Hormone beefs, chloridric chicken and international trade: Can scientific uncertainty be an informational barrier to trade?*

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Abstract

We study international trade of innovative goods subject to scientific uncertainty on consumers' health effects. Trade of these goods is often at the center of international disputes. We show that a new trade protectionism may arise because of the scientific uncertainty. A free riding effect is individuated implying a more conservative behaviour by countries. We also study the informative role played by producers (lobbies) in revealing valuable information. We find that producers revel more information when the effects of harmful consumption on health are long lasting. Our results are robust to several extensions (e.g. product labeling, firm liability).

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Non-technical Abstract

If we look at recent history, we observe that international institutions, as the GATT before and the WTO now, proved to be successful in reducing international trade barriers. However, credibility and enforcement of international agreements may become an issue when the contracting parties are not equally informed. This is confirmed by the observation that most of actual trade disputes are linked to informational issues. When a new product is introduced, countries have to decide if to allow consumption or not. Taking this decision they try to evaluate expected costs and benefits. The effects on consumers' health of new products such as drugs, genetically modified plants, animals grown with hormones, chicken carcasses chlorine washed are generally imperfectly known. It is striking to see that almost all the above quoted cases are actually at the center of international trade disputes. Typically the country which develops the new good (or the cost saving production process) argues that other countries do not allow consumption of the product to protect domestic competitors. On the other side, banning countries claim their freedom to choose on domestic consumer safety and to refuse risky products according to national preferences and information. In these cases the role played by international institutions seems limited as countries are reluctant to delegate supra-national authorities decisions on domestic consumption uncertainty.

The main results of the paper are the following. First, allowing the innovative good, a country generates freely available information given by the observation of consumption effects. Thus, governments are confronted with a decision making problem where the information flow is endogenous (it depends on decisions) and is a strategic variable: each country would like the other to allow the innovative good, test it and provide the information. Second, information revelation by lobbies turns out to depend on the long lasting or short lived effects of harmful consumption. Lobbies reveal more information when the harmful effects are long lasting. Third, scientific uncertainty proves to be an informational barrier to trade. In fact, governments adapt their choices to the so called Precautionary Principle: they ban consumption more often when more information is waited in the future. Scientific progress pushes toward more conservative decisions today.

1 Introduction

Most of the economists facing with the Paul Krugman's famous question "*Is free trade passé after all?*" (Krugman (1987)), would today answer "*Yes, it is*". Moreover, if we look at recent history, we observe that international institutions, as the GATT before and the WTO now, proved to be successful in reducing international trade barriers.[1] Economists' favor towards free trade may have played some role in this success. However, a fundamental ingredient of this success is surely the improved credibility and enforcement power of international trade institutions. This mechanism proved to be particularly efficient with the traditional trade barriers (tariffs, duties, subsidies, quotas, voluntary export restraints, etc.). In these cases, the bargained terms of international agreements are observable by all the involved parties and international institutions can efficiently act as enforcing courts.[2]

However, credibility and enforcement of international agreements may become an issue when the contracting parties are not equally informed. This is confirmed by the observation that most of actual trade disputes are linked to informational issues. A striking case is supplied by safety standards and product safety regulation.[3] With this respect the GATT (General Agreement on Trade and Tariffs) allowed countries to ban importation of goods that were thought to have been produced unsafely, provided that the exclusion were based on adequate scientific testing. This is the key point developed in our paper. First, we study if and how a new trade protectionism may arise from scientific uncertainty on the safety of innovations. Second, we analyze the informative role played by producers in providing evidence pro or against the innovative goods. Finally, countries' decision process to ban or accept the innovation is described.

When a new product is introduced, countries have to decide if to allow consumption or not. Taking this decision they try to evaluate expected costs and benefits. Information on the probability distribution of possible

[1] The "Kennedy" GATT round (1964-67) induced a 30% multilateral cut in tariffs on manufactures goods. Similarly the Tokyo Round obtained a further 30% reduction as well as the Uruguay Round.

[2] Even if GATT had no legal force, it efficiently relied on voluntary compliance of its members to maintain credibility.

[3] Another example is dumping, an always hot international topic. The difficulty for countries to agree (contract) on dumping is due to the fact that firms' production costs are not perfectly verifiable. Comparisons between costs and prices is always somehow arbitrary, thus the difficulties for countries to agree on.

consequences is crucial. The effects on consumers' health of new products (or a cost saving production process innovations) are generally imperfectly known. Even knowing the set of possible consequences of consumption (the states of nature), one still does not know the exact probabilities of events. (Our interpretation of scientific uncertainty differs from risk mainly for the possibility to diminish over time.)

Policy makers try to state effects and associated probabilities of new drugs, and if they allow it, their knowledge on safeness is still partial. Similarly happens for genetically modified plants. When we eat a pizza with genetically modified tomatoes (even if it is as good as usual) we do not know with certainty its effects on our health. The same is true for the meat of animals grown with hormones, for chicken carcasses washed with chlorine solution and for french cheese made with non-pasteurized milk.[4]

It is striking to see that almost all the above quoted cases are actually at the center of international trade disputes. Typically the country which develops the new good (or the cost saving production process) argues that other countries do not allow consumption of the product to protect domestic competitors. On the other side, banning countries claim their freedom to choose on domestic consumer safety and to refuse risky products according to national preferences and information. In these cases the role played by international institutions seems limited for at least two reasons. First, countries are reluctant to delegate supra-national authorities decisions on topics characterized by uncertainty on domestic consumption. Second, the presence of scientific uncertainty makes almost impossible the way of internationally enforced agreements. The consequence is a growing number of bilateral trade disputes.

The setting we address in this paper is the one of an innovation on the production process allowing for a substantial cost reduction. There are innovating firms with the rights to exploit the new products and firms producing competing close substitutes. The traditional and the new good only differ with respect to the production process. This may have altered the characteristics of the product making it dangerous for consumer health.

If the new product is accepted, the innovating firms may be able to drive competitors out of the market thanks to the substantial cost reduction. It is then in the interest of both innovating and traditional firms to provide

[4]For more details see, for example, The Economist, January 24-30th, 1998, and June 13-19th 1998.

evidence supporting their own interests. In this context of imperfect information, firms engage their R&D departments in experimenting the new product safeness. In so doing, lobbies become an important (even if biased) source of information for countries.

Heterogeneity in preferences and information on consumption effects could easily explain any difference in countries' decisions. Moreover, this kind of heterogeneity can be hardly justified among equally developed countries. Therefore, to make the analysis non trivial, we assume away such heterogeneity. In taking the decision to accept the innovative good, each country evaluates the expected consumption effects as well as the consequences on domestic industries. We consider two countries and we assume that both the lobby owning the innovative technology and the competing lobby engage in active information provision to the two national decision makers. The two decision makers update their prior on the new product consumption effects with the information transmitted by the lobbies and decide if to allow domestic consumption of the new good.

Economic and political science literature have recently paid attention to lobbies' ability to influence decisions not only bribing non-benevolent civil servants but also using the information they are able to provide.[5] Following this strand of literature, we assume the sole role of lobbies is to provide decision makers with valuable information for their decisions. We do not maintain that bribes do not exist in real world or are ineffective. We want to emphasize lobbies' role when decision makers face scientific uncertainty as in most of the recent trade disputes.

The main results of the paper are the following. First, allowing the innovative good, a country generates freely available information given by the observation of consumption effects. Thus, governments are confronted with a decision making problem where the information flow is endogenous (it depends on decisions) and is a strategic variable: each country would like the other to allow the innovative good, test it and provide the information. This free riding effect characterizes the equilibria of governments decision game (section 3). Second, concerning the informative role of lobbies, information revelation by lobbies depends on the long lasting or short lived effects of harmful consumption. More specifically, lobbies reveal more information

[5] See Austen-Smith (1993), (1995) and (1996), Krishna and Morgan (1998), Potters and Van Winden (1992) and Dewatripont and Tirole (1999). For an important example of bribing lobbies see Helpman and Grossman (1994).

when the harmful effects are long lasting (section 4). Third, scientific uncertainty proves to be an informational barrier to trade. In fact, governments adapt their choices to the Precautionary Principle[6]. They ban consumption more often when more information is waited in the future. Scientific progress pushes toward more conservative decisions today (section 5). Section 6 shows that our results are robust to the introduction of asymmetric priors, labeling of goods, firm's liability and different discount rates.

The plan of the paper is the following. Section 2 introduces the model. Section 3, studies governments decisions facing risky consumption, given the information provided by the lobbies. Section 4 analyses lobbies' incentives to experiment the innovative good and provide valuable information to governments. Section 5 deals with the Precautionary Principle. Section 6 proves the robustness of results to several extensions. Section 7 summarizes the results and concludes. All the proofs are in the Appendix (section 8).

2 The Model

Players. Consider two countries U (for United States) and E (for Europe) and an industry with two firms (or two groups of firms) that produce an homogeneous good: a *status quo* (or traditional) and an *innovator* firm. For the sake of concreteness, we assume that the two firms are respectively owned by E's and U's citizens and call them E and U. The *status quo* production technology is freely available to both firms. On the contrary, firm U owns a patent for an innovation allowing for cost reduction with respect to the *status quo* technology. Firms, indexed by $j \in \{U, E\}$, compete in both markets $i \in \{U, E\}$ and in each one of the two periods in which consumption takes place. To simplify the analysis markets are assumed to be of equal size. Governments are benevolent decision makers and in each period maximize a weighted sum of domestic consumer's surplus and domestic firm's profit, respectively with weights $1 - \alpha$ and α.[7] Finally, Nature decides if the innova-

[6]The principle states that "the absence of certainty, given our current scientific knowledge, should not delay the use of measures preventing a risk of large and irreversible damages to the environment, at an acceptable cost".

[7]Grossman and Helpman (1994), Feenstra and Lewis (1991) and Martimort (1996) show that α can be affected by lobbies' bribes and use this interpretation for profit weighting in social welfare functions. We do not deal with this type of lobbying, in our model the weights for profits are the same in both countries in order to focus on the informational role of lobbies.

tive technology is harmful for consumers health, state 0, or if it is not, state 1.

Information. The state of nature $\omega \in \{0, 1\}$ is the realization of a random variable Ω distributed according to a Bernoulli distribution with unknown (to both lobbies and governments) parameter θ (probability of state 1). All players share a uniform prior on θ with support $[0, 1]$.[8] (The assumption of uniform prior is discussed in section 6.) The two lobbies are in better position than governments to learn if the technology is harmful or not. Lobbies' laboratories experiment the effect of the innovative technology at a fix cost c.[9] Each lobby privately observes an independent random draw from the distribution of Ω. However, even if they have an informative advantage relative to governments, they are still not fully informed. Let $t^j \in \{0, 1\}$ denote the realization of j's draw $j = E, U$ and $p(0 \mid t)$ and $p(1 \mid t)$ respectively the probabilities that, having observed realization(s) t, consumption of the innovative good will and will not be harmful. Governments in deciding whether or not to allow the innovation can not perform experiments on their own and are therefore obliged to rely on the information they can infer from the lobbies.[10] Governments' expectation of the random draw is $Et^j = E\theta = \frac{1}{2}$. The innovation is an experience good, after a first consumption uncertainty is completely resolved and all the players learn the true state of the world.[11] Consumption could have been considered just as another experiment thus being only partially informative. However, the informational role of lobbies would still qualitatively hold. The preferences of all players are common knowledge.

Decision Sequence. Nature chooses the state of nature and lobbies privately and independently learn the result of their experiment. Having observed the realization t_j, each firm j spends resources A^j to advertise its private information. Sending a unique message to both governments the firm pushes decisions toward its best preferred outcome. Note that with advertising the cost of the message does not depend on type and then the

[8] This is modeled as in Austen-Smith (1990).

[9] For almost all the paper the presence of this fix cost is irrelevant. Hence we will make as if the lobby already knew the result of their own experiment and we will explicitly make clear when the cost to acquire information matters.

[10] Even if governments could perform experiments, lobbies' information would still remain valuable to take decisions and our results would qualitatively hold.

[11] Lobbies' private information may be the results of experiments on animals leading insights on human consumption.

possibility to separate is based on the different amounts of resources owned by different types. It is implicitly assumed that both lobbies have sufficient retained profit to finance their advertising campaigns.[12,13] Then in the decision, stage governments simultaneously choose whether to permit or not the use of the innovation for the first period consumption. The decision to ban or admit innovative goods is ultimately in the government's hands and then consumers are passive actors in our game. Given a government's decision, consumers treat the two technologies as equal: they are not able to discriminate and there is no labeling. (The case with labeling will be discussed in section 6.) In the trade game firms compete on both the European and the American markets producing with the allowed technology which they own. In the case at least one government permits the innovative good, all the players observe the effects on consumption (true state of nature). A country ends up with a zero consumer surplus even if only a fraction of citizens consumed the harmful good and only the *status quo* good is allowed in second period. This can be seen as the consequence of a strong negative externality affecting all consumers in the country (e.g. policy makers know that even if only a small number of consumers is harmed, they greatly loose popularity between non harmed citizens too). We will account for both the cases in which having consumed an harmful good today does and does not affect the benefits of tomorrow's consumption, respectively long lasting and short lived effects. When the innovative good proves to be not harmful, it is allowed by both governments also in the second period. When none of the governments allows the innovative good in the first period, consumption provides no information. The timing is summarized in figure 1.

Players' strategies and payoffs. While player's preferences are defined over outcomes, outcomes are the consequences of policies and of the prevailing state of nature. Let $D = (d^U, d^E)$ denote governments' first period decisions

[12]Note that signalling with prices is not possible in our setting. In fact, decisions are taken after signalling and lobbies' types only differ in second period profits (see later). This means, that signalling in prices would amount in letting lobbies to announce the price they will use in the second period. Moreover, one would also have to assume that governments have the power to make pricing promises enforced.

[13]Signalling models of this type can be found in the political economy and in the advertising (industrial organization) literature. For the first strand see among the others Gerber (1996) and Pratt (1997), for the second see Kihlstrom and Riordan (1984) and Yang (1994).

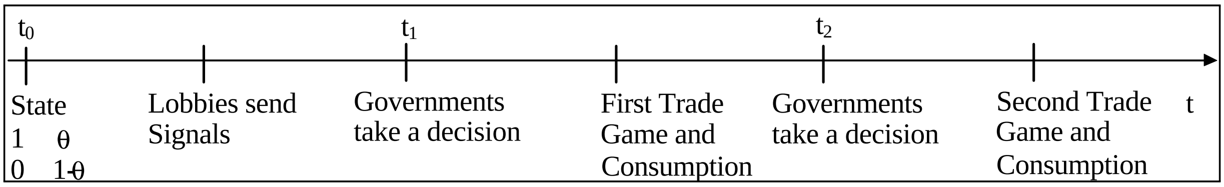

Figure 1:

with d^i belonging to the set of policies for each government $\{y, n\}$. With $d^i = y$ the new technology is allowed and with $d^i = n$ the new technology is banned. The vector of first period decisions D takes values in set $\Psi = \{N, NY, Y\}$ with $Y = (y, y)$ both countries admit the innovation, with $N = (n, n)$ both ban the good and with $D = NY \in \{(n, y), (y, n)\}$ one bans and the other admits the good.

Consumption of the innovative good fully reveal the true state of nature. Then, if first period consumption proved to be harmful, in second period both countries set $d = n$ otherwise $d = y$. We thus implicitly assume that, if the innovative good proves to be safe, country E prefers the larger consumption it can obtain with the innovative technology and is ready to sacrifice the local lobby's profit. (See the discussion of condition (1).)

As firms compete for each market, their profits depend on both governments' decisions. Π_n is the profit each firm earns in a single market where the innovative good is banned. $\Pi_y^U \geq (\Pi_n \geq)\Pi_y^E$ are respectively firm U and E profits earned in a country which allows the innovation. When $t = (t^E, t^U)$ firm j's profits are $\Pi_D^j(t) - A^j$ where

$$\Pi_D^j(t) = \sum_i \Pi_{d^i}^j + \hat{\Pi}_D^j(t),$$

and $\hat{\Pi}_D^j(t)$ is the second period profit. Discount rate is set to zero for simplicity. (See the discussion in section 6.) Firm j's profit, given his private information t^j and given countries' decisions is

$$\Pi_D^j\left[(t^j, 1)\right] p\left(1 \mid t^j\right) + \Pi_D^j\left[(t^j, 0)\right] p\left(0 \mid t^j\right) - A^j.$$

Note that second period profits $\hat{\Pi}_D^j(t)$depend on first period decisions of both countries. In fact, if both countries set $d^i = n$, there is no updating on health effects and second period decisions remain the same. On the contrary, if at least one country sets $d^i = y$, the effect of the innovative good is observed and the disclosed information affects second period decisions.

When $t = (t^E, t^U)$ government i's welfare is

$$W^i_D(t) = \alpha \left[\Pi^i_D(t) - A^i\right] + (1-\alpha) \left[CS_{d^i}(t) + \widetilde{CS}^i_D(t)\right],$$

where $CS_{d^i}(t)$ and $\widetilde{CS}^i_D(t)$ are respectively the expected values of the first and second period consumer's surpluses. When first period decision is n, then first period consumption is safe and $CS_n(t) = CS_n$, when it is y then $CS_y(t) = CS_y\ p(1 \mid t)$, with $CS_y \geq CS_n$.[14]

Second period consumer surpluses and profits with long lasting (LL) and short lived (SL) effects on health are summarized in the following table.

	Long Lasting	Short Lived
$\widetilde{\Pi}^j_N(t)$	$2\Pi^j_n$	$2\Pi^j_n$
$\widetilde{\Pi}^j_{NY}(t)$	$\Pi^j_n p(0 \mid t) + 2\Pi^j_y p(1 \mid t)$	$2\Pi^j_n p(0 \mid t) + 2\Pi^j_y p(1 \mid t)$
$\widetilde{\Pi}^j_Y(t)$	$2\Pi^j_y p(1 \mid t)$	$2\Pi^j_n p(0 \mid t) + 2\Pi^j_y p(1 \mid t)$
$\widetilde{CS}_N(t)$	CS_n	CS_n
$\widetilde{CS}^i_{NY}(t)$	$\begin{cases} d^i = y: & CS_y p(1 \mid t) \\ d^i = n: & CS_n p(0 \mid t) + CS_n p(1 \mid t) \end{cases}$	$CS_n p(0 \mid t) + CS_y p(1 \mid t)$
$\widetilde{CS}^i_Y(t)$	$CS_y p(1 \mid t)$	$CS_n p(0 \mid t) + CS_y p(1 \mid t)$

Table 1: Second period payoffs.

With LL the market of a country accepting an harmful innovation shuts down in second period and therefore there is neither consumption nor profits. On the contrary, with SL in second period consumers are again able to enjoy consumption and then second period profits are not zero.

It is important to note that each country's welfare depends on both countries' decisions for two reasons. Firstly, through domestic firm's profit, secondly through the second period consumer surplus.

Concerning second period decisions both countries allow the innovative consumption if it *proved to be safe* in first period and ban it otherwise. This is always true for country U as it gets larger consumer surplus and

[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 prevailing with d^i. The cost saving innovative technology implies $P^*_y \leq P^*_n$ and then $CS_y \geq CS_n$. Note that if $CS_n > CS_y$ and $\Pi_n > \Pi_y$ Europe would always ban the innovative good.

profits. Country E, informed on the safeness of the innovative good, prefers to consume more than to let the local lobby earn larger profits if

$$(1-\alpha)CS_y + \alpha\Pi_y^E \geq (1-\alpha)CS_n + \alpha\Pi_n \qquad (1)$$

This hold true whenever country E attaches a sufficiently higher weight to consumer surplus than to profits. With the previous assumption both governments face the issue of trading off risky consumption with domestic producers' profits. If countries attached too a large weight to profits these would be so important that the trade-off becomes irrelevant. Country U (E) would systematically admit (ban) the innovative good.

3 The Governments' decision game

Governments E and U observe messages $A = \left(A^U, A^E\right)$ which are sent simultaneously and decide what strategy to play. We will deal with pure strategies both for governments and lobbies.[15] A strategy of government i is then a function

$$d^i : \Re_+ \times \Re_+ \to \{n, y\}$$

Governments update their beliefs on consumption safeness $\mu(A) = p\,(1 \mid t)\,\lambda\,(t \mid A)\,,$ where $\lambda\,(t \mid A)$ is the probability that having observed message A types are t. The updating process will depend on the kind of equilibrium of the signaling game. If both lobbies play a separating strategy ($A^j\,(t^j) \neq A^j\left(\hat{t}^j\right)$, $t^j \neq \hat{t}^j$, for $j = E, U$) we say that the equilibrium is *fully informative.* In this case governments will learn both lobbies' types. If one lobby plays a separating strategy and the other a pooling strategy, we say the equilibrium is *partially informative.* Governments will be able to update their beliefs on one lobby's type. Finally, when both lobbies play a pooling strategy ($A^j\,(t^j) = A^j\left(\hat{t}^j\right)$, $t^j \neq \hat{t}^j$, for $j = E, U$), we say the equilibrium is *uninformative*, and governments will not update their beliefs.

Therefore, the kind of signaling game equilibrium and equilibrium messages let countries learn information I on the experimental results, where $I \in \mathcal{I}$ with $\mathcal{I} = \{I_j\}_{j=1,5}$ and $I_1 = (0,0)$, $I_2 = (0)$, $I_3 = \{(0,1), (1,0), \emptyset\}$, $I_4 = (1)$, $I_5 = (1,1)$. For example when a fully informative equilibrium prevails, countries may learn information in I_1, I_3, I_5 depending on lobbies

[15] Restricting lobbies strategies to be pure is without loss of generality.

messages. The ordering of set $\mathcal{I}$ implies that information I_{j+k}, $k \geq 0$, provides more favorable evidence for the innovation safeness than information I_j, other way stated $p(1|I_{j+k}) \geq p(1|I_j)$. Note that in a fully informative equilibrium when types are $t = (0,1)$ or $t = (1,0)$ governments remain with the same *a priori* on consumption safeness as in an uninformative equilibrium. The two pieces of evidence provided by the lobbies cancel out because of the uniform prior assumption.

We will use information I generated by the signalling game to study countries' behavior without the need to specify the kind of equilibrium prevailing. With a slight abuse of notation $W_D^i(I)$ denotes country i expected welfare and $D(I)$ the vector of decisions for a given information I. The normal form of governments' decision game is represented in the following table.

	$d^U = y$	$d^U = n$
$d^E = y$	$W_{yy}^U(I)$ $W_{yy}^E(I)$	$W_{ny}^U(I)$ $W_{ny}^E(I)$
$d^E = n$	$W_{yn}^U(I)$ $W_{yn}^E(I)$	$W_{nn}^U(I)$ $W_{nn}^E(I)$

Table 2: Governments' decision matrix

We now study governments' decisions. The following lemma deals with multiplicity of equilibria in the governments' decision game.

Lemma 1 *Both for LL and SL, multiple equilibria in decisions exist only if $D^* = NY$. If (n, y) is an equilibrium decision, so (y, n) is. If (y, n) is an equilibrium decisions, then (n, y) may or may not be an equilibrium decision.*

The lemma implies that when $D^* = Y$ or $D^* = N$ then equilibrium decisions are unique. We now study how governments' decisions change according to the available information.

Proposition 2 *(i) If $D^*(I_j) = Y$ then $D^*(I_{j+k}) = Y$ for any $k \geq 0$.*
(ii) If $D^*(I_j) = NY$ then $D^*(I_{j+k}) = N$ is impossible for any $k \geq 0$.

The proposition shows that (i) when both countries admit the innovative good for a certain information they also admit it for a more favorable (to the innovative good) information; (ii) when at least one of the two countries admits the good for a certain information, it is impossible that both the countries ban the good for a more favorable information. With proposition

2 one can summarize the changes in equilibria. In the following table, given the equilibrium prevailing with I_j indicated in the first column, the second column indicates the Nash equilibrium decisions which are not impossible with a better information I_{j+k}.

$D^*(I_j)$	$D^*(I_{j+k}), k \geq 0$
(y, y) (unique)	(y, y)
(y, n) (possibly multiple with (n, y))	$(y, n), (y, y)$
(n, y) (multiple with (y, n))	$(n, y), (y, y)$
(n, n) (unique)	$(n, n), (y, n), (n, y), (y, y)$

Table 3

An information which is more favorable to the innovative technology always increases the expected value of consumers' surplus in the payoffs of both countries. In fact, these are composed by terms CS_y weighted by $p(1|I_j)$ and/or terms CS_n weighted either by 1 or by $1 - p(1|I_j)$. Thus being $CS_y > CS_n$ a better reliability for the innovative technology ($I_{j+k} \geq I_j$ and then $p(1|I_{j+k}) \geq p(1|I_j)$) is a good news for both countries with respect to consumer surpluses. Consider now profits. Country U owns the innovative firm and experiments more favorable to the innovative technology are always good news. On the contrary, country E owns the competing *status quo* firm and experiments more favorable to the innovative technology are bad news.[16] Thus, for E two opposite effects are at play. However, when consumer surplus is evaluated sufficiently more than profits then the first effect prevails and payoffs increase with I_{j+k} also in E. For country E it turns out that condition (1) (i.e. safe consumption preferable for both countries) makes the consumption effect prevail over the profit one.

Allowing the innovative good, a country generates freely available information due to the effects of consumption. Thus, governments are confronted with a decision making problem where the information flow is endogenous (it depends on decisions) and is a strategic variable: each country would like the other to allow the innovative good, tests it and provide the information. Dealing with these two aspects, proposition 2 shows unexpected decision makers' behavior. It is possible that $D^*(I_j) = (y, n)$ while the equilibrium prevailing with more favorable information is $D^*(I_{j+k}) = (n, y)$. Similarly, it

[16]It is straightforward to see that if $\alpha = 1$, that is all the weight is given to profits, then the unique equilibrium which prevails for any I is (y, n).

may be $D^*(I_j) = (n, y)$ and $D^*(I_{j+k}) = (y, n)$. In both cases the decisions of the two countries reverse and go in directions opposite to the expected ones. The explanation of these two phenomena hinges on a free-riding behavior on information acquisition which can be summarized in the following corollary.

Corollary 3 *A country accepting the innovation for a given information may free-ride in information acquisition (with consumption) and ban the innovative good for more favorable information.*

$D^*(I_j) = (y, n)$ confirms what one should expect: country U which is more biased toward the innovative technology (to protect local industry) accepts the new good and country E, more biased for the traditional technology, bans it. An increase in the safeness of the new technology may make country E accepting the new good. However, in this way country E freely provides new information on the innovative good and, consequently, country U may decide to wait for the arrival of the information and temporarily ban the risky good ($D^*(I_{j+k}) = (n, y)$ prevails). Similarly it happens in the other case. Moreover notice that equilibrium $D^*(I_j) = (n, y)$ is somehow unexpected as E accepts the good while U, more biased for the innovation, bans it. This equilibrium can be explained with a similar reasoning. Country E, given that country U decides not to consume the innovative good, may decide to allow consumption in order to get the new information from consumption. Similarly, a single government who must rely only on its consumption decisions to obtain new information would generally accept the good more often than it would do facing another government. Assume $\alpha = 0$ and SL, it is simple to show that for $p(1|I) \in \left[\frac{CS_n}{2CS_y - CS_n}, \frac{CS_n}{CS_y}\right]$ the two decision makers say NY, while a single decision maker would say y.

Finally, notice that, the free riding behavior relies on small changes in the available information. In fact, when this is sufficiently large, then each country allows the innovation irrespectively of the other country's decision.

4 The Signaling game

Lobbies send signals simultaneously thus, when each lobby sends a message, it does not know what are the other lobby's type and message. Moreover, governments receive the two messages simultaneously. The strategy of lobby is the map,

$$A^j : \{0,1\} \rightarrow \Re_+$$

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

The equilibrium concept used for the signalling game is that of *sequential equilibrium.* Thus, a set of strategies $(d^{*\,E}, d^{*\,U}, A^{*\,E}, A^{*\,U})$ and a set of beliefs $\mu(A)$ form a sequential equilibrium if, (1) each agent takes an expected utility maximizing action conditional on the others' behavior and on the agent's beliefs; (2) beliefs are derived from Bayes' Rule when defined. A formal definition is given in Appendix.[17] We limit ourselves to the analysis of *fully informative* and of *partially informative* equilibria. We will not explicitly treat uninformative equilibria. To simplify notation we indicate with $\{D^*(I_1), D^*(I_3), D^*(I_5)\}$ and $\{D^*(I_2), D^*(I_4)\}$ decisions prevailing respectively in fully and partially informative equilibria.

Lemma 1 shows that *a priori* we cannot exclude the existence of multiple equilibria in the governments' decision game. Therefore, to study advertising behavior of lobbies one should answer the question of which equilibrium decisions lobbies think will prevail. However, note that multiplicity only exists with equilibrium decisions (n, y) and (y, n) which are payoff equivalent for lobbies. Therefore, lobbies will play the same strategies no matter what equilibrium decisions will prevail. Given that our goal is a comparison of LL and SL effects on information revelation by lobbies we will loosely refer to payoff equivalent (for the senders) equilibria as the same equilibria.[18]

To address advertising behavior note first that the cost of the message (i.e. the cost of advertising) does not depend on lobbies' types. Consider

[17]Our choice of sequential equilibrium has an important consequence on beliefs. Although this equilibrium concept places no restrictions on out of equilibrium beliefs, it has some impact on the kind of games with multiple receivers we are analyzing. The definition of 'consistency' in Kreps and Wilson (1982) implies that the receivers' beliefs can be regarded as the limit of a sequence of beliefs derived through Bayes' Rule from a sequence of completely mixed strategies. Since a single sequence defines the beliefs for both governments, their beliefs coincide along this sequence, and in its limit. So this equilibrium concept requires that receivers E and U possess the same beliefs in and out of the equilibrium path. This restriction makes the study of semi-separating equilibria tractable. See on this topic Banks (1991).

[18]For example when we say that a partially informative equilibrium arises when governments'decisions are $\{(n,n),(y,n)\}$, we live aside the companion equilibrium $\{(n,n),(n,y)\}$ which exist as well.

lobby E and define with $\bar{A}$ and $\underline{A}$ respectively the gain of type 0 and type 1 from making governments believe that the true type is 0 and not 1. Type 0 will be able to separate from type 1 if $\bar{A} > \underline{A}$. In fact, only in this case type 0 can set an advertising level $\bar{A} > A^* > \underline{A}$ such that type 1 does not find it profitable to mimic this advertising (its net gain from mimicking would be $\underline{A} - A^* < 0$) and such that the same type 0 gains more than the advertising expenses (net gain $\bar{A} - A^* > 0$). Inverting types the same reasoning can be followed for lobby U. We analyze information revelation by lobbies studying how $\bar{A} - \underline{A}$ varies according to countries' decisions and the kind of equilibrium prevailing (fully or partially informative). Lobbies' information revelation is studied in the following two propositions respectively for SL and LL effects.

Proposition 4 *With SL effects,*
(i) there exist no fully informative equilibria;
(ii) Partially informative equilibria arise only when decisions are $\{N, NY\}$ *or* $\{N, Y\}$*. Lobby U separates while lobby E pools.*

First note that the difference $\bar{A} - \underline{A}$ is the same for both lobbies. Moreover, with SL it can be shown that $\bar{A} - \underline{A}$ is either a linear function of the difference $\Pi_n - \Pi_y^j$ or zero. In the former case, when $\Pi_n - \Pi_y^j$ is positive for one lobby, it is negative for the other, and thus a fully informative equilibrium cannot exist while a partially informative equilibrium can exist. On the contrary, when decisions are such that the $\bar{A} - \underline{A}$ is zero, cost c to perform experiments makes unprofitable to experiment the innovative good and then lobbies have nothing to signal. To understand why $\bar{A} - \underline{A}$ with SL is either a linear function of $\Pi_n - \Pi_y^j$ or a zero, we note that $\bar{A} - \underline{A}$ can be divided in a first period and a second period difference. Both these differences are either zero or a linear function of $\Pi_n - \Pi_y^j$. Moreover, full informative equilibria do not exist also because whenever the two lobbies tried to advertise in order to convince countries, their information revelation may turn out with no effect on countries' updating of consumer safeness. This happens for example when lobby E and U signals respectively types 0 and 1. Facing information $I = (0, 1)$ countries remain with the same a priori and lobbies' activities *counteract* and cancel out. Concerning partially informative equilibria, in $\bar{A} - \underline{A}$ all the first period profits do not depend on types and always cancel out. Expected profits to be earned in the second period are the same whenever at least one country accepts the innovative good for any I and, as a consequence, the second period difference is zero. Moreover, in partially informative equilibria the only lobby which finds profitable to advertise is U. This is due to the fact that whenever $\bar{A} - \underline{A} \neq 0$ it is $\bar{A} - \underline{A} = [p(1|1) - p(1|0)] \left(\Pi_y^j - \Pi_n\right)$ which is positive only for $j = U$ and the innovative good lobby advertises even if the other does not.

With LL effects the following proposition summarizes the cases in which information revelation by lobbies arises.

Proposition 5 *With LL,*

(i) fully informative equilibria arise when the three decisions are different and, if $2\Pi_n > \Pi_y^U$, *when they are* $\{N, NY, NY\}$, $\{N, Y, Y\}$, $\{NY, Y, Y\}$;

(ii) partially informative equilibria arise when decisions are $\{NY, Y\}$, $\{N, Y\}$, $\{N, NY\}$. *In the first two cases both lobbies may separate. In the latter lobby U always separates and lobby E separates if* $2\Pi_y^E > \Pi_n$.

With LL, when first period decisions are NY or Y, expected second period profits are no more equal and then the payoffs' structure is more complex than with SL. This is due to the fact that when the innovative good is consumed in one country and proves to be harmful, then second period profit earned by lobbies in that country are always zero thus breaking the symmetry in the value of $\bar{A} - \underline{A}$.

Comparing LL and SL we can underline two effects. Firstly, with LL both types 0 and 1 of lobby E gain more respect to SL to make countries believe they are type 0 instead of type 1. Similarly, both types of lobby U gain less to make countries believe they are type 1 instead of type 0. Secondly, for lobby E the type who would like to separate ($t^E = 0$) gains more than the other type. Similarly, for lobby U the type who would like to mimic gains less than the other type. This second effect makes $\bar{A} - \underline{A} > 0$ more likely with LL than SL as the following corollary summarizes.

Corollary 6 *When consumption effects are long lasting lobbies are more useful in generating valuable information for countries' decisions.*

5 Scientific uncertainty as an informational barrier to trade

We now study how decisions and advertising are affected when consumption is less informative. For simplicity we assume the extreme case when consumption of the innovative good provides no information at all on health effects and the only information available is the one of lobbies. This analysis is related to the literature on decision theory which examines the effect of a better information structure on investment in prevention.[19] Gollier, Jullien and Treich (1999) noted that the intensity (rather than the probability) of potential losses could depend on the accumulation of earlier exposures to the risk. Therefore they interpret the Precautionary Principle as the need to reduce the expected financial impact of a loss, i.e., self-insurance. Immordino (1998) gives an alternative interpretation of the Precautionary Principle as requiring more self-protection rather than more self-insurance. The two approaches seem indeed to be complementary: the "self-insurance approach" is more suited to cases such as the greenhouse effect, whereas the "self-protection approach" better describes other scientific uncertainties. By limiting dangerous behaviors (e.g. eating less hormone beef), one actually lowers the probability of getting a diseases, not their intensity.

Our model is closer in spirit to the self-protection approach given that the consumption of the new product is characterized by a probability of being harmful. However, our setting differs from this literature because (i) decision makers act strategically, (ii) information generation is endogenous (when consumption is informative).

To isolate the effect due to the strategic behavior of the decisions makers we assume that the process of information generation is exogenous: before the second governments' decisions takes place, scientific progress completely eliminate the scientific uncertainty no matter if the good was consumed or not in first period. The only difference with the endogenous information case is in the payoffs of N. With this first period decisions, in second period countries can take advantage of scientific progress. When consumption does not provide any information on the riskiness of the innovative good, governments' decisions are the same in both periods. (Governments' decision matrices both for the exogenous and the no-information cases can be found in the Appendix.)

In our setting if governments adapted their choices to the Precautionary Principle they would ban consumption more often if more information is waited in the future. In fact we show that going from no information to perfect information it is impossible to accept the innovative good for a

[19] As defined by Ehrlich and Becker (1972) there are two methods for reducing the expected financial impact of a loss: reducing the probabilities of suffering losses (self-protection), and reducing the severity of a loss (self-insurance).

country that used to ban it. The following proposition states that scientific uncertainty pushes toward more conservative decisions today if effects of consumption on health are LL.

Proposition 7 *For the same set of parameters and for the same information transmitted by lobbies, when information is exogenous and perfect* $d^{*i} = y$ *is impossible if with no informative consumption* $d^{*i} = n$*. When consumption is non informative* $d^{*i} = n$ *is impossible if with exogenous and perfect information* $d^{*i} = y$*.*

The idea of Gollier and others was to rationalize the Precautionary Principle through the existence of an irreversibility effect. In their seminal works Arrow and Fisher (1974) and Henry (1974) establish the result that, given an irreversibility constraint, present actions should be restricted so as to keep options open in the future. In the literature, this is called the 'quasi-option effect'. That is, the more information the decision maker expects to receive, the less he will want to "throw it away" by constraining future choices. They showed that a risk-neutral agent should take stronger actions to prevent future irreversible risks if he expects obtaining better information. With the previous proposition we showed that this result extends to a setting where decision makers act strategically and the following result can be stated.

Corollary 8 *Scientific uncertainty can become an informational barrier to trade.*

Finally, with SL harmful consumption in first period has no effects on second period. Therefore there is no link between first period decision and second period payoff and there is no reason for governments to restrict first period consumption to take advantage of the information expected in the future.

6 Extensions

Asymmetric priors Our previous results are obtained under the assumption of a uniform prior distribution over θ. There exist at least two possible interpretations of scientific uncertainty. Firstly, uncertainty on critical issues in science can be considered subjective thus leading to different probability distribution for different agents (multiple priors approach). Secondly, when there exists no clear evidence in favor or against innovation safeness, uniform priors have some appeal on grounds of symmetry. It is however important to understand the extent to which our results are robust to alternative specifications. A natural generalization for asymmetric priors in our setting is the $Beta(a, b)$ distribution for θ. It can be easily shown that the only results which are affected by a and b different from 1 (which corresponds to the uniform case) are those in proposition 5. Moreover, a and b different from 1 may introduce new fully informative equilibria with LL, then corollary 6 holds a fortiori.

Labeling There are supporters of the idea to label goods and let consumers choose without governments participating in the decision process (this is often the position taken by the US authorities in the disputes with EU). Our model with $\alpha = 0$ corresponds to the case of labeling. In fact, there may exist two possibilities. Governments may or may not take part in the decision process. In the latter case the decision makers of our model with $\alpha = 0$ would exactly act as consumers who can choose and discriminate among labeled goods. In the former, if governments ban the good, consumers would have banned it *a fortiori*. If they admit it, consumers still have the possibility to choose the traditional good. In other words, governments tend to admit the innovation more often than consumers and do not restrict consumers' decision set. Once again, the relevant decision is that of consumers. All our results hold for a sufficiently small α as it can be seen in condition (1) and then for $\alpha = 0$.

Firms liability The innovative firm may be made liable for damages caused to consumers. It is then interesting to study how our model is affected when the innovator (lobby U) has to pay a penalty d if its good proves to be harmful. As one would expect firm's liability tends to increase the information provided by lobby U. It is now easier for $t^U = 1$ to separate from $t^U = 0$. In fact, with liability it gains relatively more to let countries know it is a type 1, than $t^U = 0$ could gain in doing so. The expected liability cost is smaller for $t^U = 1$ than for $t^U = 0$. It can then be shown that with SL fully informative equilibria may arise for a sufficiently high d. Similarly, with LL fully and partially informative are both more likely. Moreover, the liability d does not affect the comparison of necessary conditions for separation (in both fully and partially informative equilibria) with SL and LL and then separation with LL is still more likely than with SL. With this respect corollary (6) still holds. Finally, it can be shown that for a given equilibrium, a smaller d is required to have separation with LL than with SL.

Discounting the future *Ceteris paribus*, a discount rate $\delta \neq 1$ naturally implies different decisions of governments. However, it can be easily shown that the way governments' decisions are affected by information does not depend on the value of discounting. Consequently, both lemma 1 and proposition 2 hold for any δ. With SL proposition 4 is unchanged and, with LL, proposition 5 qualitatively holds (the fully informative equilibria condition becomes $(1+\delta)\Pi_n > \Pi_y^U$). Thus also corollary 6 remains true. Finally, proposition 7 and corollary 8 simply hold for any δ.

7 Conclusion

We argued that most of actual trade disputes are linked to informational issues. When a new product or process is lunched in the market, countries have to decide if to allow consumption or not. This decision could be particularly difficult if there are doubts on the safeness of the new product. This happens everyday for genetically modified plants, for the meat of animals grown with hormones, for chicken carcasses washed with chlorine solution, etc. It is striking to see that most of the above quoted cases both lack of definitive scientific testing and are at the center of international trade disputes.

We show that scientific uncertainty is an informational barrier to trade. Protectionism may arise because of the uncertainty related to these new goods, governments ban consumption more often if more information is waited in the future. We also study the informative role played by producers in revealing information. We find that producers revel more information when the effects of harmful consumption on health are long lasting. Finally, we identify a free riding effect in governments' decisions. Allowing the innovative good, a country generates new information given by the observation of the effects on consumption. Once produced, information is freely available therefore each country would like the other to allow the innovative good, tests it and make the information public.

References

[1] Arrow, K.J., and Fisher, A.C., (1974), Environmental preservation uncertainty, and irreversibility, *Quarterly Journal of Economics*, 88, 312-319.

[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] Banks, J.S., (1991), *Signaling Games in Political Science, fundamentals of pure and applied economics*, Harwood Academic Publishers.

[7] Brander, J.A., and Krugman, P., (1983), A "Reciprocal Dumping" model of international trade, *Journal of International Economics*, 15, 313-323.

[8] Dewatripont M. and J. Tirole (1999), Advocates, *Journal of Political Economy*, 107, 1-39.

[9] Ehrlich, I.,and Becker, G., (1972), Market insurance, self-protection and self-insurance, *Journal of Political Economy*, July-August, 623-648.

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

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

[12] Gollier, C., Jullien, B., and Treich, N., (1999), Learning and irreversibility: An economic interpretation of the "Precautionary Principle", *Journal of Public Economics.*

[13] Grossman, G., and Helpman, E., (1994), Protection for sale, *American Economic Review*, 84, 883-850.

[14] Henry, C., (1974), Investment decisions under uncertainty: the irreversibility effect, *American Economic Review*, 64, 1006-1012.

[15] Immordino, G., (1998), Self-protection, information and the Precautionary Principle, mimeo, Université de Toulouse.

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

[17] Kreps, D., and Wilson, R., (1982), Sequential Equilibrium, *Econometrica* 50, 863-894.

[18] Krishna, V., and Morgan J., (1998), A Model of expertise, mimeo.

[19] Krugman, P., (1987), Is free trade passé, *Journal of Economics Perspectives*, 1, 131-144.

[20] Martimort, D., (1996), The multiprincipal nature of government, *European Economic Review*, 40, 673-685.

[21] Pratt, A., (1997), Campaign advertising and voter welfare, working paper of the Departement of Econometrics, Tilburg University.

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

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

8 Appendix

Definition of Sequential Equilibrium

A list of strategies $(d^{*E}, d^{*U}, A^{*E}, A^{*U})$ and a set of beliefs $\lambda(t \mid A)$ constitute an equilibrium if:

(C1) $\forall j \in \{E, U\}, \forall t^j \in \{0,1\}, A^{*\,j} \in \arg\max_{A^j} E_{t\text{-}j} U^j \left(d^{*E}, d^{*U}, A^j, t^j, t^{\text{-}j}\right)$ where $E_{t\text{-}j} U^j \left(d^{*E}, d^{*U}, A^j, t^j, t^{\text{-}j}\right) =$

$\sum_{t\text{-}j} p\left(t^{\text{-}j} \mid t^j\right) \Pi_D^j \left(A^j, t\right)$ and the index $\text{-}j$ stands for the other lobby;

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

where $U^i \left(\mu^A, d^{*\text{-}i}, A^*, d^i\right) = \sum_{t \in T} \lambda\left(t \mid A^*\right) W_{d^i d^{*\text{-}i}} \left(A^i, t\right)$, 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 (t) or information (I). $p(1|t) = \int_0^1 \theta f(\theta|t) d\theta$ where θ is the unknown probability of state 1 and $f(\theta|t)$ is its conditional distribution. We have $f(\theta|t) = h(t|\theta)g(\theta)/h(t)$ where $g(.)$ is the common knowledge prior on θ, $h(t|\theta)$ is the probability that given a certain θ the experiments yield to result t and $h(t) = \int_0^1 h(t|\theta)g(\theta)d\theta$. Thus we can write,

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

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

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 $p(1|01) = p(1|10) = (1+a)/(2+a+b)$, $p(1|00) = a/(2+a+b)$, $p(1|1) = (1+a)/(1+a+b)$, $p(1|0) = a/(1+a+b)$. Of course the uniform prior correspond to the Beta case with $a = b = 1$.

Proof of lemma 1

(i) If (n,y) is an equilibrium pair of decisions, then $W^E_{ny}(I) - W^E_{nn}(I) \geq 0$ and $W^U_{ny}(I) - W^U_{yy}(I) \geq 0$. It is then simple to show that the first implies $W^U_{yn}(I) - W^U_{nn}(I) \geq 0$ and the second implies $W^E_{yn}(I) - W^E_{yy}(I) \geq 0$. In fact, in the former case it is, both for LL and SL,

$$\left[W^U_{yn}(I) - W^U_{nn}(I)\right] - \left[W^E_{ny}(I) - W^E_{nn}(I)\right] = \alpha\left(\Pi^U_y - \Pi^E_y\right)[1 + 2p(1|I)] > 0$$

and then $\left[W^U_{yn}(I) - W^U_{nn}(I)\right] > 0$. Similarly,

$$\left[W^E_{yn}(I) - W^E_{yy}(I)\right] - \left[W^U_{ny}(I) - W^U_{yy}(I)\right] = \alpha\left(\Pi^U_y - \Pi^E_y\right) > 0.$$

(ii) Proceeding as in (i) one can show that if $W^E_{yn}(I) - W^E_{yy}(I) \geq 0$ and $W^U_{yn}(I) - W^U_{nn}(I) \geq 0$, the following may or may not be true, $W^E_{ny}(I) - W^E_{nn}(I) \geq 0$ and $W^U_{ny}(I) - W^U_{yy}(I) \geq 0$.

(iii) We show that if $W^U_{nn}(I) - W^U_{yn}(I) \geq 0$ then $W^U_{yy}(I) - W^U_{ny}(I) \geq 0$ is impossible. With simple algebra one can write, both for LL and SL,

$$W^U_{yy}(I) - W^U_{ny}(I) = -\left[W^U_{nn}(I) - W^U_{yn}(I)\right] - p(1|I)\left[(1-\alpha)(CS_y - CS_n) + 2\alpha(\Pi^U_y - \Pi_n)\right]$$

The second square bracket on the r.h.s. is strictly positive and this prove the result. (Notice that, obviously, if a certain cell in the matrix for the decision game (table 2) is an equilibrium, none of the adjacent cells can be an equilibrium). Finally, reverting the proof one shows that if (y,y) is an equilibrium then (n,n) can never be so. ■

Proof of proposition 2

First we sign the effects of a greater I on countries' payoffs. Then, for each couple of equilibrium decisions we verify how necessary conditions are affected by the change in I. With SL, let us define $\Delta W^i_D = W^i_D(I_j) - W^i_D(I_{j+k})$ with

$k \geq 0$. We then have,

$$\begin{array}{ll} (a) & \Delta W^U_{nn} = 0 \\ (b) & \Delta W^U_{ny} = \Delta p \left[2\alpha \left(\Pi^U_y - \Pi_n\right) + (1-\alpha)(CS_y - CS_n)\right] > 0 \\ (c) & \Delta W^U_{yn} = \Delta W^U_{yy} = \Delta_t p (1-\alpha) CS_y + \Delta W^U_{ny} > 0 \\ (d) & \Delta W^E_{nn} = 0 \\ (e) & \Delta W^E_{yn} = \Delta p \left[2\alpha \left(\Pi^E_y - \Pi_n\right) + (1-\alpha)(CS_y - CS_n)\right] \\ (f) & \Delta W^E_{ny} = \Delta W^E_{yy} = \Delta p (1-\alpha) CS_y + \Delta W^E_{yn} \end{array}$$

with $\Delta p = p(1 \mid I_{j+k}) - p(1 \mid I_j) > 0$.

(i) For $D(I_j) = (y, y)$ to be an equilibrium it must be that $W^U_{yy}(I_j) - W^U_{ny}(I_j) \geq 0$ and $W^E_{yy}(I_j) - W^E_{yn}(I_j) \geq 0$ and we ask if these inequalities still hold with $I_{j+k}, k \geq 0$. The answer is yes, in fact in both of them the first term increases more than the second (see (c) and (f)). Thus, if $D^*(I_j) = (y, y)$ then $D^*(I_{j+k}) = (y, y)$. Moreover, the previous lemma showed that equilibrium (y, y) is unique and then starting with this equilibrium an increase in I can only lead to the same (unique) equilibrium.

(ii-a) Now we prove that $D^*(I_j) = (y, n)$ and $D^*(I_{j+k}) = (n, n)$ are impossible. In fact, looking at the previous (a) and (c) we see that if country U prefers equilibrium (y, n) to (n, n) with I_j then it can not prefer (n, n) to (y, n) with I_{j+k}.

(ii-b) We now prove that $D^*(I_j) = (n, y)$ and $D^*(I_{j+k}) = (n, n)$ is impossible. Suppose, on the contrary that decisions follow the previous pattern. For this to happen it must be $\Delta W^E_{ny} - \Delta W^E_{nn} \leq 0$ or

$\Delta p \left[\ 2\alpha \left(\Pi^E_y - \Pi_n\right) + \ (1-\alpha)(2CS_y - CS_n)\right] \leq 0$, or, again,

$$\alpha \geq \tilde{\alpha} \equiv \frac{2CS_y - CS_n}{2\left(\Pi_n - \Pi^E_y\right) + (2CS_y - CS_n)}$$

However, condition (1) requires that $\alpha \leq \hat{\alpha}$ with

$$\hat{\alpha} \equiv (CS_y - CS_n) / \left[\left(\Pi_n - \Pi^E_y\right) + (CS_y - CS_n)\right]$$

and it then remains to prove that $\hat{\alpha} - \tilde{\alpha} \leq 0$ to exclude the case at hand. Define $\pi \equiv \Pi_n - \Pi^E_y$ and $\gamma \equiv CS_y - CS_n$, we can write

$$\hat{\alpha} - \tilde{\alpha} \ = \ \frac{\gamma}{\pi + \gamma} - \frac{2\gamma + CS_n}{2\pi + 2\gamma + CS_n}$$

$$
\begin{aligned}
&= \frac{\gamma\left(2\pi+2\gamma+CS_n\right)-\left(2\gamma+CS_n\right)\left(\pi+\gamma\right)}{\left(\pi+\gamma\right)\left(2\pi+2\gamma+CS_n\right)}\\
&= \frac{-\pi\ CS_n}{\left(\pi+\gamma\right)\left(2\pi+2\gamma+CS_n\right)}<0
\end{aligned}
$$

which concludes the proof.[20]

Concerning LL effects (a)-(f) rewrite as follows:

$$
\begin{aligned}
&(a)\ \ \Delta W_{nn}^{U}=0\\
&(b)\ \ \Delta W_{ny}^{U}=\Delta p\left[\alpha\left(2\Pi_y^U-\Pi_n\right)+(1-\alpha)\left(CS_y-CS_n\right)\right]>0\\
&(c)\ \ \Delta W_{yn}^{U}=\Delta p\left[2\left(1-\alpha\right)CS_y+\alpha\left(2\Pi_y^U-\Pi_n\right)\right]>0\\
&(c')\ \ \Delta W_{yy}^{U}=\Delta p2\left[\left(1-\alpha\right)CS_y+\alpha\Pi_y^U\right]>0\\
&(d)\ \ \Delta W_{nn}^{E}=0\\
&(e)\ \ \Delta W_{yn}^{E}=\Delta p\left[\alpha\left(2\Pi_y^E-\Pi_n\right)+(1-\alpha)\left(CS_y-CS_n\right)\right]\\
&(f)\ \ \Delta W_{ny}^{E}=\Delta p\left[2\left(1-\alpha\right)CS_y+\alpha\left(2\Pi_y^E-\Pi_n\right)\right]\\
&(f')\ \ \Delta W_{yy}^{E}=\Delta p2\left[\left(1-\alpha\right)CS_y+\alpha\Pi_y^E\right]>0
\end{aligned}
$$

Then the proofs for (i) and (ii-a) similarly follow. For (ii-b) one similarly proves that $\hat{\alpha}-\tilde{\alpha}=\frac{\gamma}{\pi+\gamma}-\frac{2\gamma+2CS_n}{2\pi+2\gamma+2CS_n-\Pi_n}<0$. ■

Proof of propositions 3 and 4

We first need three intermediary lemmas

Lemma 9 *With LL and SL there exist no separating equilibrium when the three decisions* $\{D(I_1),D(I_3),D(I_5)\}$ *are equal.*

Proof. Observing messages, governments learn information I which, in this kind of equilibrium, corresponds to lobbies types $t=(t^U,t^E)\in\{(0,0),(0,1),(1,0),(1,1)\}$. 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 10 ***Fully Informative Equilibria.*** *With LL and SL the advertising levels* $(A^{*U}(1),A^{*U}(0),A^{*E}(1),A^{*E}(0))$ *are separating equilibrium strategies iff* $A^{*U}(0)=A^{*E}(1)=0$, $\underline{A}^U\leq A^{*U}(1)\leq\bar{A}^U$, $\underline{A}^E\leq A^{*E}(0)\leq\bar{A}^E$,

[20] Notice that both $(\pi+\gamma)$ and $(2\pi+2\gamma+CS_N)$ are strictly positive.

where $\underline{A}^U = -\bar{A}^E = A'$ $\bar{A}^U = -\underline{A}^E = A''$ *and*

$$\begin{aligned} A'' &\equiv \Pi^U_{D(A^{*U}(1),A^{*E}(1))}\left((1,1)\right)p(1|1) + \Pi^U_{D(A^{*U}(1),A^{*E}(0))}\left((1,0)\right)p(0|1) + \\ &\quad -\Pi^U_{D(0,A^{*E}(1))}\left((1,1)\right)p(1|1) - \Pi^U_{D(0,A^{*E}(0))}\left((1,0)\right)p(0|1), \\ A' &\equiv \Pi^U_{D(A^{*U}(1),A^{*E}(1))}\left((1,0)\right)p(1|0) + \Pi^U_{D(A^{*U}(1),A^{*E}(0))}\left((0,0)\right)p(0|0) + \\ &\quad -\Pi^U_{D(0,A^{*E}(1))}\left((1,0)\right)p(1|0) - \Pi^U_{D(0,A^{*E}(0))}\left((0,0)\right)p(0|0), \end{aligned}$$

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

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

where, given the specified beliefs, $D(A^U, A^{*E}(1))$, $D(A^U, A^{*E}(0))$ are decisions respectively taken when types are believed (0,1) (0,0), as long as $A^U \neq A^{*U}(1)$. Maximizing the previous expression w.r.t. A^U optimal advertising is zero, then a necessary and sufficient condition for (C1) in the definition of the sequential equilibrium (see previously in the appendix) to hold for $j = U$, $t^U = 1$ is,

$$\begin{aligned} &\Pi^U_{D(A^{*U}(1),A^{*E}(1))}\left((1,1)\right)p(1|1) + \Pi^U_{D(A^{*U}(1),A^{*E}(0))}\left((1,0)\right)p(0|1) - A^{*U}(1) \geq \\ &\geq \Pi^U_{D(0,A^{*E}(1))}\left((1,1)\right)p(1|1) + \Pi^U_{D(0,A^{*E}(0))}\left((1,0)\right)p(0|1) \end{aligned} \tag{2}$$

or

$$A'' \geq A^{*U}(1)$$

Similarly, type 0 of lobby U, setting a $A^U \neq A^{*U}(1)$, can get a profit

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

that is, at maximum,

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

Thus a necessary and sufficient condition for (C1) to hold for $j = U$, $t^U = 0$ is,

$$\Pi^U_{D(A^{*U}(1),A^{*E}(1))}((1,0))\,p(1|0) + \Pi^U_{D(A^{*U}(1),A^{*E}(0))}((0,0))\,p(0|0) - A^{*U}(1) \leq$$
$$\leq \Pi^U_{D(0,A^{*E}(1))}((1,0))\,p(1|0) + \Pi^U_{D(0,A^{*E}(0))}((0,0))\,p(0|0) \quad (3)$$

or

$$A' \leq A^{*U}(1)$$

Putting together (2) and (3) we obtain,

$$A' \leq A^{*U}(1) \leq A''$$

It is thus necessary that

$$\bar{A}^U - \underline{A}^U = A'' - A' \geq 0 \quad (4)$$

Consider now lobby E. Type 0 wants to separate from type 1 and proceeding in a similar way as with lobby U, conditions (2) and (3) have the equivalents $\bar{A}^E \geq A^{*E}(0)$, $\underline{A}^E \leq A^{*E}(0)$ with $\underline{A}^E = -A''$ $\bar{A}^E = -A'$. Putting together the two, a necessary condition is

$$\bar{A}^E - \underline{A}^E = A'' - A' \geq 0 \quad (5)$$

(note that $\bar{A}^E - \underline{A}^E$ is equal to $\bar{A}^U - \underline{A}^U$ permuting lobbies' indexes in profits). ■

Lemma 11 ***Partially Informative Equilibria.*** *With LL and SL, if lobby U separates, the advertising levels* $(A^{*U}(1), A^{*U}(0))$ *are separating equilibrium strategies iff* $A^{*U}(0) = 0$, $\underline{A}^U \leq A^{*U}(1) \leq \bar{A}^U$. *If lobby E separates, the advertising levels* $(A^{*E}(1), A^{*E}(0))$ *are separating equilibrium strategies iff* $A^{*E}(1) = 0$, $\underline{A}^E \leq A^{*E}(0) \leq \bar{A}^E$, *where*

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

Out of equilibrium believes satisfy the following conditions,

$$\beta^j_h \leq \bar{\beta}^j_h \quad (6)$$

with $\bar{\beta}^j_h \equiv$

$$\frac{\Pi^j_{D(0,A^{*-j}(0))}((h,0))p(0|h)+\Pi^j_{D(0,A^{*-j}(1))}((h,1))p(1|h)+\varepsilon-\Pi^j_{D(\varepsilon,A^{*-j}(0))}((h,0))p(0|h)-\Pi^j_{D(\varepsilon,A^{*-j}(1))}((h,1))p(1|h)}{\Pi^j_{D(\varepsilon,A^{*-j}(0))}((h,0))p(0|h)+\Pi^j_{D(\varepsilon,A^{*-j}(1))}((h,1))p(1|h)-\Pi^j_{D(\varepsilon,A^{*-j}(0))}((h,0))p(0|h)-\Pi^j_{D(\varepsilon,A^{*-j}(1))}((h,1))p(1|h)}$$

$\varepsilon > 0$ *and* $h = 0, 1$, $j = E, U$.

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 $h = 0, 1$ which make indeed both lobby j's types pooling. For type $h = 0, 1$ of lobby $j = E, U$ the condition is the following,

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

$$\geq \beta^j_h \left[\Pi^j_{D(\varepsilon,A^{*-j}(0))}((h,0))\,p(0|h) + \Pi^j_{D(\varepsilon,A^{*-j}(1))}((h,1))\,p(1|h)\right] +$$

$$+\left(1-\beta^j_h\right)\left[\Pi^j_{D(\varepsilon,A^{*-j}(0))}((h,0))\,p(0|h) + \Pi^j_{D(\varepsilon,A^{*-j}(1))}((h,1))\,p(1|h)\right] - \varepsilon$$

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

Proof of proposition 4

(i) In a fully informative equilibrium A^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 $t = (t^U, t^E)$. The next step is to show when either $\bar{A}^E - \underline{A}^E$ or $\bar{A}^U - \underline{A}^U$ are non positive and the necessary conditions are violated (see lemma 10).

Using table 2 one simply derives all the possible cases which are summarized in the next table. Then explicitly calculating $\bar{A}^U - \underline{A}^U$, $\bar{A}^E - \underline{A}^E$ we verify when one of the two is strictly negative. Note that when equilibrium decisions are $\{NY, NY, NY\}$, 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	$\bar{A}^j - \underline{A}^j$
(1)	$\{N, N, NY\}$	$\Pi^j_y - \Pi_n$
(2)	$\{N, N, Y\}$	$(\Pi^j_y - \Pi_n)4/3$
(3)	$\{NY, NY, Y\}$	$(\Pi_n - \Pi^j_y)/3$
(4)	$\{N, NY, NY\}$	$(\Pi_n - \Pi^j_y)/3$
(5)	$\{N, Y, Y\}$	$(\Pi_n - \Pi^j_y)2/3$
(6)	$\{NY, Y, Y\}$	$(\Pi_n - \Pi^j_y)/3$
(7)	$\{N, NY, Y\}$	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, $\bar{A}^j -$

$\underline{A}^j = 0$ 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 A^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 $t^j \in \{0, 1\}$. The next step is to show when either $\bar{A}^E - \underline{A}^E$ or $\bar{A}^U - \underline{A}^U$ are non positive and the necessary conditions for the partially informative equilibrium are violated (see lemma 11). All the possible cases are summarized in the next table. Explicitly calculating $\bar{A}^U - \underline{A}^U$, $\bar{A}^E - \underline{A}^E$ we verify when one of the two is strictly negative.

	Decisions	$\bar{A}^j - \underline{A}^j$
(1)	$\{NY, Y\}$	0
(2)	$\{N, NY\}$	$\left(\Pi_y^j - \Pi_n\right) 2/3$
(3)	$\{N, Y\}$	$\left(\Pi_y^j - \Pi_n\right) 2/3$

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 $\bar{A}^j - \underline{A}^j > 0$ 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 (6) in lemma 11. 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.	$\bar{\beta}_0^j$	$\bar{\beta}_1^j$
$\{N, NY\}$	$\{(n,n),(n,n),(n,y)\}$	1	1
$\{N, NY\}$	$\{(n,n),(n,n),(y,y)\}$	2/3	5/7
$\{N, NY\}$	$\{(n,n),(n,y),(n,y)\}$	0	0
$\{N, NY\}$	$\{(n,n),(n,y),(y,y)\}$	0	0
$\{N, Y\}$	$\{(n,n),(n,n),(y,y)\}$	1	1
$\{N, Y\}$	$\{(n,n),(n,y),(y,y)\}$	1/4	1/2
$\{N, Y\}$	$\{(n,n),(y,y),(y,y)\}$	0	0

■

Proof of proposition 5

(i) The proof follows the lines of proposition 4 and then we directly provide the table of equilibrium decisions.

	Decisions	$\bar{A}^j - \underline{A}^j$
(1)	$\{N, N, NY\}$	$\Pi_y^j - \Pi_n$
(2)	$\{N, N, Y\}$	$4/3\left(\Pi_y^j - \Pi_n\right)$
(3)	$\{NY, NY, Y\}$	$1/3\left(\Pi_y^j - \Pi_n\right)$
(4)	$\{N, NY, NY\}$	$1/3\left(2\Pi_n - \Pi_y^j\right)$
(5)	$\{N, Y, Y\}$	$2/3\left(2\Pi_n - \Pi_y^j\right)$
(6)	$\{NY, Y, Y\}$	$1/3\left(2\Pi_n - \Pi_y^j\right)$
(7)	$\{N, NY, Y\}$	$\Pi_n/3$

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

(ii) Concerning partially informative equilibria the proof is as in proposition 4 and then we directly provide the table of equilibrium decisions and out-of-equilibrium believes.

	Decisions	$\bar{A}^j - \underline{A}^j$
(1)	$\{NY, Y\}$	$\Pi_n/3$
(2)	$\{N, NY\}$	$\left(2\Pi_y^j - \Pi_n\right)/3$
(3)	$\{N, Y\}$	$\Pi_y^j 2/3$

Equilibrium	Out-of-Equ.	$\bar{\beta}_0^j$	$\bar{\beta}_1^j$
$\{NY, Y\}$	$\{(y,n),(y,n),(y,y)\}$	1	1
$\{NY, Y\}$	$\{(y,n),(y,y),(y,y)\}$	0	0
$\{NY, Y\}$	$\{(n,n),(y,n),(y,y)\}$	1	1
$\{NY, Y\}$	$\{(n,n),(y,y),(y,y)\}$	$\frac{4\Pi_y^j - 5\Pi_n}{6\Pi_y^j - 8\Pi_n}$	$\frac{6\Pi_y^j - 9\Pi_n}{2(5\Pi_y^j - 8\Pi_n)}$
$\{N, NY\}$	$\{(n,n),(n,n),(n,y)\}$	1	1
$\{N, NY\}$	$\{(n,n),(n,n),(y,y)\}$	$\frac{4\Pi_y^j - 6\Pi_n}{6\Pi_y^j - 8\Pi_n}$	$\frac{5\Pi_y^j - 6\Pi_n}{7\Pi_y^j - 8\Pi_n}$
$\{N, NY\}$	$\{(n,n),(n,y),(n,y)\}$	0	0
$\{N, NY\}$	$\{(n,n),(n,y),(y,y)\}$	0	0
$\{N, Y\}$	$\{(n,n),(n,n),(y,y)\}$	1	1
$\{N, Y\}$	$\{nn, ny, yy\}$	$\frac{\Pi_y^j - \Pi_n}{4\Pi_y^j - 7\Pi_n}$	$\frac{2(\Pi_y^j - \Pi_n)}{4\Pi_y^j - 5\Pi_n}$
$\{N, Y\}$	$\{nn, yy, yy\}$	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 $\{NY, Y\}$, $\{(n,n),(y,y),(y,y)\}$ simple algebra shows that E always separate, while to have U separating it must be $\Pi_y^U \notin [5/4\Pi_n, 8/5\Pi_n]$. When equilibrium and out-of-equilibrium decisions are respectively $\{N, NY\}$, $\{(n,n),(n,n),(y,y)\}$ simple algebra shows that E always separate, while to have U separating it must be $\Pi_y^U \notin [8/7\Pi_n, 3/2\Pi_n]$. When equilibrium and out-of-equilibrium decisions are respectively $\{N, Y\}$, $\{(n,n),(n,y),(y,y)\}$ simple algebra shows that E always separate, while to have U separating we must have that $\Pi_y^U > 7/4\Pi_n$. ■

Proof of proposition 7

When consumption does not provide any information on the riskiness of the innovative good, governments' decisions are the same in both periods and the payoff matrix with respect to decisions, for a certain I, is the following table.

	y	n
y	$\alpha(4\Pi_y^U - A^U) + (1-\alpha)2CS_y(I)$ $\alpha(4\Pi_y^E - A^E) + (1-\alpha)2CS_y(I)$	$\alpha\left(2\Pi_y^U + 2\Pi_n - A^U\right) + (1-\alpha)2CS_n$ $\alpha(2\Pi_y^E + 2\Pi_n - A^E) + (1-\alpha)2CS_y(I)$
n	$\alpha\left(2\Pi_y^U + 2\Pi_n - A^U\right) + (1-\alpha)2CS_y(I)$ $\alpha\left(2\Pi_y^E + 2\Pi_n - A^E\right) + (1-\alpha)2CS_n$	$\alpha(4\Pi_n - A^U) + (1-\alpha)2CS_n$ $\alpha(4\Pi_n - A^E) + (1-\alpha)2CS_n$

Table 3: Non informative consumption

If we assume LL the payoff matrix is the following.

	y	n
y	$\alpha(2\Pi_y^U - A^U) + (1-\alpha)CS_y(I)$ $+p(1 \mid I)\left[\alpha 2\Pi_y^U + (1-\alpha)CS_y\right]$ $\alpha(2\Pi_y^E - A^E) + (1-\alpha)CS_y(I)$ $+p(1 \mid I)\left[\alpha 2\Pi_y^E + (1-\alpha)CS_y\right]$	$\alpha\left[\left(\Pi_y^U + \Pi_n\right) - A^U\right] + (1-\alpha)CS_n$ $+p(0 \mid I)\left[\alpha\Pi_n + (1-\alpha)CS_n\right]$ $+p(1 \mid I)\left[\alpha 2\Pi_y^U + (1-\alpha)CS_y\right]$ $\alpha[(\Pi_y^E + \Pi_n) - A^E] + (1-\alpha)CS_y(I)$ $+p(0 \mid I)\alpha\Pi_n$ $+p(1 \mid I)\left[\alpha 2\Pi_y^E + (1-\alpha)CS_y\right]$
n	$\alpha[\left(\Pi_y^U + \Pi_n\right) - A^U] + (1-\alpha)CS_y(I)$ $+p(0 \mid I)\alpha\Pi_n$ $+p(1 \mid I)\left[\alpha 2\Pi_y^U + (1-\alpha)CS_y\right]$ $\alpha\left[\left(\Pi_y^E + \Pi_n\right) - A^E\right] + (1-\alpha)CS_n$ $+p(0 \mid I)\left[\alpha\Pi_n + (1-\alpha)CS_n\right]$ $+p(1 \mid I)\left[\alpha 2\Pi_y^E + (1-\alpha)CS_y\right]$	$\alpha(2\Pi_n - A^U) + (1-\alpha)CS_n$ $+p(0 \mid I)\left[\alpha 2\Pi_n + (1-\alpha)CS_n\right]$ $+p(1 \mid I)\left[\alpha 2\Pi_y^U + (1-\alpha)CS_y\right]$ $\alpha(2\Pi_n - A^E) + (1-\alpha)CS_n$ $+p(0 \mid I)\left[\alpha 2\Pi_n + (1-\alpha)CS_n\right]$ $+p(1 \mid I)\left[\alpha 2\Pi_y^E + (1-\alpha)CS_y\right]$

Table 4: Exogenous Information

Firstly, we need to compare decisions in the two cases when governments are provided with the same ex-ante information set (priors on θ). Secondly, observe that with non informative consumption profits do not depend on types, thus lobbies can never send credible signals to governments. With no information revelation, governments are left with unchanged uniform priors on θ. Thus, in the case of non informative consumption one has to consider either pooling or separating equilibria in which the revealed information $I \in I_3$. In all these cases $p(1 \mid I) = p(0 \mid I) = 1/2$. It is easy to verify that the equilibrium $(n, y)_{no-\inf}$ (the subscript $no - \inf$ stands for non informative consumption) and the equilibrium $(n, y)_{\inf}$ (inf stands for exogenous information) are impossible.

For the first part of the proposition we prove that, given a certain country's decision is a n with no informative consumption, it is impossible that its decision turns to a y with exogenous information. More specifically, (i-a) given an equilibrium $(y, n)_{no-\inf}$the following equilibrium is impossible $(y, y)_{\inf}$. Similarly, (ii-a) with $(n, n)_{no-\inf}$ it is impossible that $\{(y, n), (y, y)\}_{\inf}$. Let us denote with $(W_D^i)_{\inf}$, $(W_D^i)_{no-\inf}$ the payoffs of government i with decisions D respectively with and without information.

(i-a) To have $(y, n)_{no-\inf}$ as an equilibrium it is needed that $\left(W_{yn}^E - W_{yy}^E\right)_{no-\inf} \equiv F > 0$ and $\left(W_{yn}^U - W_{nn}^U\right)_{no-\inf} > 0$. To have $(y, y)_{\inf}$ as an equilibrium it is needed that $\left(W_{yy}^E - W_{yn}^E\right)_{\inf} > 0$ and $\left(W_{yy}^U - W_{ny}^U\right)_{\inf} > 0$. With simple algebra one shows that $\left(W_{yy}^E - W_{yn}^E\right)_{\inf} < -F$ and then $\left(W_{yn}^E - W_{yy}^E\right)_{no-\inf} > 0$ and $\left(W_{yy}^E - W_{yn}^E\right)_{\inf} > 0$ are not compatible.

(ii-a) Proceeding as in (i-a) one finds that $\left(W_{nn}^E - W_{ny}^E\right)_{no-\inf} \equiv F > 0$ and $\left(W_{nn}^U - W_{yn}^U\right)_{no-\inf} = B > 0$ are required for $(n, n)_{no-\inf}$ but $\left(W_{yy}^E - W_{yn}^E\right)_{\inf} < -F$ and $\left(W_{yn}^U - W_{nn}^U\right)_{\inf} < -B$ are respectively required by $(y, y)_{\inf}$ and $(y, n)_{\inf}$.

The second part of the proposition is proved simply inverting the procedure used for the first part of the proof. ■