaravilli 2, 40126 Bologna, Italy; calzolari@economia.unibo.it. Fax [0039]0512098040

‡Fundazione Salernitana Sichelgaita and CSEF University of Salerno, D.S.E. via ponte Don Melillo, 80084, Fisciano (SA), Italy; giimmo@tin.it

# 1 Introduction

Recent history shows that international institutions (GATT and now WTO) proved successful in reducing international trade barriers.[1] Economists' advocacy of free trade may have played some role, but a fundamental ingredient in this success has surely been the improved credibility and enforcement power of international trade institutions. These proved particularly efficient in dismantling traditional trade barriers such as tariffs, duties, subsidies, quotas, voluntary export restraints, etc. In all these cases, the negotiated terms of international agreements are, in a broad sense, observable and known to all the parties, and international institutions can efficiently act as enforcing courts.[2]

However, the credibility and enforcement of international agreements may become an issue when incomplete information plays a role in the terms negotiated. In fact, most actual trade disputes nowadays are linked to informational issues. A striking case is safety standards and product safety regulation.[3] In this respect, GATT already allowed countries to ban imports of goods that were thought to be produced unsafely, provided that the exclusion was based on adequate scientific testing. This observation touches on the point developed in our paper.

When a new product or a cost-saving production process is invented, countries have to decide whether or not to allow its consumption or use. In taking this decision, they try to evaluate expected costs and benefits, but as a rule the effects of innovations on consumers' health are imperfectly known. In most cases, even knowing the set of possible consequences on health (i.e. the states of nature), one still does not generally know their exact probabilities. When deciding to authorize or ban the consumption of genetically modified organisms (GMOs), national authorities try to assess their effects on health and associated risks. However, the knowledge on safeness is normally imperfect. The same applies to new drugs, the meat of animals raised on hormones, chicken carcasses washed with hydrochloric solution to cut costs, and cheese made with non-pasteurized milk.[4] In this respect, scientific uncertainty over innovations differs from risk mainly in the possibility of its diminishing over time, as new information becomes available.

Strikingly, almost all these examples are actually the focus of international trade disputes. The countries whose firms develop the innovation (for example the US) contend that the others ban consumption in order to protect domestic competitors. The banning countries (for example EU) claim their right to decide on domestic consumer safety and to refuse risky products according to the infor-

[1] The "Kennedy round" (1964-67) induced a 30% multilateral cut in tariffs on manufactured goods. The Tokyo Round obtained a further 30% reduction, and the Uruguay Round proceeded in the same direction.

[2] Even if GATT had no legal force, it could realistically count on the voluntary compliance of its members to maintain credibility.

[3] Another is dumping, a perennially hot issue internationally. The difficulty in reaching agreement on dumping stems from the fact that firms' production costs are not perfectly verifiable. Comparison between costs and prices is always somehow arbitrary, so it is hard for countries to agree on definitions, parameters and gauges.

[4] Similarly, during the eighties the possibility that mad cow disease could be transmitted to humans was uncertain. For more details on these and other examples see The Economist, Feb. 5, 2000, Jan. 29, 2000, May 1, 1999, Feb. 20, 1999, Jan. 15, 2000, Jan. 24, 1998, Jun. 13, 1998, Aug 9, 1997.

mation available and national preferences. In these cases the role played by international institutions is quite limited for at least two reasons: first, countries are reluctant to delegate to supra-national authorities decisions on matters characterized by safety uncertainty. Second, scientific uncertainty makes it very complicated to enforce international agreements. As an example, facing the potential, but not proved, risk of negative effects on human beings, the EU decided to prohibit the consumption of beefs raised with hormones. This decision contrasted those safety rules the EU itself contributed to establish within the WTO and shows that scientific uncertainty may weaken international agreements. The consequence of scientific uncertainty is a growing number of bilateral trade disputes.

This paper addresses the case of an innovation in the production process that cuts costs substantially (such as GMOs, hormone treatments of livestock, or chlorine solution to rinse animal carcasses, etc.). In our model (Section 2) there are innovating firms with the rights to the new (potentially unsafe) process and firms employing safe traditional processes. The traditional and innovative goods differ only in the production process, which in the latter case may have altered the characteristics of the product making it a health risk.[5]

Heterogeneity in preferences and information could easily explain any observed difference in countries' decisions. However, such heterogeneity among equally developed countries is hard to justify and to make the analysis non-trivial, we assume it away. If the innovation is accepted in a country, the innovators may be able to drive competitors out of that market. So, in making the decision to accept the innovation, each country evaluates both the expected consumption effects and the repercussions for domestic industries.

We consider two countries. For the sake of concreteness, we assume the innovating firm is located in one and the traditional firm in the other. Countries' decisions naturally affect firms' profit, so it is in the interest of both the innovating and the traditional firm to provide evidence on their own behalf. Even if research on such innovations is performed mostly by firms, nevertheless public research plays also a role. However, here we focus on the informative role of lobbies and leave aside this possibility with no effect on our results. Hence, the two decision-makers update their prior on the new product's effects with the information supplied by firms and decide whether to allow domestic consumption.

Economic and political science literature have recently focused on lobbies' ability to influence decisions, not only by bribing non-benevolent civil servants (as in Grossman and Helpman 1994) but also by using the information they are able to provide (as in Austen-Smith 1993, 1995, 1996, Krishna and Morgan 2001, Potters and Van Winden 1992 and Dewatripont and Tirole 1999). In the first case lobbies (licitly or illicitly) offer the decision makers funds trying to condition the decision process in their favor. Alternatively, lobbies may exploit the private information they have obtained with expertise in their activities. Following this second strand of literature, we assume the only role of lobbies is to provide decision-makers with valuable information relevant to their decisions. We do not

[5]For simplicity, in what follows, we speak indifferently of innovative product or process innovation. What matters is simply that the new and the traditionally produced good are close substitutes except for the possible effect on health.

contend that bribes do not exist or are not effective, but we want to emphasize the informational role of producers' lobbies in cases of scientific uncertainty, as in most of the recent trade disputes. In this context of imperfect information, firms engage their R&D departments in testing the safeness of the innovation. They are thus an important (albeit biased) source of information for countries and we study their incentives to truthfully reveal information in a signalling model with burned money (which in practice may represent various signalling strategies such as advertisement) and costly information acquisition.

By authorizing the innovative good, a country generates freely available information from the observation of consumption effects. The use of past consumption information in actual trade disputes is reported, for example, in several documents of The United States Mission to the European Union (USEU 1999a and 1999b) and of the WTO (WTO 1999). The Food and Drug Administration has monitored the effects of consumption of hormone beefs in US without noticing negative effects on human beings. As a consequence, US authorities maintain that the use of hormones in beef production is safe and the European ban is not justifiable. Similarly, when the spread of "mad cow disease" was observed in the early eighties, there was scientific uncertainty over the possibility of its transmission to human beings. Several national authorities nevertheless decided to allow animal flours in livestock feeds (a product-increasing practice). The consumption of those animals by humans provided empirical evidence of the disease's transmissibility and allowed some governments to ban the importations of meet from countries where the infection proliferated.

Here we show that governments are confronted with a decision problem in which the information flow is both endogenous (it depends on their decisions) and a strategic variable: each country would like the other to allow the good, test it, and provide the safety information. This free-riding effect turns out to be important to the decision-making process; it characterizes the equilibria of governments' decision game (Section 3). As a consequence, we also show that if a supra-national authority could be credibly delegated the decision process, it would accept the innovation more often than the two independent countries, as long as consumer surplus is not of minor importance in the welfare function. The public good nature of information makes scientific uncertainty an informational barrier to trade.

We show that there are equilibria where the innovative lobby always reveals information truthfully (Section 4). We further show that the ability of firms to provide useful information depends on whether the presumed damage to health is long-lasting or short-lived. When the effects are short-lived, it is impossible for both lobbies to credibly signal useful information; only the innovative firm can provide information. When they are long lasting, both lobbies can provide information at once (possibly counteracting one another), and the traditional lobby may produce useful information. Thus, in general, lobbies generate more information when the harmful effects are long-lasting (Section 5).

Section 6 summarizes the results and discusses some extensions. All the proofs are in the Appendix.

## 2 The Model

*Players.* Consider two countries $E$ (for Europe) and $U$ (for the United States) and an industry with two firms (or two groups of firms) that produce a homogeneous good: a *status quo* (or traditional) firm and an *innovator*. For concreteness, we assume that the firms are respectively owned by $E$'s and $U$'s citizens and call them firm $E$ and $U$. The *status quo* production technology is freely available to both, but firm $U$ owns a patent for an innovation allowing for a cost reduction. Firms, indexed by $j \in \{U, E\}$, compete in both markets $i \in \{U, E\}$; consumption takes place in two periods. To simplify the analysis, the markets are assumed to be of equal size. Governments are benevolent decision-makers and in each period maximize a weighted sum of domestic consumers' surplus and domestic firms' profit, respectively carrying weights $1 - \alpha$ and $\alpha$.[6] Finally, Nature decides if the innovative technology is harmful for consumers health (state $-1$) or if it is not (state 1).

*Information.* The state of nature is the realization of a random variable $\omega \in \{-1, 1\}$ distributed according to a Bernoulli distribution with parameter $\theta$, the probability of state 1, unknown to both lobbies and governments. All players share a uniform prior on $\theta$ with support $[0, 1]$ (as in Austen-Smith 1990)[7]. The lobbies are in a better position than the governments to learn whether the technology is harmful or not (see the introduction on this). Lobbies' labs test the effect of the new technology at a fixed cost $c$.[8] Each lobby privately observes an independent random draw from the distribution of $\omega$. Despite their information advantage over governments, the way scientific uncertainty is modelled implies the lobbies are still not fully informed. Performing its experiment, firm $j$ learns information $I^j \in \{-1, 1\}$. Let $p(-1|I)$, $p(1|I)$ denote the probabilities that, knowing information $I$, consumption of the innovative good is and is not harmful.

Hence, in our model nobody knows the true state of nature and lobbies are an important source of information. This modeling option well describes actual scientific uncertainty we address in the paper.

Even if governments could perform experiments, lobbies' information would still remain valuable to decision. Hence, focusing on the informative role of lobbies we assume for simplicity that in deciding whether to allow the innovation, governments cannot run experiments on their own and so must rely

[6] Grossman and Helpman (1994), Feenstra and Lewis (1991) show that $\alpha$ can be affected by lobbies' bribes and use this interpretation for profit weighting in social welfare functions. We do not consider this type of lobbying; we set the weights for profits equal in both countries in order to focus on the informational role of lobbies.

[7] Our assumption on uniform prior distribution has some appeal on grounds of symmetry. A natural generalization for asymmetric prior distributions in our setting is the $Beta(c, d)$ distribution for $\theta$. It is easy to show that the unique effect of asymmetric priors ($c$ and $d$ different from 1) is that they may introduce new fully informative equilibria with long-lasting. Hence, all our results hold.

[8] For most of our discussion this fixed cost is irrelevant. Hence we will proceed as if each lobby already knew the result of its own testing and state expressly when the cost of acquiring information matters. Governments may do not know, contrary to our assumptions, whether lobbies performed the experiment. This interesting possibility is left for future research.

on the information they can infer from the lobbies.[9] The innovation is an experience good (Nelson 1970); after the first consumption uncertainty is completely resolved and all the players learn the true state of the world.[10] The preferences of all players are common knowledge.

*Decision Sequence.* Nature chooses the state of nature and lobbies privately and independently learn the outcome of their experiments. Having observed the realization $I^j$, each firm $j$ "burns" a quantity $M^j$ of money to advertise its private information. Sending the same message to both governments, the firm lobbies for its preferred outcome. Note that with advertising the cost of the message does not depend on type, and the possibility of separating is based on the different amounts of resources held by different types. It is implicitly assumed that both lobbies have enough retained profits to finance their campaigns.[11] Then, in the decision stage, governments simultaneously choose whether to allow the innovation for first-period consumption.

The decision to ban or admit innovative goods is ultimately in the government's hands, and consumers are passive actors. Given a government's decision, consumers treat the two technologies as equal: they are not able to discriminate. These assumptions are justified in our positive analysis by two factual observations. First, as we highlighted in the introduction, the main actors of the current international disputes on risky innovations are national authorities. Therefore, our principal aim is to study the way actual trade disputes are related to governments' decision process. Second, some observers advocate labeling goods and letting consumers choose. As we already emphasized, such an analysis is not the main issue of our study. Certainly, a more comprehensive model could take consumers into account. However, note that the underlying scientific uncertainty makes the decision process a complex one, requiring specific skills to process and acquire the available information. Hence, consumers must bear some non negligible fixed cost to become active players. When the cost is high enough consumers are discouraged from bearing it. This would make labeling less central for our positive analysis.

In the trade game firms compete on both the European and the American markets producing with the allowed technology which they own. When at least one government authorizes the innovative

[9] Public agencies performing experiments are not modeled in the paper but would not alter any of the results. In fact, agencies' experiments would allow to update the probability of a safe innovation, say, into $p'$ and then all the results would go through simply substituting $p$ with $p'$.

[10] Lobbies' private information may be derived from experiments on animals that produce insights vis-à-vis human beings. Actual consumption could be assumed to be just one more experiment and thus only partially informative. The informational role of lobbies would still qualitatively hold, however.

[11] Signalling models of the type we use are common in the literature on political economy (e.g. Gerber 1996 and Pratt 1997) and advertising (e.g. Kihlstrom and Riordan 1984 and Yang 1994). Caswell and Padberg (1996) argue that in food markets, as the one we are considering, competition among the sellers is expressed in the use of advertising rather than pricing. Signalling with prices is not possible in our setting. In fact, lobbies' types only differ in second-period profits (see below) and price-signalling would amount to letting lobbies announce the price they will use in the second period. One would also have to assume that governments have the power to enforce pricing promises. Even if a more complex model may accommodate the use of informative prices, we rely on advertising for the just mentioned reasons and for the sake of simplicity.

good, all the players observe the effects on consumption (true state of nature). On second-period decisions, for concreteness we posit that both countries allow the innovative consumption if it is *proved safe* and ban it otherwise. This is naturally true for country $U$ as, with a safe innovation, it gets both larger consumer surplus and higher profits. If the innovative good is safe, country $E$ prefers the consumption gain from the new technology and is prepared to sacrifice the local lobby's profit, whenever the country attaches a sufficiently greater weight to consumer surplus than to profits. In this case both governments face a trade off between risky consumption and domestic producers' profits.[12] When the innovation is proved to be harmful in first period, both governments of course ban it in the second. Finally, when neither government authorizes the innovative product, consumption provides no information. The timing is summarized in figure 1.

Figure 1 here

*Players' strategies and payoffs.* Let $D = (d^U, d^E)$ denote governments' first-period decisions, with $d^i$ belonging to the set of policies for each government $\{a, b\}$; $d^i = a$ means the new technology is allowed, $d^i = b$ that it is banned. The pair of first-period decisions $D$ takes values in set $\Psi = \{B, BA, A\}$ with $A = (a, a)$ both countries allow the innovation, with $B = (b, b)$ both ban it, and with $BA \in \{(b, a), (a, b)\}$ one bans and the other allows it.

As firms compete in both markets, their profits depend on both governments' decisions. $\Pi_b$ is the profit each firm earns in a single market where the innovative good is banned. $\Pi_a^U \geq (\Pi_b \geq) \, \Pi_a^E$ are respectively firm $U$ and firm $E$ profits earned in a country that allows the innovation. The inequality simply states that the innovators earns more in those markets in which they can sell the cost-saving innovation, while traditional producers earn less where they face competition from innovators.

Firm $j$'s profit, given its private information $I^j$ and given governments' decisions, is $\Pi_D^j\left(I^j\right) - M^j$ where

$$\Pi_D^j\left(I^j\right) = \sum_i \Pi_{d^i}^j + \tilde{\Pi}_D^j\left(I^j\right),$$

and $\tilde{\Pi}_D^j\left(I^j\right)$ is the expected second-period profit. The discount rate is set to zero for simplicity.[13] Note that second-period profits $\tilde{\Pi}_D^j\left(I^j\right)$ depend on the first-period decisions of both countries. In fact, if both ban the product (both set $d^i = b$), there is no updating on health effects and second-period decisions remain unchanged. But if at least one country sets $d^i = a$, the effect of the innovative good is observed and the information disclosed affects second-period decisions.

The welfare of country $i$ knowing information $I$ is

$$W_D^i(I) = \alpha\left[\Pi_D^i(I) - M^i\right] + (1-\alpha)\left[CS_{d^i}(I) + \widetilde{CS}_D^i(I)\right], \tag{1}$$

[12] If this were not so and, for example, countries attached too a small weight to consumer surplus, profits would be all-important, the tradeoff irrelevant, and the whole analysis uninteresting.

[13] It is easily shown that the way governments' decisions are affected by information does not depend on the exact value of the discount factor. All our results holds qualitatively.

where $CS_{d^i}(I)$ and $\widetilde{CS}_D^i(I)$ are respectively the expected values of the first- and second-period consumers' surpluses. When the first-period decision is $b$, then first-period consumption is safe and $CS_b(I) = CS_b$; when it is $a$, then $CS_a(I) = CS_a\ p(1 \mid I)$, with $CS_a \geq CS_b$, because a country ends up with zero consumer surplus even if only a fraction of citizens consumed the harmful good.[14] As with profits, the expected second-period consumer surplus depends on the first-period decisions of both countries, $D$.

If the first-period decision has been to ban the innovation in both countries ($B$), then no new information is available and second period decision remains the same. Firm $j$ produces with the traditional technology for both markets earning profit $\widetilde{\Pi}_B^j(I) = 2\Pi_b$ and consumption is safe $\widetilde{CS}_B(I) = CS_b$. If at least one of the two countries has accepted the innovation ($A$ or $BA$), after the first period consumption all the players learn the true state of the world. When the innovation proves to be safe (with probability $p(1 \mid I)$), both countries accept it, whereas when it proves to be harmful (with probability $p(-1 \mid I)$), they both ban it. Hence, expected second period profits and consumers' surpluses are

$$\widetilde{\Pi}_D^j(I) = 2\Pi_b p(-1 \mid I) + 2\Pi_a^j p(1 \mid I)$$
$$\widetilde{CS}_D^i(I) = CS_b p(-1 \mid I) + CS_a p(1 \mid I).$$

with $D = A$ or $BA$.

It is important to note that each country's welfare depends on both countries' decisions for two reasons: domestic firms' profits, and second-period consumer surplus.

In section 5 we will extend our basic model to consider innovations which may have long-lasting harmful effects: today's consumption of an harmful good affects tomorrow's ability to benefit from consumption.

# 3 Governments' decision and information

Governments $E$ and $U$ observe messages $M = (M^U, M^E)$, which are sent simultaneously by lobbies, and decide their strategy. We will deal with pure strategies both for governments and lobbies.[15] A strategy of government $i$ is thus a function

$$d^i : \Re_+ \times \Re_+ \rightarrow \{b, a\}$$

Governments update their beliefs on the safety of consumption. The updating process will depend on the kind of equilibrium that characterizes the signaling game. If both lobbies play a separating

[14] $CS_i = \int_0^{y(P^*)} P(u)\,du - P[y(P^*)]\,y(P^*)$, where $y(.)$ and $P(.)$ are respectively the demand and the inverse demand functions, and $P_i^*$ is the equilibrium price with $d^i$. The cost-saving technology implies $P_a^* \leq P_b^*$, hence $CS_a \geq CS_b$. Note that if $CS_b > CS_a$ and $\Pi_b > \Pi_a$, Europe will always ban the new good. Finally, the normalization to zero of the consumer surplus of an harmful innovation has no consequences for the results. It can be interpreted as stemming from a strong negative externality affecting all consumers (policy-makers know that if even a tiny number of consumers are harmed, their popularity among the rest of the citizenry will plummet).

[15] Restricting lobbies strategies to be pure does not entail any loss of generality.

strategy ($M^j\left(I^j\right) \neq M^j\left(\hat{I}^j\right)$, $I^j \neq \hat{I}^j$, for $j = E, U$), we say that the equilibrium is *fully informative.* In this case, governments obtain both lobbies' information. If one lobby plays a separating strategy and the other a pooling strategy, we say the equilibrium is *partially informative.* Governments update their beliefs using only one lobby's information. Finally, when both lobbies play a pooling strategy ($M^j\left(I^j\right) = M^j\left(\hat{I}^j\right)$, $I^j \neq \hat{I}^j$, for $j = E, U$), we say the equilibrium is *uninformative*, and governments will be unable to update their beliefs.

Therefore, the kind of signaling game equilibrium and messages determine the information $I$ that governments can obtain on the experimental results, where $I \in \{-2, -1, 0, 1, 2\}$. For example when a fully informative equilibrium prevails, countries may learn information in $\{-2, 0, 2\}$ depending on lobby types and messages. When the information learned is $I = (-1, 1)$ or $I = (1, -1)$, the uniform distribution of $\theta$ implies that governments remain with their same priors as when they learn no information at all ($I = 0$). However, when the data of the two lobbies coincide, they are summed (cases $-2, 2$). Information $I+k$, $k \geq 0$, provides more favorable evidence for the safety of the innovation than information $I$; in other terms, $p(1|I+k) \geq p(1|I)$.

We will take as given the information $I$ generated by lobbies in the signaling game, so that we will be able to analyze governments' decision process independently of the signalling strategies of lobbies. $W_D^i(I)$ denotes country $i$'s expected welfare and $D(I)$ the vector of decisions for a given information $I$. The normal form of the governments' decision game is represented in the following table.

Table 1 here

Studying governments' decisions gives rise to the following proposition:

**Proposition 1** *In the space of the relevant parameters,* $(\alpha, p(1|I)) \in [0,1]^2$, *there exist four non-empty regions with corresponding decisions: (i)* $(b,b)$; *(ii)* $\{(a,b),(b,a)\}$; *(iii)* $(a,b)$; *(iv)* $(a,a)$. *If at least one country admits the innovation, it is impossible that both countries ban the good given more favorable (to the innovation) information. If both countries admit the innovation given a certain information they also admit it for more favorable information.*

First, the proposition shows that multiple equilibria exist only when the parameters are such that $(b,a)$ is an equilibrium. To understand the second part of the proposition, notice first that information more favorable to the innovative technology always increases the expected consumers' surplus for both countries. In fact, this consists of terms $CS_a$ weighted by $p(1|I)$ and terms $CS_b$ weighted either by 1 or by $1 - p(1|I)$. Thus, since $CS_a > CS_b$, greater reliability for the innovative technology (i.e. $I + k \geq I$ with $k \geq 0$ and hence $p(1|I+k) \geq p(1|I)$) is good news for both countries with respect to consumer surpluses. Second, considering profits, country $U$ owns the innovative firm and experiments more favorable to the new technology are always good news for it. Country $E$, with the competing *status quo* firm, finds that experiments favorable to the innovative technology are bad news for profits. But, as $E$ is ready to accept a safe innovation, greater demonstrated reliability makes it more inclined to accept the innovation.

The results of proposition 1 are summarized in the $(\alpha, p(1|I))$ space by the figure below.[16]

Figure 2 here

The threshold $\alpha^i_{d^{i'}}$ in Figure 2 indicates the loci $(\alpha, p(1|I))$ such that country $i$ is indifferent between accepting or banning the innovation, given that country $i'$ takes a decision $d^{i'}$ with $i \neq i'$. For $\alpha$ *larger* than $\alpha^E_{d^U}$ and any decision $d^U$ country $U$ may take, country $E$ bans the innovation. In fact, a larger $\alpha$ gives more weight to profits and pushes $E$ to protect the domestic industry (i.e. to ban the innovation). On the contrary, for $\alpha$ smaller than $\alpha^U_{d^E}$ and any decision $d^E$ country $E$ may take, country $U$ bans the innovation.

The space $(\alpha, p(1|I))$ is then partitioned into four areas characterized by different decisions. For example, in area $(b, b)$ the probability of a safe innovation is small and, for sufficiently low $\alpha$, country $U$ is induced to ban the innovation too. A similar reasoning can be applied to areas $(a, b)$ and $(a, a)$. The last zone $\{(a, b), (b, a)\}$ identifies pairs of $\alpha$ and $p(1|I)$ such that multiple equilibria exist with the two countries taking opposite decisions.

By authorizing the innovative product, a country generates freely available information deriving from consumption itself. Thus, governments are confronted with a decision-making problem in which the *information* flow is *endogenous* (it depends on decisions) and is a *strategic* variable: each country would like the other to allow the good, test it and provide the information. Dealing with these two aspects, Proposition 1 reveals some unexpected decision-maker behavior. In fact, it is possible that decisions are $D^*(I) = (a, b)$, and the equilibrium decisions that prevail with more favorable information become $D^*(I + k) = (b, a)$. Similarly, it may be $D^*(I) = (b, a)$ and $D^*(I + k) = (a, b)$. In both cases, the decisions reverse, moving in directions opposite to those expected. The explanation for these two phenomena hinges on free-riding in information acquisition, which is summarized in the following corollary.

**Corollary 1** *A country accepting the innovation for a given information may free-ride in information acquisition and ban the innovative good for more favorable information.*

Consider first decision $D^*(I_j) = (a, b)$, which confirms what one should expect. Being biased in favor of the new technology (to help local industry), country $U$ accepts the new good, whereas, with its bias towards the traditional, $E$ bans it. An increase in safety may move country $E$ to accept the new good, but in this way country $E$ provides free new information on the innovative good, so $U$ may decide to wait for the arrival of the information and temporarily suspend authorization $(D^*(I + k) = (b, a)$

[16]The details for the different cases can be found in the proof of the proposition.

prevails). Similarly it may happen that decision $D^*(I) = (b, a)$ is transformed into $D^*(I + k) = (a, b)$. Moreover, notice that equilibrium decisions $D^* = (b, a)$ can be thought of as unexpected, in that $E$ accepts the good while $U$, more innovation-prone, bans it. This equilibrium can be explained by analogous reasoning: when country $U$ decides not to allow the innovative good, country $E$ may opt for its consumption in order to generate new information.

Note that free-riding relies on small changes in the available information. In fact, when information is abundant enough (i.e. there is "small" scientific uncertainty), then each country decides regardless of the other's decision.

The behavior described in Corollary 1 does not rely on the fact that countries have different preferences. In fact, as we have shown, it also holds when $\alpha = 0$. This result may suggest the reason why two developed countries (with similar preferences and available information) such as the USA and Europe may take different decisions on the GMOs' debate. One could interpret this result saying that scientific uncertainty turns out to be an informational barrier to trade. Protectionism may arise because of the uncertainty related to new goods, and governments will ban consumption more often when more information is expected from their counterparts in the future.

### 3.1 The role of a supra-national authority

If countries could credibly delegate the decision process, how would a supra-national authority decide? Before turning to the informative role of lobbies, we compare the two countries' decisions with those of a single and supra-national authority like the WTO.

Assume the supra-national authority equally values national welfares in (1) and can decide either to ban or admit the good everywhere (respectively decisions $B$ or $A$) or admit in one country and ban in the other one (decision $BA$).[17]

Let us discuss first the case where no weight is given to profits ($\alpha = 0$). Two interesting effects are at play inducing the supra-national authority to accept more often the innovation. First, the choice among decisions $(b, b)$ and $(a, a)$ is driven by the same condition employed by a decision maker on a single market who compares decisions $b$ and $a$ (i.e. $b$ is preferred to $a$ iff $p(1|I) \leq CS_b/(2CS_a - CS_b)$). As a single decision maker, the supra-national authority can count only on its own consumption decisions to obtain new information and, consequently, will be more ready to admit the innovation. Second, consider two independent governments where one of the two has decided to ban. The other's decision will be driven by comparing the (sure) payoff of decision $b$, $CS_b$, with the (expected) payoff of $a$

$$p(1|I)CS_a + p(1|I)\left(CS_a - CS_b\right), \tag{2}$$

[17]With a restricted decision set $\{A, B\} \subset \{A, BA, B\}$ for the sovra-national authority, our results still qualitatively hold, as we show in the proof. However, this restriction may seem exogenously affecting the comparison with the two governments' case. Hence, we also allow decision $BA$ even if its political feasibility may do not go unquestioned in the context of the WTO, as the consuming country is effectively testing the innovation also for the other one.

where the second term shows that if the innovation is safe, it will be profitably consumed also in the second period with a gain $CS_a - CS_b$. Now, compare with the supra-national authority who has decided to ban the innovation in one national market. A ban in the other market surely gives $CS_b$ in that market as with the two independent governments. On the contrary, if the innovation is admitted and proves to be safe, the supra-national authority can profit of second period gains on two markets instead of a single one. It internalizes the future benefits of a safe innovation in all the markets and, *ceteris paribus*, will accept the innovation more often than the two governments.

Both these two effects hinge on the *informational externality* at work with two independent governments and form the basis of the free riding effect.

When the profit weight $\alpha$ increases, a third effect operates possibly counteracting with the previous two. As for the trade off between consumer surplus and profits, the supra-national authority employs "mean" preferences with respect to governments in country $U$ and $E$. Hence, a part from the informational externality, it tends to ban the innovation more often than country $U$ and less often than country $E$. For $\alpha$ sufficiently large, the government of country $U$ "sacrifices" consumer surplus to profits and accepts the innovation for any $p(1|I) \geq 0$, any decision of country $E$ and independently of the free riding effect. This may not be the case for the supra-national authority employing less extreme preferences. If the probability of a safe innovation is low then it would still prefer to ban the innovation in both countries. On the contrary, if the innovation is almost sure, having the supra-national authority less extreme preference than country $E$, either decisions coincide or the supra-national authority accepts the innovation more often than country $E$. Finally, for intermediate values of $p$, the effects compensate and decisions coincide.

**Proposition 2** *It always exists a* $\hat{\alpha} \in (0,1)$ *such that for* $\alpha \leq \hat{\alpha}$ *a supra-national authority does not accept the innovation less often than two independent governments. For* $\alpha > \hat{\alpha}$*, it does not accept less (more) often if* $p(1|I) > \hat{p}_2$ *(*$p(1|I) < \hat{p}_1$*) and equally decides if* $p(1|I) \in [\hat{p}_1, \hat{p}_2]$.

Proposition 2 compares the cooperative outcome for two countries delegating their decisions to a supra-national authority like the WTO with the independent decisions case. If profits are given small relevance in the decision process, the free riding effect prevails and the two countries inefficiently ban the innovation too often reducing aggregate social welfare. On the contrary, when profits are important, decisions may diverge with delegation simply because the supra-national authority employs less extreme preferences than national authorities.

# 4 The informative role of producer lobbies

Lobbies send signals simultaneously, so when a lobby sends a message, it does not know the type and message of other lobby . Moreover, governments receive the two messages simultaneously. The strategy of the lobby $j$ is the mapping

$$M^j : \{-1, 1\} \rightarrow \Re_+$$

For example, $M^U(1)$ is the advertising of lobby $U$, having observed an experiment $I^U = 1$.

The equilibrium concept for the signaling game is *prefect Bayesian equilibrium (PBE)*. Thus, a set of strategies $(d^{*E}, d^{*U}, M^{*E}, M^{*U})$ and a set of beliefs $\lambda(I \mid M)$ form a PBE if: (1) each agent undertakes an (expected) utility-maximizing action conditional on the others' behavior and his own beliefs; (2) beliefs are derived from Bayes' Rule when defined. A formal definition is given in the Appendix.

We limit our analysis to *fully informative* and *partially informative* equilibria, not explicitly treating uninformative ones. To simplify notation we indicate with $\{D^*(-2), D^*(0), D^*(2)\}$ and $\{D^*(-1), D^*(1)\}$ the decisions in fully and partially informative equilibria respectively, for the corresponding information available.

Proposition 1 shows that *a priori* we cannot rule out multiple equilibria in the governments' decision game, so to study the advertising behavior of lobbies one should determine which equilibrium decisions the lobbies think will prevail. However, multiplicity of equilibria only exists with equilibrium decisions $(b, a)$ and $(a, b)$, which are payoff-equivalent for the lobbies. Accordingly, lobbies play the same strategies no matter what equilibrium decisions prevail. Hence, we refer loosely to payoff-equivalent equilibria (for the senders) as the same equilibria.[18]

In addressing advertising behavior there are two main points to be noted. First, the cost of the message (i.e. of advertising) does not depend on the lobby's information (or type). Second, lobby $E$ prefers banning decisions for the innovative good, while lobby $U$ prefers authorization. Consequently, lobby $E$ would always claim to have observed a bad experimental result (i.e. to be a type $I^E = -1$) and lobby $U$ a good one (i.e. $I^U = 1$). Hence, in principle the information provided by lobbies is biased, but under some circumstances it can nevertheless be useful to governments.

We denote with $\bar{M}^E$ the gain of type $-1$ from making governments believe that the true type is $-1$ and not 1. Similarly, $\underline{M}^E$ is the gain of type 1 from making governments believe again that the true type is $-1$ and not 1. The type $-1$ lobby will be able to separate itself from type 1 if $\bar{M}^E > \underline{M}^E$. In fact, only in this case can type $-1$ set an advertising level $\bar{M}^E > M^* > \underline{M}^E$ such that type 1 does not find it profitable to mimic this advertising (its net gain from mimicking would be $\underline{M}^E - M^* < 0$) and such that the type $-1$ himself gains more than the advertising expenses (net gain $\bar{M}^E - M^* > 0$). Inverting types, the same reasoning can be followed for lobby $U$. The variable $\bar{M}^U$ ($\underline{M}^U$) is the gain of type 1 ($-1$) from making governments believe that the true type is 1 and not $-1$. Hence, when $\bar{M}^E - \underline{M}^E > 0$ and/or $\bar{M}^U - \underline{M}^U > 0$, lobbies are in a position to provide information useful to the government decision.

Now we analyze information revelation by lobbies, studying how $\bar{M}^E - \underline{M}^E$ and $\bar{M}^U - \underline{M}^U$ vary

[18] For example, when we say that a partially informative equilibrium arises when governments'decisions are $\{(b, b), (a, b)\}$, we leave aside the companion equilibrium $\{(b, b), (b, a)\}$, which also exists.

with countries' decisions and with the kind of equilibrium (fully or partially informative). The aim of the analysis on the informational role of lobbies is to verify whether lobbies may provide valuable information (possibly at once), for any decision countries may take given the available information.

**Proposition 3** *(i) There is no fully informative equilibria; (ii) there are partially informative equilibria where lobby $U$ separates while lobby $E$ pools.*

Notice the advantage in transmitting information of the innovative lobby as compared with the traditional one. A consequence of this advantage is that one should not expect to observe the traditional lobby spending resources in lobbying activities. To better understand this proposition, first note that the differences between gains $\bar{M}^E - \underline{M}^E$ and $\bar{M}^U - \underline{M}^U$ are identical except for the indexes used for the profit functions.[19] Consider first partially informative equilibria and lobby $U$. The gain $\bar{M}^U$ of type $I^U = 1$ for convincing governments that his type is indeed $I^U = 1$ and not $-1$ is

$$\begin{aligned} \bar{M}^U = \;& \Pi^U_{D(1)} + \Pi^U_{D(1),1} p(1|1) + \Pi^U_{D(1),-1} p(-1|1) + \\ & -\Pi^U_{D(-1)} - \Pi^U_{D(-1),1} p(1|1) - \Pi^U_{D(-1),-1} p(-1|1) \end{aligned}$$

and

$$\begin{aligned} \underline{M}^U = \;& \Pi^U_{D(1)} + \Pi^U_{D(1),1} p(1|-1) + \Pi^U_{D(1),-1} p(-1|-1) + \\ & -\Pi^U_{D(-1)} - \Pi^U_{D(-1),1} p(1|-1) - \Pi^U_{D(-1),-1} p(-1|-1) \end{aligned}$$

where $\Pi^U_{D,1}$ is the second-period profit for the two markets when the first-period decision is $D$ *and* consumption has shown that the innovative good is safe, whereas $\Pi^U_{D,-1}$ when consumption is harmful.[20] Hence, the possibility for both lobbies of credibly signaling depends only on second-period profits and not on first-period profits. In fact,

$$\bar{M}^j - \underline{M}^j = [p(1|1) - p(1|-1)] \left[ \Pi^j_{D(1),1} - \Pi^j_{D(-1),1} \right]$$

where the first bracket is strictly positive and the second is either positive (when $D(-1)$ is $B$) or zero (when $D(-1)$ is $BA$ or $A$). Thus, either the willing-to-separate type (of both lobbies) gains exactly the same amount as the willing-to-imitate type ($\bar{M}^j - \underline{M}^j = 0$), and the cost $c$ makes it unprofitable to perform experiments, or else they gain more in case of lobby $U$ and less in case of lobby $E$. Hence, lobby $U$ may be able to separate and provide information, whereas lobby $E$ never does.

To better understand why lobby $E$ is never in a position to provide valuable information to governments, notice that the expected second-period gain for the willing-to-separate type (i.e. $I^E = -1$) is $p(1|-1) \left[ \Pi^E_{D(-1),1} - \Pi^E_{D(1),1} \right]$ ($> 0$), while the corresponding gain of the willing-to-imitate

[19] The reason is that it is type $-1$ of lobby $E$ and type 1 of lobby $U$ that want to separate. Moreover, the gain of lobby $I^U = 1$ from convincing governments that its experiment resulted in $I^U = 1$ is equal (except for the indexes on profits) to the loss incurred by lobby $I^E = 1$ from failing to convince the governments that his experiment showed an unsafe innovation. With a slight abuse of notation we can thus write $\underline{M}^U = -\bar{M}^E$ and $\bar{M}^U = -\underline{M}^E$.

[20] Note that $\Pi^U_{B,1} = 2\Pi^U_b$ because no country experienced the innovation and for any other first-period decision $D$, $\Pi^U_{D,1} = 2\Pi^U_a$. The expected second-period gains are nil when the innovation proves to be harmful in the first period.

type (i.e. $I^E = 1$) is $p(1|1)\left[\Pi^E_{D(-1),1} - \Pi^E_{D(1),1}\right]$ ($> 0$), which is larger than the foregoing because $p(1|1) > p(1|-1)$. Type $I^E = 1$ has observed a bad result of the experiment (for him, the innovation is likely to be safe). He knows then it is more probable that, if consumption of the innovation is allowed somewhere in the first period, it will prove to be safe and the second-period decisions will be to admit the innovation in all markets. The probability of this event is greater for a type $I^E = 1$ than for a type $I^E = -1$ and the gain obtainable from convincing governments that the experiment led to result $-1$ is greater for type $I^E = 1$ than for type $I^E = -1$. Naturally, the opposite holds for lobby $U$.

Consider now fully informative equilibria. They do not exist because whenever the two lobbies try to advertise in order to convince governments, their information revelation turns out to have no effect on countries' updating of consumer safety data. In fact, when lobbies $E$ and $U$ respectively signal types $-1$ and 1, countries remain with their original *a priori* views and lobbies' activities *counteract* one another. Formally, this is shown by observing that whenever $\bar{M}^j - \underline{M}^j$ is (strictly) positive or negative one of the two lobbies cannot separate and when it is zero the cost $c$ of performing experiments makes it unprofitable to test the innovative good, and lobbies will then have nothing to signal.

The results of this section have emphasized the informative role of lobbies in case of scientific uncertainty. We have shown that the innovative lobby can be indeed an important source of information, whereas this is never the case for the one producing the traditional good. This result is consistent with some observed activities of firms dealing with genetically modified organisms. In fact, unlikely to traditional firms, several biotech firms spend huge amount of resources in advertising campaigns and similar activities in promoting their products safety.[21] Moreover, Proposition 3 also holds with a supra-national authority. As Proposition 2 shows, decisions do not necessarily coincide with two governments and a supra-national authority. However, lobbies' incentives in providing information are uniquely derived by the possibility to modify the decision in a market and lobbies do not care whether this decision is taken by one or two authorities.

In the next section we further develop this analysis by considering long-lasting harmful effects. This will prove relevant as we have shown that lobbies' ability to provide information (also) relies on profits earned in the second period and on markets at that time.

# 5 Long-lasting harmful effects

In the previous sections an harmful innovation had no effect on second period payoffs (short-lived effects). However, the underlying uncertainty may also relate to the persistence of damages of harmful innovation and in some cases the diseases induced by a dangerous innovation may have long-lasting effects. Comparing short-lived and long-lasting effects is both relevant from a factual and theoretical point of view. In our simple two periods model this can be analyzed by considering damages which

[21] For example, in June 1998 Monsanto launched a £1 million, 3 month advertising campaign in the UK and France to 'encourage a positive understanding of food biotechnology'. Moreover, this firm finances several educational web sites on biotechnologies.

also affects tomorrow's consumption.

When the damages are long lasting, we assume that not only first period consumers' surplus is zero, but also in the second period consumers cannot benefit from consumption and both profits and consumers' surplus are zero.[22] With respect to short-lived payoffs, the terms relating to an harmful innovation (i.e. those multiplied by $p\,(-1 \mid I)$) vanish and second period payoffs are:

| | |
|---|---|
| $\widetilde{\Pi}^j_B(I) = 2\Pi_b$ | $\widetilde{CS}_B\,(I) = CS_b$ |
| $\widetilde{\Pi}^j_{BA}(I) = \Pi_b p\,(-1 \mid I) + 2\Pi^j_a p\,(1 \mid I)$ | $\widetilde{CS}^i_{BA}\,(I) = \begin{cases} d^i = a: & CS_a p\,(1 \mid I) \\ d^i = b: & CS_b p\,(-1 \mid I) + CS_a p\,(1 \mid I) \end{cases}$ |
| $\widetilde{\Pi}^j_A(I) = 2\Pi^j_a p\,(1 \mid I)$ | $\widetilde{CS}^i_A\,(I) = CS_a p\,(1 \mid I)$ |

Clearly, the comparative statics of decisions with respect to parameters $\alpha$, $p(1|I)$ is affected in the two cases, as the following proposition shows. However, all our results in section 3 concerning countries' decisions hold (see the proof of proposition 1), as well as those on the supra-national decision maker (see the proof of proposition 2). Concerning countries' decisions, the following proposition naturally holds, also for a supra-national authority.

**Proposition 4** *With long–lasting effects either the two countries ban the innovation more often than they would do with short-lived, or decisions coincide in the two cases.*

As for lobbying activity, with long-lasting, when the innovative good is consumed in a country and proves to be harmful, the second-period profit of lobbies in that country are always zero. This means that when first-period decisions are $BA$ or $A$, expected second-period profits are no longer equal and, similarly, when the innovation proves to be harmful, the second-period profits do depend on the decisions taken in the first period. This happens because in the country that allowed the innovation there is no second-period consumption and the profit is zero, while in the country that did not allow it, the profit is $\Pi_b$. From the foregoing it follows that the payoff' structure is less symmetrical and more complex than with short-lived. The following proposition summarizes the cases in which information revelation by lobbies occurs.

**Proposition 5** *With long-lasting effects, (i) there exist fully informative equilibria; (ii) there exist partially informative equilibria in which both lobbies may separate.*

Obviously, the symmetry between $\bar{M}^E - \underline{M}^E$ and $\bar{M}^U - \underline{M}^U$ also holds with long-lasting effects. Considering partially informative equilibria, let us highlight two main effects. First, with long-lasting both types of lobby $U$ gain less from making countries believe they are type 1 instead of type $-1$. In fact, when the innovation proves to be harmful, second period profits are lost. However, as

[22]The main results in this section would qualitatively hold also with a less extreme assumption on the negative second period effects of a harmful innovation.

$p(-1|1) < p(-1|-1)$, the willing-to-separate type ($I^U = 1$) loses less than the willing-to-imitate one, by comparison with the short-lived case. Hence, $\bar{M}^U - \underline{M}^U$ increases with respect to short-lived (where this difference was either zero or positive), this means that lobby $U$ is able to provide information more often.

Second, both types of lobby $E$ gain more from making countries believe they are type $-1$ instead of type 1. The damages of an harmful innovation shuts down second period markets for the traditional technology too. Moreover, the willing-to-separate type ($I^E = -1$) gains more than the willing-to-imitate one. Consequently, $\bar{M}^E - \underline{M}^E$ increases with respect to short-lived (where this difference was either zero or negative). This means that lobby $E$ may now able to provide information, when $\bar{M}^E - \underline{M}^E$ becomes positive.

A similar reasoning applies with fully informative equilibria.

The persistence of negative effects with long-lasting effects increases the incentives for both lobbies to separate and provide useful information, which explains why in Proposition 5 fully informative equilibria may arise and why in partially informative equilibria lobby $E$ too may provide useful information.

The following Corollary summarizes the difference between short-lived and long-lasting effects.

**Corollary 2** *When consumption effects are long-lasting, lobbies are more useful in generating valuable information for countries' decisions than with short-lived effects.*

The previous results show that the ability of firms to provide useful information depends on whether the presumed damage to health is long-lasting or short-lived. Contrary to short-lived, when the effects are long-lasting, both lobbies can provide information at once (possibly counteracting one another), and the traditional lobby (alone) may produce useful information. Thus, in general, lobbies generate more information when the harmful effects are long-lasting.

## 6 Conclusion and extensions

We have argued that most actual trade disputes today are linked to informational issues. When a new product or process is launched, countries have to decide whether to allow its consumption. This decision may be particularly difficult if there are doubts as to the safety of the new product. This happens for genetically modified plants, for the meat of animals grown with hormones, for chicken carcasses washed with chlorinated solution, etc. It is a striking fact that most of these cases at the center of international trade disputes are characterized by a lack of definitive scientific testing.

We identify a free-riding effect in government decision-making. By allowing the innovative good a country gets new information generated by observation of the effects. Once produced, the information is freely available, so each country would prefer for the other to allow the good, test it and make the results public. Hence, the public good nature of information makes scientific uncertainty an informational barrier to trade.

We characterize the Perfect Bayesian Equilibria of the signalling game where the producing firms lobby national authorities providing information. In particular, we show that there are equilibria where the lobby of the innovative country always reveals information truthfully.

The ability of firms to provide useful information depends on whether the presumed damage to health is long-lasting or short-lived. We show that lobbies generate more information when the harmful effects are long-lasting.

Some observers advocate labeling goods and letting consumers choose, without governments participating in the decision process (a position often taken by US authorities in disputes with the EU). An interesting extension of our model could take consumers into account. This is the subject of ongoing research as well as motivating lobbies to perform experiments and acquire costly information is indeed an interesting topic. A policy which may be effective with this respect is damage liability. When the innovative firm is made liable for damages to consumers, liability may tend to increase the amount of information that the innovative lobby provides, also affecting the incentives of the producers' lobby of the traditional good.

## References


[1] Anderson, K. and C.P. Nielsen, 2000, GMOs, foods safety and the environment: what role for trade policy and the WTO?, CIES policy discussion paper 0034.

[2] Austen-Smith, D. 1990, Information Transmission in Debate, American Journal of Political Science 34 (1), 124-152.

[3] Austen-Smith, D. 1993, Interested Experts and Policy Advice: Multiple Referrals under Open Rule, Games and Economic Behavior 5, 3-43.

[4] Austen-Smith, D. 1995, Campaign Contribution and Access, American Political Science Review 89, 3, 566-581.

[5] Austen-Smith, D. 1996, Endogenous Informational Lobbying, mimeo, Department of Political Science Northwestern University.

[6] Caswell, J.A. and D.I. Padberg, 1992, Toward a more comprehensive theory of food labels, American Journal of Agricultural Economics 74, 460-68.

[7] Dewatripont M. and J. Tirole, 1999, Advocates, Journal of Political Economy 107, 1-39.

[8] Feenstra, R. and T. Lewis, 1991, Negotiated trade restrictions with private political pressure, Quarterly Journal of Economics, 56, 1287-1307.

[9] Fudenberg, D. and J. Tirole, 1991a, Game Theory, Cambridge, Mass.: MIT Press.

[10] Fudenberg, D. and J. Tirole, 1991b, Perfect Bayesian equilibrium and sequential equilibrium, Journal of Economic Theory, 53, 236-260.

[11] Gerber, A. 1996, Rational voters, candidate spending and incomplete information: a theoretical analysis with implication for campaign finance reform, mimeo.

[12] Grossman, G. and E. Helpman, 1994, Protection for sale, American Economic Review, 84, 833-850.

[13] Kihlstrom, R.E. and M.H. Riordan, 1984, Advertising as a signal, Journal of Political Economy 92, 427-450.

[14] Krishna, V. and J. Morgan, 2001, A Model of expertise, Quarterly Journal of Economics, 116, 2, 747-775

[15] Nelson, P. 1970, Information and consumer behavior, Journal of Political Economy, 78, 311-29.

[16] Pratt, A. 1997, Campaign advertising and voter welfare, working paper of the Department of Econometrics, Tilburg University.

[17] Potters, J., and F. Van Winden, 1992, Lobbying and Asymmetric Information, Public Choice, 74, 269-292.

[18] USEU, 1999a, A Primer on Beef Hormones, available at http://www.useu.be/issues/BeefPrimer022699.html

[19] USEU, 1999b, The ban on U.S. beef: what are the real issues? available at http://www.useu.be/issues/hormone0608.html

[20] WTO, 1999, Dispute settlement: Measures Concerning Meat and Meat Products (Hormones), available at http://www.wto.org/wto/english/tratop_e/dispu_e/distabase_wto_members2_e.htm

[21] Yang, B.Z., 1994, Simultaneous advertising as a signal of product quality, Australian Economic Papers, 186-199.

# 7 Appendix

**Definition of Perfect Bayesian Equilibrium**

A list of strategies $(d^{*E}, d^{*U}, M^{*E}, M^{*U})$ and a set of beliefs $\lambda(I \mid M)$ constitute an (pure strategy) Perfect Bayesian Equilibrium if:

(C1) $\forall j \in \{E, U\}, \forall I^j \in \{-1, 1\}, \ M^{*\,j} \in \arg\max_{M^j} E_{I\text{-}j} U^j \left(d^{*E}, d^{*U}, M^j, I^j, I^{\text{-}j}\right)$

where $E_{I\text{-}j} U^j \left(d^{*E}, d^{*U}, M^j, I^j, I^{\text{-}j}\right) = \sum_{I\text{-}j} p\left(I^{\text{-}j} \mid I^j\right) \Pi_D^j \left(M^j, I\right)$ and the index $\text{-}j$ stands for the other lobby;

(C2) $\forall i \in \{E, U\}, \forall M, \ d^{*i} \in \arg\max_{d^i} U^i \left(\lambda, d^{*\text{-}i}, M, d^i\right)$

where $U^i \left(\lambda, d^{*\text{-}i}, M, d^i\right) = \sum_I \lambda(I \mid M) W_{d^i d^{*\text{-}i}} \left(M^i, I\right)$, and index $\text{-}i$ stands for the other country;

(C3) beliefs are derived from strategies and priors using Bayes Rule, when this is defined.

**Calculation of probabilities**

We now show how to calculate the interim probability of a safe innovative good for a given vector of lobbies' types $(I)$ or information $(I)$. $p(1|I) = \int_0^1 \theta f(\theta|I) d\theta$ where $\theta$ is the unknown probability of state 1 and $f(\theta|I)$ is its conditional distribution. We have $f(\theta|I) = h(I|\theta)g(\theta)/h(I)$ where $g(.)$ is the common knowledge prior on $\theta$, $h(I|\theta)$ is the probability that given a certain $\theta$ the experiments yield to result $I$ and $h(I) = \int_0^1 h(I|\theta)g(\theta)d\theta$. Thus we can write,

$$p(1|I) = \frac{\int_0^1 \theta h(I|\theta)g(\theta)d\theta}{\int_0^1 h(I|\theta)g(\theta)d\theta}$$

The prior is a uniform on [0,1], then $g(\theta) = 1$. When $I = (1, 1)$, then $h(I|\theta) = \theta^2$ and $p(1|I) = \frac{\int_0^1 \theta^3 d\theta}{\int_0^1 \theta^2 d\theta} = \frac{3}{4}$, when $I = (-1, 1)$ or $(1, -1)$ then $h(I|\theta) = \theta(1-\theta)$ and $p(1|I) = \frac{\int_0^1 \theta^2(1-\theta)d\theta}{\int_0^1 \theta(1-\theta)d\theta} = \frac{1}{2}$, when $I = (-1, -1)$ then $h(I|\theta) = (1-\theta)^2$ and $p(1|I) = \frac{\int_0^1 \theta(1-\theta)^2 d\theta}{\int_0^1 (1-\theta)^2 d\theta} = \frac{1}{4}$. Finally, when $I = 1$ then $p(1|I) = \frac{\int_0^1 \theta^2 d\theta}{\int_0^1 \theta d\theta} = \frac{2}{3}$, when $I = -1$ then $p(1|I) = \frac{\int_0^1 \theta(1-\theta)d\theta}{\int_0^1 (1-\theta)d\theta} = \frac{1}{3}$.

In the general case of a prior distributing according to a $Beta(a, b)$ we have $g(\theta) = (\theta^{a-1}(1\text{-}\theta)^{b-1})/Beta(a, b)$ and then $p(1|01) = p(1|10) = (1 + a)/(2 + a + b)$, $p(1|00) = a/(2 + a + b)$, $p(1|1) = (1 + a)/(1 + a + b)$, $p(1|-1) = a/(1 + a + b)$. Of course the uniform prior correspond to the Beta case with $a = b = 1$.

**Proof of proposition 1**

We calculate first the threshold functions for country $E$, $\alpha_b^E$ and $\alpha_a^E$, respectively from conditions $W_{ba}^E = W_B^E$ and $W_{ab}^E = W_A^E$. These thresholds are such that, for a given $p(1|I)$ (to simplify notation we will suppress the arguments of $p$), $\alpha > (<)\alpha_b^E$ implies $W_B^E > (<)W_{ba}^E$, and $\alpha > (<)\alpha_a^E$ implies

$W_{ab}^E > (<) W_A^E$. Simple calculations give

$$\alpha_b^E = \frac{2CS_a p - CS_b(1+p)}{2CS_a p - CS_b(1+p) + (\Pi_b - \Pi_a^E)(1+2p)};\ \alpha_a^E = \frac{CS_a p - CS_b}{CS_a p - CS_b + \Pi_b - \Pi_a^E}$$

Thresholds $\alpha_b^U$ and $\alpha_a^U$ can be calculated in a similar vein and their expressions are as $\alpha_b^E$ and $\alpha_a^E$ substituting $\Pi_a^E$ with $\Pi_a^U$.

The next step is to study the four functions $\alpha_b^E$, $\alpha_a^E$, $\alpha_b^U$ and $\alpha_a^U$ in the relevant space $(\alpha, p) \in [0,1]^2$.

- It is simple to show $\alpha_b^E$ is increasing in $p$, and positive (and smaller than one) if $p \geq h$ with $h \equiv \frac{CS_b}{2CS_a - CS_b}$, $0 \leq h \leq 1$ and takes value $d = \frac{CS_a - CS_b}{CS_a - CS_b + \frac{3}{2}(\Pi_b - \Pi_a^E)}$ $0 \leq d \leq 1$ for $p = 1$.
- It is simple to show $\alpha_a^E$ is increasing in $p$, moreover it is positive (and smaller than one) if $p \geq r$ with $r \equiv \frac{CS_b}{CS_a}$, $0 \leq r \leq 1$, $h \leq r$ and for $p = 1$ it takes value $c = \frac{CS_a - CS_b}{CS_a - CS_b + \Pi_b - \Pi_a^E}$ with $0 \leq c \leq 1$ and $c \leq d$.
- Function $\alpha_b^U$ is decreasing in $p$, moreover it is positive (and smaller than one) if $p \leq h$ and takes value $e = \frac{CS_b}{CS_b + \Pi_a^U - \Pi_b}$ $0 \leq e \leq 1$ for $p = 0$.
- Function $\alpha_a^U$ is decreasing in $p$, moreover it is positive (and smaller than one) if $p \leq r$ and takes value $e$ for $p = 0$.

Finally, to prove the existence of the four areas we have to prove that (i) $\alpha_b^E$ and $\alpha_a^U$ cross only once in the relevant range and (ii) $\alpha_b^U$ and $\alpha_a^E$ never cross each other. (i) is true as $\alpha_b^E$ is increasing, $\alpha_a^U$ is decreasing and the former crosses the $p$ axis at $h$ while the latter at $r$ with $r \geq h$. Similarly, for (ii) $\alpha_b^U$ is decreasing and crosses the $p$ axis at $h$ while $\alpha_a^E$ is increasing and crosses the $p$ axis at $r$. As an example, the set of values for $(\alpha, p)$ such that decisions are $B$ is defined by conditions $\alpha \leq \alpha_b^U$, $\alpha \geq \alpha_b^E$. The previous description of thresholds shows that the relevant constraint is $\alpha \leq \alpha_b^U$. A similar reasoning can be applied to all other areas with different decisions. Now, note that $I + k \geq I$ with $k \geq 0$ and hence $p(1|I+k) \geq p(1|I)$. Hence, inspection of the threshold functions allows to state that for any $\alpha$ and $k \geq 0$ if equilibrium decisions are $D^*(I) = A$ then $D^*(I+k) = A$; if $D^*(I) = (a,b)$ or $D^*(I) = (b,a)$ then $D^*(I+k) \in \{(a,b), BA, A\}$; if $D^*(I) = B$ then $D^*(I+k) \in \{B, (a,b), BA, A\}$. These prove the results. ■

**Proof of proposition 1 for the long-lasting case.** Proceeding as for short-lived we calculate threshold functions with $i = E, U$

$$\alpha_b^i = \frac{2(CS_a p - CS_b)}{2(CS_a p - CS_b) + \Pi_b(2+p) - \Pi_a^i(1+2p)} \quad \alpha_a^i = \frac{p(CS_a + CS_b) - 2CS_b}{p(CS_a + CS_b) - 2CS_b + \Pi_b(2-p) - \Pi_a^i}$$

- Function $\alpha_b^E$ is increasing in $p$ and positive (and smaller than one) if $p \geq r$ and takes value $d$ for $p = 1$.

- $\alpha_a^E$ is an increasing function of $p$, moreover it is positive (and smaller than one) if $p \geq r'$ with $r' \equiv \frac{2CS_b}{CS_a+CS_b}$, $0 \leq r \leq 1$, $r \leq r'$ and for $p = 1$ it takes value $c$.

- Function $\alpha_b^U$ is decreasing in $p$ if

$$\Pi_a^U \geq \Pi_b \frac{CS_b + 2CS_a}{2CS_b + CS_a} \tag{3}$$

  moreover it is positive (and smaller than one) if $p \leq r$ and takes value $f = \frac{2CS_b}{2CS_b+\Pi_a^U-2\Pi_b}$ for $p = 0$. When condition (3) does not hold $\alpha_b^U$ is increasing, it is positive (and smaller than one) if $p > r$ and takes value $g = \frac{CS_a-CS_b}{CS_a-CS_b-\frac{3}{2}(\Pi_a^U-\Pi_b)} > 1$ for $p = 1$.

- Function is $\alpha_a^U$ decreasing in $p$ if

$$\Pi_a^U \geq \Pi_b r' \tag{4}$$

  moreover it is positive (and smaller than one) if $p \leq r'$ and takes values $f$ for $p = 0$. When condition (4) does not hold, $\alpha_a^U$ is increasing, it is positive (and smaller than one) if $p > r'$ and takes value $d' = \frac{CS_a-CS_b}{CS_a-CS_b-(\Pi_a^U-\Pi_b)}$ for $p = 1$.

The main difference with short-lived is the fact that the two thresholds for $U$ can now be increasing. When both functions are decreasing the proof is as in short-lived. When the two are (or one of the two is) increasing, for the existence of the four areas and the ranking among decisions with different informations we have to show that (i) $\alpha_a^U$ and $\alpha_b^E$ cross each other only once; (ii) $\alpha_a^E$ and $\alpha_b^U$ never cross (i.e. $\alpha_a^E \leq \alpha_b^U$ when $\alpha_a^U$ is increasing); (iii) when $\alpha_a^U$ is increasing it is always $\alpha_a^U \geq \alpha_a^E$; (iv) when $\alpha_b^U$ is increasing it is always $\alpha_b^U \geq \alpha_b^E$.

(iii) and (iv) are straightforward (the thresholds for the two countries are the same functions with permuting indexes and $\Pi_a^U \geq \Pi_b$, $\Pi_a^E \leq \Pi_b$). For (i), first notice that when $\alpha_a^U$ is decreasing we are back to the proof employed with short-lived. With $\alpha_a^U$ increasing, this function crosses the $p$ axis at $r$ while $\alpha_b^E$ at $r'$ with $r' \geq r$, moreover at $p = 1$ the former values $d'$ and the latter $d$ with $d' \geq d$ which proves that the two functions necessarily cross. Moreover, solving $\alpha_a^U = \alpha_b^E$ for $p$ we obtain two solutions $p^1$ and $p^2$ with $\mathrm{Si}\,gn\left\{p^1\right\} = -\mathrm{Si}\,gn\left\{p^2\right\}$ when $\alpha_a^U$ is increasing and this means that in the relevant $(\alpha, p)$ space $\alpha_a^U$ and $\alpha_b^E$ cross only once. For (ii), condition $\alpha_a^E = \alpha_b^U$ is equivalent to a second order polynomial with two solutions $p'^1$ and $p'^2$ with $\mathrm{Si}\,gn\left\{p'^1\right\} = -\mathrm{Si}\,gn\left\{p'^2\right\}$ when $\alpha_a^U$ is increasing. Moreover, calculated at the positive root $\alpha_a^U$ turns out to be negative which implies that either $\alpha_a^E < \alpha_b^U$ or the opposite hold. However, $\alpha_a^E$ crosses the $p$ axis at $r'$ and $\alpha_b^U$ at $r$ with $r' \geq r$, it follows that $\alpha_a^E < \alpha_b^U$ whenever $\alpha_b^U$ increasing. ■

**Proof of propositions 2** Similarly to the proof of Proposition 1, one can calculate three boundaries $\alpha_B^C$, $\alpha_{BA}^C$, $\alpha_A^C$, respectively comparing the aggregate social welfare with decisions $B$ and $BA$, $B$

and $A$, and finally $A$ and $BA$. We study these functions in the $(\alpha, p)$-plane as in Figure 1. They are decreasing (increasing) if $\Delta\Pi = 2\Pi_b - \Pi_a^E - \Pi_a^U < 0 (> 0)$ and vertical if $\Delta\Pi = 0$. They cross the horizontal axis respectively where $p = z \equiv \frac{CS_b}{3CS_a - 2CS_b} < h$, $p = h$ and $p = r$. When decreasing, they intersect the vertical axis where they all take value $e' \equiv \frac{CS_b}{CS_b - \Delta\Pi} > e$. When increasing, they cross the vertical line $p = 1$ where they all take value $d' \equiv \frac{CS_a - CS_b \Delta\Pi}{CS_a - CS_b +} > c$. The value $\hat{\alpha}$ corresponds to the intersection between $\alpha_B^C$ and $\alpha_b^U$. For any value of $\alpha > \hat{\alpha}$, $\hat{p}_1$ $(\hat{p}_2)$ is obtained by the intersection of the horizontal line at $\alpha$ and $\alpha_B^C$ $(\alpha_A^C)$. Hence, one can simply verify that if $\alpha > \hat{\alpha}$ and $p < \hat{p}_1$ $(p > \hat{p}_2)$ then the two governments either takes the same decision $B$ $(A)$ as the WTO or take the decision $BA$ where the WTO would decide $B$ $(A)$. Now, plotting the functions $\alpha_B^C$, $\alpha_{BA}^C$, $\alpha_A^C$ in the three cases $\Delta\Pi \gtreqless 0$ together with the four boundaries obtained in the proof of Proposition 1, one obtains the proposition by simple inspection. ■Note that if the decision set of the WTO is $\{B, A\}$, then the only relevant boundary is $\alpha_{BA}^C$, and we have $\hat{\alpha} = 0$ with $\hat{p}_1 = \hat{p}_2$ obtained by the intersection of the line at $\alpha$ and $\alpha_{BA}^C$.

**Proof of proposition 2 for the long-lasting case**. Studying $\alpha_B^C$, $\alpha_{BA}^C$, $\alpha_A^C$ in the $(\alpha, p)$-plane as in Figure 1, they are decreasing (increasing) if $\Pi_a^E + \Pi_a^U \geq \frac{4CS_a}{CS_a + CS_b}$. They cross the horizontal axis respectively where $p = r'' \equiv \frac{2CS_b}{3CS_a - CS_b} < r$, $p = r'$ and $p = r$. When decreasing, they intersect the vertical axis where they all take value $f'' \equiv \frac{2CS_b}{2CS_b - 2\Pi_b - \Delta\Pi} > f$. When increasing, they cross the vertical line $p = 1$ where they all take value $c'' \equiv \frac{CS_a - CS_b}{CS_a - CS_b - \Delta\Pi} > c$. Then the proof exactly follows that of proposition 2 with short-lived effects. ■

**Proof of propositions 3 and 5**

We first need three intermediary lemmas

**Lemma 1** *With long-lasting and short-lived there exist no separating equilibrium when the three decisions* $\{D(-2), D(0), D(2)\}$ *are the same.*

**Proof.** Observing messages, governments learn information $I$ which, in this kind of equilibrium, corresponds to lobbies types $I = (I^U, I^E) \in \{(-1,-1), (-1,1), (1,-1), (1,1)\}$. None of the lobbies has interest to send costly messages to separate when the three decisions corresponding to the three possible $I$ are equal. ■

**Lemma 2** ***Fully Informative Equilibria.*** *With long-lasting and short-lived the advertising levels* $(M^{*U}(1),\ M^{*U}(-1),\ M^{*E}(1),\ M^{*E}(-1))$ *are separating equilibrium strategies iff* $M^{*U}(-1) = M^{*E}(1) = 0$, $\underline{M}^U \leq M^{*U}(1) \leq \bar{M}^U$, $\underline{M}^E \leq M^{*E}(-1) \leq \bar{M}^E$, *where* $\underline{M}^U = \check{M}^j$ $j = U$, $\bar{M}^E = -\check{M}^j$

$j=E$, $\bar{M}^U=\hat{M}^j$ $j=U$, $\underline{M}^E=-\hat{M}^j$ $j=E$ *and*

$$\hat{M}^j \equiv \Pi^j_{D(M^{*U}(1),M^{*E}(1))}\left((1,1)\right)p(1|1)+\Pi^j_{D(M^{*U}(1),M^{*E}(-1))}\left((1,-1)\right)p(-1|1)+ \\ -\Pi^j_{D(0,M^{*E}(1))}\left((1,1)\right)p(1|1)-\Pi^j_{D(0,M^{*E}(-1))}\left((1,-1)\right)p(-1|1),$$

$$\check{M}^j \equiv \Pi^j_{D(M^{*U}(1),M^{*E}(1))}\left((1,-1)\right)p(1|-1)+\Pi^j_{D(M^{*U}(1),M^{*E}(-1))}\left((-1,-1)\right)p(-1|-1)+ \\ -\Pi^j_{D(0,M^{*E}(1))}\left((1,-1)\right)p(1|-1)-\Pi^j_{D(0,M^{*E}(-1))}\left((-1,-1)\right)p(-1|-1),$$

**Proof.** First notice that in a separating equilibrium types which would like to mimic other types, in equilibrium optimally set advertising to zero. Type 1 of lobby $U$ and type -1 of lobby $E$ want to separate from the other type. Let equilibrium advertising be $M^{*U}(-1)=0, M^{*U}(1)$,and $M^{*E}(1)=0$ , $M^{*E}(-1)$. Lobbies send messages simultaneously and types are uncorrelated. As a consequence we can write $\lambda(I \mid M)=\lambda\left(I^U \mid M\right)\lambda\left(I^E \mid M\right)$. Consider first Lobby $U$. Exploiting the arbitrariness of off-equilibrium-path beliefs we set $\lambda\left(I^U=1 \mid M^U \neq M^{*U}(1)\right)=0$ which means that governments always infer that lobby $U$ is type $-1$ unless they observe equilibrium advertising of type 1, $M^{*U}(1)$. If type 1 of lobby $U$ deviates setting a $M^U \neq M^{*U}(1)$, he gets profit

$$\Pi^U_{D(M^U,M^{*E}(1))}\left((1,1)\right)p(1|1)+\Pi^U_{D(M^U,M^{*E}(-1))}\left((1,-1)\right)p(-1|1)-M^U$$

where, given the specified beliefs, $D(M^U,M^{*E}(1))$, $D(M^U,M^{*E}(-1))$ are decisions respectively taken when types are believed $(-1,1)(-1,-1)$, as long as $M^U \neq M^{*U}(1)$. Maximizing the previous expression w.r.t. $M^U$ optimal advertising is zero, then a necessary and sufficient condition for (C1) in the definition of the PBE (see previously in the appendix) to hold for $j=U$, $I^U=1$ is,

$$\Pi^U_{D(M^{*U}(1),M^{*E}(1))}\left((1,1)\right)p(1|1)+\Pi^U_{D(M^{*U}(1),M^{*E}(-1))}\left((1,-1)\right)p(-1|1)-M^{*U}(1) \geq \\ \geq \Pi^U_{D(0,M^{*E}(1))}\left((1,1)\right)p(1|1)+\Pi^U_{D(0,M^{*E}(-1))}\left((1,-1)\right)p(-1|1) \tag{5}$$

or

$$\hat{M}^j \geq M^{*U}(1), j=U$$

Similarly, type $-1$ of lobby $U$, setting a $M^U \neq M^{*U}(1)$, can get a profit

$$\Pi^U_{D(M^U,M^{*E}(1))}\left((1,-1)\right)p(1|-1)+\Pi^U_{D(M^U,M^{*E}(-1))}\left((-1,-1)\right)p(-1|-1)-M^U$$

that is, at maximum,

$$\Pi^U_{D(0,M^{*E}(1))}\left((1,-1)\right)p(1|-1)+\Pi^U_{D(0,M^{*E}(-1))}\left((-1,-1)\right)p(-1|-1).$$

Thus a necessary and sufficient condition for (C1) to hold for $j=U$, $I^U=-1$ is,

$$\Pi^U_{D(M^{*U}(1),M^{*E}(1))}\left((1,-1)\right)p(1|-1)+\Pi^U_{D(M^{*U}(1),M^{*E}(-1))}\left((-1,-1)\right)p(-1|-1)-M^{*U}(1) \leq \\ \leq \Pi^U_{D(0,M^{*E}(1))}\left((1,-1)\right)p(1|-1)+\Pi^U_{D(0,M^{*E}(-1))}\left((-1,-1)\right)p(-1|-1) \tag{6}$$

or

$$\check{M}^j \leq M^{*U}(1), j = U$$

Putting together (5) and (6) we obtain,

$$\check{M}^j \leq M^{*U}(1) \leq \hat{M}^j, j = U$$

It is thus necessary that

$$\bar{M}^U - \underline{M}^U = \hat{M}^j - \check{M}^j \geq 0, j = U \tag{7}$$

Consider now lobby $E$. Type $-1$ wants to separate from type 1 and proceeding in a similar way as with lobby $U$, conditions (5) and (6) have the equivalents $\bar{M}^E \geq M^{*E}(-1)$, $\underline{M}^E \leq M^{*E}(-1)$ with $\bar{M}^E = -\check{M}^j$, $\underline{M}^E = -\hat{M}^j$ $j = E$. Putting together the two, a necessary condition is

$$\bar{M}^E - \underline{M}^E = \hat{M}^j - \check{M}^j \geq 0, j = E \tag{8}$$

and $\bar{M}^E - \underline{M}^E$ is equal to $\bar{M}^U - \underline{M}^U$ permuting lobbies' indexes for profits. ■

**Lemma 3** ***Partially Informative Equilibria.*** *With long-lasting and short-lived, if lobby U separates, the advertising levels* $(M^{*U}(1), M^{*U}(-1))$ *are separating equilibrium strategies iff* $M^{*U}(-1) = 0$, $\underline{M}^U \leq M^{*U}(1) \leq \bar{M}^U$. *If lobby E separates, the advertising levels* $(M^{*E}(1), M^{*E}(-1))$ *are separating equilibrium strategies iff* $M^{*E}(1) = 0$, $\underline{M}^E \leq M^{*E}(-1) \leq \bar{M}^E$, *where*

$$\bar{M}^U \equiv \Pi^U_{D(M^{*U}(1))}(1) - \Pi^U_{D(0)}(1), \ \underline{M}^U \equiv \Pi^U_{D(M^{*U}(1))}(-1) - \Pi^U_{D(0)}(-1)$$
$$\bar{M}^E = \Pi^E_{D(M^{*E}(-1))}(-1) - \Pi^E_{D(0)}(-1), \ \underline{M}^E = \Pi^E_{D(M^{*E}(-1))}(1) - \Pi^E_{D(0)}(1)$$

*Out of equilibrium (common) believes satisfy the following conditions,*

$$\beta^j_h \leq \bar{\beta}^j_h \tag{9}$$

*with* $\bar{\beta}^j_h \equiv$
$$\frac{\Pi^j_{D(0,M^{*\text{-}j}(-1))}((h,-1))p(-1|h)+\Pi^j_{D(0,M^{*\text{-}j}(1))}((h,1))p(1|h)+\varepsilon-\Pi^j_{D(\varepsilon,M^{*\text{-}j}(-1))}((h,-1))p(-1|h)-\Pi^j_{D(\varepsilon,M^{*\text{-}j}(1))}((h,1))p(1|h)}{\Pi^j_{D(\varepsilon,M^{*\text{-}j}(-1))}((h,-1))p(-1|h)+\Pi^j_{D(\varepsilon,M^{*\text{-}j}(1))}((h,1))p(1|h)-\Pi^j_{D(\varepsilon,M^{*\text{-}j}(-1))}((h,-1))p(-1|h)-\Pi^j_{D(\varepsilon,M^{*\text{-}j}(1))}((h,1))p(1|h)}$$
$\varepsilon > 0$ *and* $h = -1, 1$, $j = E, U$.

**Proof.** For conditions on advertising levels, the proof follows the lines of the previous lemma. Moreover, when lobby $j$ pools one has to check that out of equilibrium believes exist for both types $h = -1, 1$ which make indeed both lobby $j$'s types pooling. The Perfect Bayesian Equilibrium requires that players have common beliefs (see Fudenberg and Tirole 1991a, condition B(iv) page 332). Hence they must be the same for both countries.[23] For type $h = -1, 1$ of lobby $j = E, U$ the condition is the following,

$$\Pi^j_{D(0,M^{*\text{-}j}(-1))}((h,-1))\,p(-1|h) + \Pi^j_{D(0,M^{*\text{-}j}(1))}((h,1))\,p(1|h) \geq$$

[23]This commonly accepted restriction on beliefs in perfect Bayesian equilibria simplifies the analysis but it does not go unquestioned. However, note that in our game the equivalence between perfect Bayesian and sequential equilibria applies (Fudenberg and Tirole 1991b). Had we employed the sequential equilibrium, common beliefs would have been simply a consequence of the equilibrium concept.

$$\geq \beta_h^j \left[\Pi^j_{D(\varepsilon, M^{*-j}(-1))}\left((h,-1)\right)p(-1|h) + \Pi^j_{D(\varepsilon, M^{*-j}(1))}\left((h,1)\right)p(1|h)\right] +$$

$$+\left(1-\beta_h^j\right)\left[\Pi^j_{D(\varepsilon, M^{*-j}(-1))}\left((h,-1)\right)p(-1|h) + \Pi^j_{D(\varepsilon, M^{*-j}(1))}\left((h,1)\right)p(1|h)\right] - \varepsilon$$

where $\varepsilon > 0$ infinitely small is the deviation of lobby $j$ (with respect to $M^{*j}(h) = 0$). Rearranging one gets the condition in the lemma. ■

**Proof of proposition 3**

(i) In a fully informative equilibrium $M^j$ depends on $j$'s type for $j \in \{U, E\}$. Therefore, observing messages, governments learn information $I$ which, in this kind of equilibrium, corresponds to lobbies types $I = (I^U, I^E)$. The next step is to show when either $\bar{M}^E - \underline{M}^E$ or $\bar{M}^U - \underline{M}^U$ are non positive and the necessary conditions are violated (see lemma 2).

Using table 1 one simply derives all the possible cases which are summarized in the next table. Then explicitly calculating $\bar{M}^U - \underline{M}^U$, $\bar{M}^E - \underline{M}^E$ we verify when one of the two is strictly negative. Note that when equilibrium decisions are $\{BA, BA, BA\}$, even if decisions may not be the same for different $I$, from the point of view of lobbies, these are all payoff equivalent decisions and lobbies never separate.

| | Decisions | $\bar{M}^j - \underline{M}^j$ |
|---|---|---|
| (1) | $\{B, B, BA\}$ | $\Pi_a^j - \Pi_b$ |
| (2) | $\{B, B, A\}$ | $(\Pi_a^j - \Pi_b)4/3$ |
| (3) | $\{BA, BA, A\}$ | $(\Pi_b - \Pi_a^j)/3$ |
| (4) | $\{B, BA, BA\}$ | $(\Pi_b - \Pi_a^j)/3$ |
| (5) | $\{B, A, A\}$ | $(\Pi_b - \Pi_a^j)2/3$ |
| (6) | $\{BA, A, A\}$ | $(\Pi_b - \Pi_a^j)/3$ |
| (7) | $\{B, BA, A\}$ | 0 |

In all the listed cases the necessary condition is violated for one lobby. Moreover, in case (7) both necessary conditions are violated. In fact, $\bar{M}^j - \underline{M}^j = 0$ means that the separating lobby must spend in advertising all what he gains from separating. But, to perform the experiment lobbies spend cost $c$, therefore the profit of a separating lobby would be $\Pi^j = -c < 0$ and the lobby prefers not to separate.

(ii) In a partially informative equilibrium advertising of the separating lobby $M^j$ depends on $j$'s type. Therefore, observing messages, governments learn information $I$ which, in this kind of equilibrium, corresponds to the type of the separating lobby $I^j \in \{-1, 1\}$. The next step is to show when either $\bar{M}^E - \underline{M}^E$ or $\bar{M}^U - \underline{M}^U$ are non positive and the necessary conditions for the partially informative equilibrium are violated (see lemma 3). All the possible cases are summarized in the next table. Explicitly calculating $\bar{M}^U - \underline{M}^U$, $\bar{M}^E - \underline{M}^E$ we verify when one of the two is strictly negative.

| | Decisions | $\bar{M}^j - \underline{M}^j$ |
|---|---|---|
| (1) | $\{BA, A\}$ | 0 |
| (2) | $\{B, BA\}$ | $\left(\Pi_a^j - \Pi_b\right) 2/3$ |
| (3) | $\{B, A\}$ | $\left(\Pi_a^j - \Pi_b\right) 2/3$ |

In case (1) a partially informative equilibrium can not exist for the same reason which excluded case (7) in (i). In the other cases one verifies that $\bar{M}^j - \underline{M}^j > 0$ only for lobby E.

Finally, to be sure that partially informative equilibria indeed exist we need to find at least an out-of-equilibrium belief which satisfies condition (9) in lemma 3. To this end we have to specify countries' out-of-equilibrium decisions and this is done in the following table where we also list the values of the boundary betas $\bar{\beta}_h^j$ (note that when $\bar{\beta}_h^j = 0$ it suffices to take $\beta_h^j = 0$).

| Equilibrium | Out-of-Equ. | $\bar{\beta}_{-1}^j$ | $\bar{\beta}_1^j$ |
|---|---|---|---|
| $\{B, BA\}$ | $\{(b,b),(b,b),(b,a)\}$ | 1 | 1 |
| $\{B, BA\}$ | $\{(b,b),(b,b),(a,a)\}$ | 2/3 | 5/7 |
| $\{B, BA\}$ | $\{(b,b),(b,a),(b,a)\}$ | 0 | 0 |
| $\{B, BA\}$ | $\{(b,b),(b,a),(a,a)\}$ | 0 | 0 |
| $\{B, A\}$ | $\{(b,b),(b,b),(a,a)\}$ | 1 | 1 |
| $\{B, A\}$ | $\{(b,b),(b,a),(a,a)\}$ | 1/4 | 1/2 |
| $\{B, A\}$ | $\{(b,b),(a,a),(a,a)\}$ | 0 | 0 |

■

**Proof of proposition 4** We have $r' \geq r$, $f \geq e$ and $g \geq d' \geq c \geq d$ (from proof of propositions 1 2) and then, the proof simply follows from drawing the boundary functions $\alpha_i^j$, $i = a, b$, $j = E, U, C$ with both short-lived and long-lasting and comparing the admissible decisions. ■

**Proof of proposition 5**

(i) The proof follows the lines of proposition 3 and then we directly provide the table of equilibrium decisions.

| | Decisions | $\bar{M}^j - \underline{M}^j$ |
|---|---|---|
| (1) | $\{B, B, BA\}$ | $\Pi_a^j - \Pi_b$ |
| (2) | $\{B, B, A\}$ | $4/3\left(\Pi_a^j - \Pi_b\right)$ |
| (3) | $\{BA, BA, A\}$ | $1/3\left(\Pi_a^j - \Pi_b\right)$ |
| (4) | $\{B, BA, BA\}$ | $1/3\left(2\Pi_b - \Pi_a^j\right)$ |
| (5) | $\{B, A, A\}$ | $2/3\left(2\Pi_b - \Pi_a^j\right)$ |
| (6) | $\{BA, A, A\}$ | $1/3\left(2\Pi_b - \Pi_a^j\right)$ |
| (7) | $\{B, BA, A\}$ | $\Pi_b/3$ |

Note that, in cases (4)-(6) $\bar{M}^E - \underline{M}^E > 0$ always and $\bar{M}^U - \underline{M}^U > 0$ if $2\Pi_b > \Pi_a^U$.

(ii) Concerning partially informative equilibria the proof is as in proposition 3 and then we directly provide the table of equilibrium decisions and out-of-equilibrium believes.

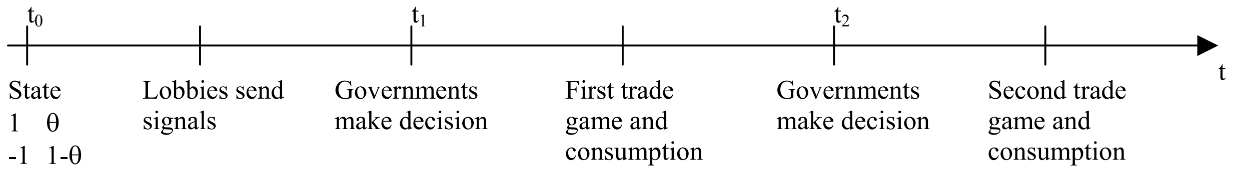
| | Decisions | $\bar{M}^j - \underline{M}^j$ |
|---|---|---|
| (1) | $\{BA, A\}$ | $\Pi_b/3$ |
| (2) | $\{B, BA\}$ | $\left(2\Pi_a^j - \Pi_b\right)/3$ |
| (3) | $\{B, A\}$ | $\Pi_a^j 2/3$ |

| Equilibrium | Out-of-Equ. | $\bar{\beta}_{-1}^j$ | $\bar{\beta}_1^j$ |
|---|---|---|---|
| $\{BA, A\}$ | $\{(a,b),(a,b),(a,a)\}$ | 1 | 1 |
| $\{BA, A\}$ | $\{(a,b),(a,a),(a,a)\}$ | 0 | 0 |
| $\{BA, A\}$ | $\{(b,b),(a,b),(a,a)\}$ | 1 | 1 |
| $\{BA, A\}$ | $\{(b,b),(a,a),(a,a)\}$ | $\frac{4\Pi_a^j - 5\Pi_b}{6\Pi_a^j - 8\Pi_b}$ | $\frac{6\Pi_a^j - 9\Pi_b}{2(5\Pi_a^j - 8\Pi_b)}$ |
| $\{B, BA\}$ | $\{(b,b),(b,b),(b,a)\}$ | 1 | 1 |
| $\{B, BA\}$ | $\{(b,b),(b,b),(a,a)\}$ | $\frac{4\Pi_a^j - 6\Pi_b}{6\Pi_a^j - 8\Pi_b}$ | $\frac{5\Pi_a^j - 6\Pi_b}{7\Pi_a^j - 8\Pi_b}$ |
| $\{B, BA\}$ | $\{(b,b),(b,a),(b,a)\}$ | 0 | 0 |
| $\{B, BA\}$ | $\{(b,b),(b,a),(a,a)\}$ | 0 | 0 |
| $\{B, A\}$ | $\{(b,b),(b,b),(a,a)\}$ | 1 | 1 |
| $\{B, A\}$ | $\{(b,b),(b,a),(a,a)\}$ | $\frac{\Pi_a^j - \Pi_b}{4\Pi_a^j - 7\Pi_b}$ | $\frac{2(\Pi_a^j - \Pi_b)}{4\Pi_a^j - 5\Pi_b}$ |
| $\{B, A\}$ | $\{(b,b),(a,a),(a,a)\}$ | 0 | 0 |

When $\bar{\beta}_0^j$ is not an exact value we have to be sure that it is non-negative and this gives the last conditions of the proposition. When equilibrium and out-of-equilibrium decisions are respectively $\{BA, A\}$, $\{(b,b),(a,a),(a,a)\}$ simple algebra shows that E always separate, while to have U separating it must be $\Pi_a^U \notin [5/4\Pi_b, 8/5\Pi_b]$. When equilibrium and out-of-equilibrium decisions are respectively $\{B, BA\}$, $\{(b,b),(b,b),(a,a)\}$ simple algebra shows that E always separate, while to have U separating it must be $\Pi_a^U \notin [8/7\Pi_b, 3/2\Pi_b]$. When equilibrium and out-of-equilibrium decisions are respectively $\{B, A\}$, $\{(b,b),(b,a),(a,a)\}$ simple algebra shows that E always separate, while to have U separating we must have that $\Pi_a^U > 7/4\Pi_b$. ■

| | $d^U = a$ | $d^U = b$ |
|---|---|---|
| $d^E = a$ | $W^U_{aa}(I)$<br>$W^E_{aa}(I)$ | $W^U_{ba}(I)$<br>$W^E_{ba}(I)$ |
| $d^E = b$ | $W^U_{ab}(I)$<br>$W^E_{ab}(I)$ | $W^U_{bb}(I)$<br>$W^E_{bb}(I)$ |

Table 1: Governments' decision matrix



t0
t1
t2
t
State
1 θ
-1 1-θ
Lobbies send signals
Governments make decision
First trade game and consumption
Governments make decision
Second trade game and consumption


Figure 1

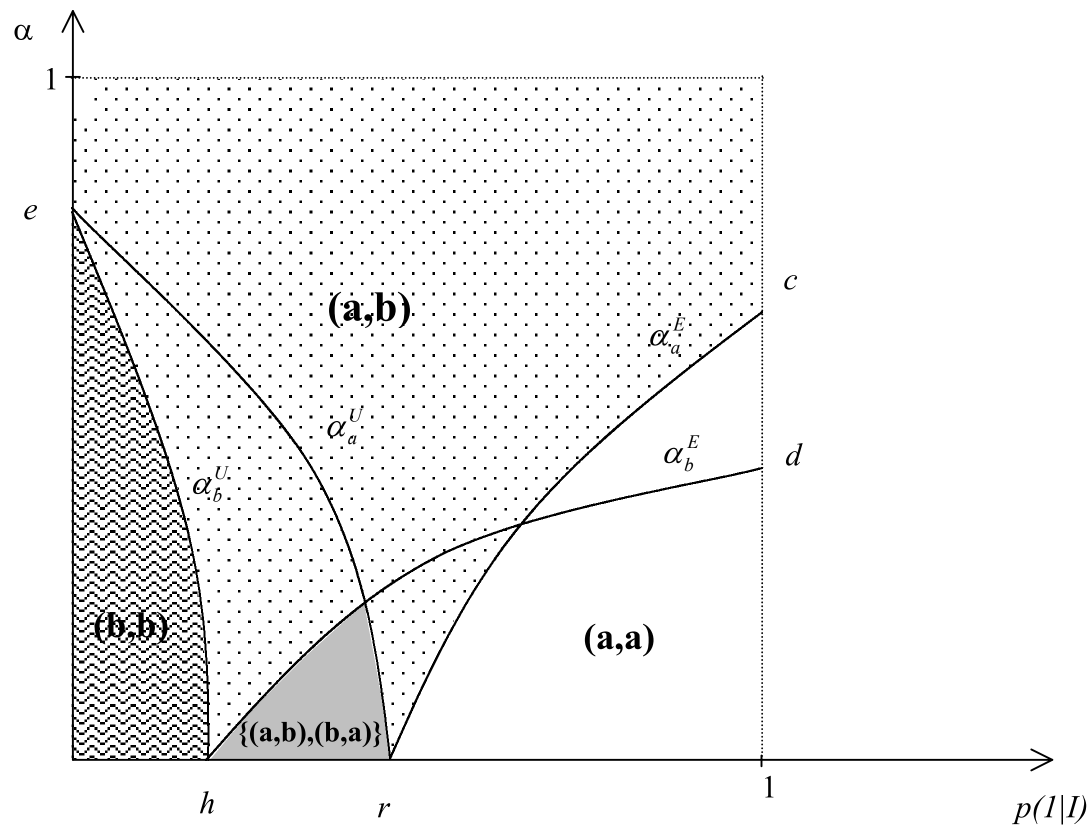



Figure 2: Governments decisions