The Effects of Dispute Settlements on the Trade Agreements: A Continuous Model

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Abstract: This paper is a continuous extension of the paper Maggi and Staiger (2011) in two aspects that both the state space and trading policy space are continuous instead of binary discrete. And the WTO Dispute Settlement Body(DSB) will have the binary ruling-free trade or not- once a dispute is invoked between importing and exporting countries. In the static game, the findings are basically a refinement of those in Maggi and Staiger (2011) such as there is no free trade unless it's the ruling of the WTO DSB and the empty contract will always be dominated by the vague contract. Another contribution of this paper is to find an innovative way to model the strength of the precedent in the dynamic games,i.e., the DSB ruling at a specific state can be automatically applied to its neighboring states. For the cases when disputes will be invoked in the future, the optimal choice of precedent strength is to make the exporter country file complaint whenever there is protection(which is defined as "No Tolerance" rule in the paper). Otherwise, it's optimal to have no precedent.

1. Introduction

Most trade agreements will exhibit two ways of incompleteness: one is that they don't specify all parties' behaviors with sufficient details; the other is that they miss the points that all parties' obligations should be strictly contingent on the situations. One reason is that it's optimal to have incomplete contracts due to the cost of writing contracts. See Battigalli and Maggi (2002) and Horn et al. (2010) for details. The main idea of this paper is that the roles of the WTO Dispute Settlement Body(DSB) could helpfully "complete" the incomplete contracts by interpreting the vague parts, gap-filling the empty parts and granting exceptions of even rigid parts of the trade agreements. The first paper on this subject is given by Maggi and Staiger (2011). Actually the difference between their paper and mine is that they use discrete model approach to describe the state space and the binary importing policy choices while everything is continuous in my model. But I try to adopt most of their terminologies and setting ups to fit the continuous model.

One reason of using continuous approach is to be more close to the reality. As we know, the importing policy can be very complicated and can not even be quantified easily especially for non-tariff barrier to trade such as the product standards, customs and administrative entry procedures,etc. So it's reasonable to treat the importing policy as a continuous variable to model the fact that the importing government has the power to modifies the rules by any level they want. Also the states of the real world is also very complicated. Both economical and political situations can change continuously and have multi dimensions even though the decisions are made at a specific state. A continuous state space is more suitable for capturing these points. Meanwhile I can check the robustness of the results in Maggi and Staiger (2011) when we extend the discrete model to continuous setups. The most of results can still hold with light modification.[1] But some beautiful and rigorous results don't exist any more in the continuous case such as the inversely relation between the pro-trade bias in DSB rulings and the pro-trade bias in policy outcomes. But instead, the latter will imply the former in the continuous model but not vice versa. That's because the free trade can only be obtained by the DSB ruling if dispute is invoked. Otherwise, there will be two positive protection levels, high and low. So even there is pro-trade bias in DSB ruling, it still can not results in pro-trade bias in policy outcome.

The other reason is that the advantage of continuous setting ups can helps to model the strength of the precedent of DSB ruling in the later dynamic (two period) setting. This topic is not covered in Maggi and Staiger (2011) but can not be avoided in the continuous approach. That's because the probability of recurrence of the same situation is zero. Thus there is no need to consider the precedent of the DSB ruling at a specific stat because the effect of the precedent is zero. So naturally, I define the strength of the precedent of a DSB ruling is to what extent the same ruling can be applied to the neighboring similar situations. By the continuity of the state space, the strength is the size of the neighborhood of the given situation when the ruling will be automatically carried out. This innovative approach to quantify the strength of the precedent are quite distinct from the large legal literature's conventional discuss on the role of legal precedent.[2] Another difference, of course, is that legal literature concerns about domestic court system rather than international trade agreement.

Due to the filing complaint cost for the exporters, in every state, the importer will always choose between a low protection level, which make the exporter country indifferent between filing complaint and keep silent, and a high protection level. The free trade only exists when the disputes are invoked and the DSB ruling is free trade. Those findings are consistent in all the static and dynamic games considered in this paper. This is an extension of the original paper that the equilibrium policy is just free trade and protection. And it's more reasonable because the trade barrier is almost everywhere and the optimal importing policy may not be achieved without the existence of the trade organizations such as GATT(before 1995) and WTO(after 1995).[3]

As mentioned above, the main contribution of the paper is to find an innovative way to model the strength of precedent in the dynamic games with continuous state space. The basic idea is that the DSB ruling at a specific state can be automatically applied to its neighboring states. It does make sense that there is no repeats of exactly the same states in the world so the precedent can only apply to the similar situations. Also due to everything is continuous such as the payoff functions, the state and policy space, the DSB rulings should be quite similar and smooth for states close to each other. Then naturally we can consider the optimality of the strength of precedent. The most exciting result on the optimal strength is that the optimal choice of precedent strength is to make the exporter country file complaint whenever there is protection(which is defined as "No Tolerance" rule in the paper) for the cases that disputes will be invoked in the future. Here the precedent will lead the disputes invoked in the first period to save the litigation costs and efficiency loss in the future. Similarly, if no disputes will be invoked in the

[1] For example, the results of the comparison of the three different incomplete contracts in static model are almost the same in both cases. See Proposition 2 for details.

[2] A recent paper by Ponzetto and Fernandez (2008) analysis the evolutionary process of the case law(or judge-ruled-case law) towards the efficiency law by analyzing the benefits versus the costs of the precedent. But they didn't consider how the precedent can apply to the similar situations.

[3] The importance of the WTO and its precedent GATT is undoubted and is still an interesting topic in the trade literature.

next period, “No Tolerance" rule is optimal when the DSB ruling error is small. Otherwise, it's optimal to have no precedent. That's also reasonable because, when the accuracy of DSB ruling is really low, there would be a lot of efficiency loss to make the precedent of the erratic ruling. In sum, the “No Tolerance" rule is optimal in most cases, which is exactly the assumption in Maggi and Staiger (2011).

The precedent has been extended to two forms depending on whether both parties can appeal the DSB ruling result. If not, it is exactly the case in Maggi and Staiger (2011) that the DSB ruling at the first period should be strictly carried over to the second period. So no one can disobey the DSB ruling and we say "no appeal" is allowed for both countries. But in reality, both countries can appeal. So the second case is also considered. Here I introduce a special of appeal such that the appeal will occur whenever there is ruling error. I call this kind of appeal as “efficient appeal". Even though it looks very special, it actually stands for the cases that the DSB will make the ruling decision for each period and improve the ruling quality over time. We compare the expected ex ante efficiency loss among both forms of precedent the institutions might have. No doubt that the institutions with efficient appeal will strictly dominate the ones without appeal. So it's optimal for the WTO DSB to make necessary adjustment each period to approximate the “correct" ruling decision.

The rest of the paper is organized as follows. The second part is about the basic static model. The third part is about two forms of dynamic games with the precedent depending on whether appeal is allowed. Both cases are covered. The last section is conclusion. Currently most of the calculation steps have been removed to the appendix to make it more readable.

2. Basic Model

The one-period model set up is quite similar to Maggi and Staiger(2011) except that there is a continuous importing policy and state space rather than the binary importing policy and discrete state space. Now the assumptions are listed briefly. The importing country choose policy $\tau \in [0, \infty]$ to maximize its payoff function $\omega(\tau, s)$ where $s \equiv (s_1, s_2, \ldots, s_N)$ is a vector of continuous state variables. Each state variable s_i represents the states such as "the unemployment rate" or "the balance of trade" or "the index of the stock market" or even "the results in the public opinion polls". All of these political factors will influence the government's payoff function. Assume $\omega(\tau, s)$ is concave in τ and maximized at $\tau^N(s)$ which is the Nash equilibrium protection level if there is no WTO Dispute Settlement Body(DSB). So $\omega(\tau, s)$ is increasing over $[0, \tau^N(s)]$ and decreasing over $[\tau^N(s), \infty]$.[4] So importing government will probably choose state contingent importing policies but the protection level will not exceed the Nash level. Suppose the state s has a distribution function $F(\cdot)$ which has density function $f(\cdot)$ with compact support set denoted by Σ. The exporting country is assumed to be passive and don't have exporting policy. Its payoff function is $\omega^*(\tau, s)$. Assume $\omega^*(\tau, s)$ is decreasing over $[0, \infty]$ for all state s.

Although exporting country can not change importing country's policy directly, they can choose to file complaint to WTO Dispute Settlement Body(DSB) after the importing country choose the protection level τ in state s. That will incur costs c and c^* to the importer and exporter respectively.[5] Once the exporting country file complaint, it's WTO Dispute Settlement

[4]See Bagwell and Staiger (2001) and Bagwell and Staiger (2005)for a concrete example for ω and ω^* where the political weight on the import-competing section is indicated by a one-dimension current state variable. A different point between their assumptions and here is that the exporting country can also choose the importing tariff rate while importing goods from the importing country. But here the exporting country's retaliation by choosing tariffs on importing from the importing country is omitted.

[5]Same as in Maggi and Staiger (2011), the costs c and c^* are treated as parameters. This paper doesn't consider the looser of a dispute will incur additional cost (such like reputation damage, or more litigation costs)

Agency (DSB) to determine the importing policy. So the DSB ruling τ^{DSB} should maximize joint payoffs of both countries i.e. $\omega(\tau, s) + \omega^*(\tau, s)$. Notice both payoff functions are concave and maximal point for the former function is $\tau^N(\cdot)$ and zero for the latter one, so normally the maximal point for the sum should be lie between zero and $\tau^N(\cdot)$ for each state. To make it simple, assume the optimal policy is quite close to or equal to zero for some state s. That's because increase of the protection level will harm the exporting country more than the benefit of the importing country.[6] But for the other states when the domestic import-competition sector suffer quite a lot, the political pressures rise and the importing country government has to raise the protection level. Then the optimal importing policy would more likely equal or be close to the Nash level $\tau^N(\cdot)$. Now divide the state space Σ into two disjoint subspace σ^P and σ^{FT}. Still try to simplify the analysis, assume that for $s \in \sigma^{FT}$, we get $\tau = 0$ will maximize the joint payoff $\omega(\tau, s) + \omega^*(\tau, s)$. But for $s \in \sigma^P$, we get $\tau = \tau^N(s)$ will maximize the joint payoff $\omega(\tau, s) + \omega^*(\tau, s)$. That is, for some state s the first best policy is free trade and this state subset is denoted by σ^{FT} while for the other subsets σ^P,the first best policy is the Nash protection $\tau^N(s)$. Assume that state s is observed by all the governments and DSB but the payoff functions $\omega(\tau, s), \omega^*(\tau, s)$ are observed by only the two governments not the DSB. Once the dispute is invoked,the DSB will make the binary ruling-free trade or not- based on the signals information about the payoff functions. Denote the probability that the DSB will make the wrong judge about the state s belonging to σ^{FT} or σ^P by $q(s)$ and $q(s) \in [0, \frac{1}{2}]$.[7] That is, the DSB's ruling is no worse than tossing a coin. Thus the WTO DSB's ruling function is given by

$$\tau^{DSB}(\tau, s) = \begin{cases} 0 & \text{if DSB believes } s \in \sigma^{FT}; \\ \tau^N(s) & \text{if DSB believes } s \in \sigma^P. \end{cases}$$

To do the comparative-static analysis, consider the equi-proportional changes in the precision of the DSB ruling. Write $q(s) = q \cdot k(s)$ where $q \in [0, 1]$ and $k(s) \in [0, \frac{1}{2}]$. So the parameter q captures the overall quality of the DSB information and ruling precision.

The trade agreement between importing country and exporting country is consisted of the state contingent protection level upper bound $\tau(s)$ for some state s in Σ.[8] It is possible that two countries reach agreement over whole state space Σ (rigid contract,R) or subset of Σ (vague contract,V) or empty set(silent contract, D). The reason for the incompleteness of the contract is a complicated question which will be omitted temporarily here.[9] According to Maggi and Staiger (2011), there are different roles of DSB depending on the degree of power. First nonactivist DSB just have enforcement role(n) which has lowest degree of power. Second the interpretation role (i) has a intermediate degree of power. That is, DSB can interpret obligations or rights that are ambiguous in the contract. Third the modification role (m) and gap-filling role(g) embody the highest degree of power. They give DSB the authority to add or to diminish the rights or obligations in the contract. The three different forms of contract corresponds to the different mandate roles of the WTO DSB. For rigid contract (R), only the modification role (m) is relevant. For vague contract (V), we only need to consider interpretation role (i). For silent contract(D), only gap-filling role(g)is needed. The institute founded by the trading countries is just a combination of contract and the corresponding mandate role of WTO DSB. So there are three activist-DSB institutions denoted by R_m, V_i, D_g and three nonactivist-DSB institutions

since it doesn't change the logic of the analysis.

[6]In this case, $\omega'(t, s) + \omega^{*\prime}(t, s) < 0$ for all t. That is the loss of the exporting country will dominate the welfare gain of the importing country. Especially when the political pressure in the importing country is small and there is no much incentive for the importing country to impose the protection.

[7]In most case, we will keep this restriction. It will be pointed out when there are exceptions that $q(s)$ might lie beyond the upper boundary.

[8]It's obvious that the importing country will propose the protection upper bound and the exporting country prefers free trade. So the final trade agreement will determine the final protection level within the two boundaries.

[9]Some papers consider the contracting costs during the contract procedures such as Battigalli and Maggi (2002), Horn et al. (2010),etc.

denoted by R_n, V_n, D_n. The optimal institution is defined if it's designed to maximize the ex ante joint payoff of the two countries.

The timing of the game is defined as below:
Stage 0. The institution is designed.
Stage 1. The state s is realized.
Stage 2. The importer government choose protection policy $\tau \in [0, \tau^N(s)]$.
Stage 3. The exporter government choose whether to file complaint with the DSB.
Stage 4. The DSB issues a ruling τ^{DSB}.
Stage 5. Payoffs are realized.

Notice that there is no direct transfers between the two governments after the DSB ruling. So there is no room for renegotiation in my model. See Maggi and Staiger (2012) for trade agreement with renegotiation.

2.1. Pure Strategy Subgame Perfect Equilibrium

In this part, given DSB's binary ruling function as above, we use backward induction to solve for the pure strategy subgame perfect equilibrium for the static game. First look at the nonactivist-DSB institutions. Since DSB has no mandate power, no dispute will be invoked. D_n will induce the importer policy $\tau^N(s)$ for all s. The vague contract V_n will dominate D_n since the former will achieve the first-best outcome at some states which are explicitly covered in the contract although in the leftover states it will induce the same outcome as D_n. But we can not compare ex ante V_n and R_n because it depends on the parameters. Now consider the pure strategy subgame perfect equilibrium with activist DSB ruling. All calculations based on the two possible cases of state s realized are listed below. By the game tree, it's easy to notice the two cases are symmetric and just need to substitute $q(s)$ in case (ii) for $1 - q(s)$ in case (i).

(i) for state $s \in \sigma^{FT}$, suppose importer government choose $\tau(s) \in [0, \tau^N(s)]$. Then the exporter will decide on whether to file complaint by comparing the expected benefit and the litigation cost c^*, i.e.

$$Pr(\tau^{DSB} = 0|s)(\omega^*(0, s) - \omega^*(\tau(s), s)) > c^*$$

Notice the probability that DSB makes mistake is $q(s)$. So the above inequality can be rewritten as

$$(1 - q(s))(\omega^*(0, s) - \omega^*(\tau(s), s)) > c^* \Rightarrow \omega^*(\tau(s), s) < \omega^*(0, s) - \frac{c^*}{1 - q(s)}$$

Since $\omega^*(\tau, s)$ is strictly decreasing in τ for all s, so its inverse function exists and is denoted by $(\omega_s^*)^{-1}$. Then DSB is invoked if and only if

$$\tau(s) > (\omega_s^*)^{-1}(\omega^*(0, s) - \frac{c^*}{1 - q(s)}) \equiv \bar{\tau}(s)$$

Now turn to the importer government. Since $\omega(\tau, s)$ is increasing over $[0, \tau^N(s)]$ and is maximized at $\tau^N(s)$, so importer will choose between importer policy $\bar{\tau}(s)$ and $\tau^N(s)$ if $\bar{\tau}(s) < \tau^N(s)$. Actually if c^* is small enough, then $\bar{\tau}$ is close to 0 and less than $\tau^N(s)$.[10] Otherwise, $\bar{\tau}(s) \geq \tau^N(s)$ and importer government will impose $\tau^N(s)$. In the case $\bar{\tau}(s) < \tau^N(s)$, importer will choose $\bar{\tau}(s)$ over $\tau^N(s)$ if and only if

$$\omega(\bar{\tau}(s), s) \geq (1 - q(s))\omega(0, s) + q(s)\omega(\tau^N(s), s) - c$$

Define function $D(q(s), c, c^*) = (1 - q(s))\omega(0, s) + q(s)\omega(\tau^N(s), s) - c - \omega(\bar{\tau}(s), s)$. It is easy to obtain D is a decreasing function of c and c^*. So the higher the litigation costs, the less likely

[10] By the monotonicity of $\omega^*(\cdot, s)$,then $\bar{\tau}(s) < \tau^N(s)$ iff $c^* < (1 - q(s))[\omega^*(0, s) - \omega^*(\tau^N(s), s)], \forall s \in \sigma^{FT}$. Notice that $q(s) \in [0, \frac{1}{2}]$, we can get one sufficient condition $c^* < \frac{1}{2} \inf_{s \in \sigma^{FT}} [\omega^*(0, s) - \omega^*(\tau^N(s), s)]$.

the importer will choose high protection.[11] Also notice $\frac{\partial D(q(s),c,s)}{\partial q(s)} = -\omega(0,s) + \omega(\tau^N(s),s) - \frac{\omega'(\bar{\tau}(s),s)}{(\omega^*)'(\bar{\tau}(s),s)} * \frac{-c^*}{(1-q(s))^2}$. When c^* is small enough, then the partial derivative $\frac{\partial D(q(s),c,s)}{\partial q(s)}$ is positive. That is, the import policy is $\bar{\tau}(s)$ if $q(s)$ is small enough. Thus if the accuracy of the DSB ruling is good enough, the importing government will impose the threshold protection level $\bar{\tau}(s)$ to just make the exporter will not file complaint. If not, the Nash protection level will be imposed and the DSB will be invoked. Now I introduce the notation Σ_H^{FT} (and Σ_L^{FT}) which stand for the subset of Σ^{FT} and the importing country will impose the high(and low for Σ_L^{FT}) protection policy. Similarly for the notation Σ_H^P and Σ_L^P below.

The results are different from Maggi and Staiger (2011) in the following aspects: (1) In their model, the importer government will choose free trade(corresponding to the protection level equal 0) if the DSB ruling is accurate enough. Here even so, there is a intermediate protection level $\bar{\tau}(s) > 0$. And in both cases the DSB is not invoked. (2) Also in their paper, the exporter will file complaint immediate if there is protection under the condition that the cost c^* is small enough. But here we have to require the cost $c^* = 0$ to make it happen. Therefore, here the exporter government will tolerate some protection and keep silent due to even very small litigation cost. The main reason for these staff lie in the continuous assumptions of importing policy and payoff functions of the two governments. So the importer can take advantage of the exporter.

(ii) for state $s \in \sigma^P$,given importer government choose $\tau(s) \in [0, \tau^N(s)]$ and condition in part(i), exporter will file a complaint if and only if[12]

$$q(s)(\omega^*(0,s) - \omega^*(\tau(s),s)) > c^* \Rightarrow \tau(s) > (\omega_s^*)^{-1}(\omega^*(0,s) - \frac{c^*}{q(s)}) \equiv \bar{\tau}(s)$$

Now we still consider c^* is small enough and $q(s)$ is bounded above 0 so that $\bar{\tau}(s)$ is close to 0 and less than $\tau^N(s)$.[13] It's different from part(i) since the $q(s) \in [0, \frac{1}{2}]$ and it is the denominator. Similar to above discussion, the importer government will impose $\bar{\tau}(s)$ if and only if

$$\omega(\bar{\tau}(s),s) \geq q(s)\omega(0,s) + (1-q(s))\omega(\tau^N(s),s) - c$$

Similarly we can define the difference function D and D is a decreasing function of c, c^* and $q(s)$. So the above inequality holds if $q(s)$ is large enough(probably close to $\frac{1}{2}$) or the litigation cost c or c^* is large enough. That is, the probability of DSB ruling error and litigation costs being large enough can make the exporter government choose the low level protection $\bar{\tau}(s)$ and exporter government will not file complaint. If not, the importer government will impose the high level protection $\tau^N(s)$ and the DSB will be invoked.

For the same reason as in part (i), the differences of the results away from Maggi and Staiger (2011) lies in the following facts: (1) if the first-best policy is protection, then the importer will choose the protection level immediately which corresponding to $\tau^N(s)$. But here importer government may choose low level protection level $\bar{\tau}(s)$ if the accuracy is low and the litigation cost for the importer is large enough. (2) With accuracy improving i.e.$q(s)$ decreasing, the importing government will increase protection level from $\bar{\tau}(s)$ to $\tau^N(s)$.

But how the results in Maggi and staiger(2011)that the importer country will always choose high protection when it's the first-best policy can still hold here? The necessary and sufficient condition is that $c \leq q(s)\omega(0,s) + (1-q(s))\omega(\tau^N(s),s) - \omega(\bar{\tau}(s),s)$ for all s. And one sufficient condition which can guarantee the inequality is that $c \leq \frac{1}{2}[\omega(0,s) + \omega(\tau^N(s),s)] -$

[11]Notice $\bar{\tau}$ is an increasing function of the c^*. So the higher the litigation cost for the exporter, the higher the reservation protection level for the exporter and the less incentive for the importing country to increase the protection.

[12]Same as in part(i), we denote the intermediate protection level by $\bar{\tau}(s)$. But they are of different formulas and it's easy to check the intermediate protection level is larger in state $s \in \sigma^P$ than in state $s \in \sigma^{FT}$.

[13]Similarly the condition for $\bar{\tau}(s) < \tau^N(s)$ is $c^* < q(s)[\omega^*(0,s) - \omega^*(\tau^N(s),s)], \forall s \in \sigma^P$. That is, $c^* < \inf_{s\in\sigma^P} q(s)[\omega^*(0,s) - \omega^*(\tau^N(s),s)]$.

$\max_{s\in\sigma^P} w(\bar{\tau}(s))$. That is, even the accuracy of the DSB ruling is no better than the coin flip, the high protection policy will still be imposed when it's the first-best policy.[14]

Now combine the two parts above, we can get the import policy information. One thing is for sure, there is no free trade and the importer will choose between two protection levels: the intermediate level $\bar{\tau}(s)$ and high level $\tau^N(s)$ for each state s. The results are summarized in the Proposition 2.

Proposition 1. *Suppose* $\inf_{s\in\Sigma} q(s) > 0$ *and litigation cost* c^* *of exporter government is small enough such that* $0 < \bar{\tau}(s) < \tau^N(s)$ *for all state s. Then exporter government will file complaint to DSB once protection level exceed* $\bar{\tau}(s)$ *and the importer government will choose protection level* $\tau(s) \in \{\bar{\tau}(s), \tau^N(s)\}$ *during the trade.*
(i) for $s \in \sigma^{FT}$*, importer country choose low level protection* $\bar{\tau}(s) = (\omega_s^*)^{-1}(\omega^*(0,s) - \frac{c^*}{1-q(s)})$ *iff*

$$\omega(\bar{\tau}(s), s) \geq (1 - q(s))\omega(0, s) + q(s)\omega(\tau^N(s), s) - c \tag{1}$$

With either probability of DSB error $(q(s))$ *increasing or importer's litigation costs* (c, c^*) *decreasing, the importer's protection level will change from low level* $\bar{\tau}(s)$ *to high level* $\tau^N(s)$ *and exporter will change from keeping silent to complaining.*
(ii) for $s \in \sigma^P$*, importer country choose low level protection* $\bar{\tau}(s) = (\omega_s^*)^{-1}(\omega^*(0,s) - \frac{c^*}{q(s)})$ *iff*

$$\omega(\bar{\tau}(s), s) \geq q(s)\omega(0, s) + (1 - q(s))\omega(\tau^N(s), s) - c \tag{2}$$

With either probability of DSB error $(q(s))$ *or importer's litigation costs* (c, c^*) *decreasing, the importer's protection level will more likely to change from low level* $\bar{\tau}(s)$ *to high level* $\tau^N(s)$ *and exporter will change from keeping silent to complaining.*

There is no free trade any more without the DSB intervention. That's due to the continuity of the importing policy and positivity of the litigation fee c^* for exporter country. So that the importer country will take advantage of the exporter government in the trade agreements. But with the accuracy of the DSB ruling improving, the first-best policy $\tau = \tau^N(s)$ for $s \in \sigma^P$ can be achieved. There is additional efficiency loss comparing to the binary policy model in Maggi and Staiger (2011).

2.2. The optimal Institution

Now consider the ex ante efficiency loss associated with the activist-DSB institutions D_g, V_i and R_m respect to the first-best policy. And compare those losses to determine the optimal institutions. To make the expression simple, we define the efficiency loss function denoted by $\Gamma(\tau, s)$ in state s when the importer policy is τ.

$$\Gamma(\tau, s) = \begin{cases} \omega(0, s) + \omega^*(0, s) - \omega(\tau, s) - \omega^*(\tau, s) & \text{if } s \in \sigma^{FT} \\ \omega(\tau^N(s), s) + \omega^*(\tau^N(s), s) - \omega(\tau, s) - \omega^*(\tau, s) & \text{if } s \in \sigma^P \end{cases}$$

Notice that joint payoff $\omega(\tau, s) + \omega^*(\tau, s)$ is maximized at $\tau = 0$ for $s \in \sigma^{FT}$ and at $\tau = \tau^N(s)$ for $s \in \sigma^P$, $\Gamma(\tau, s)$ is that it is increasing in τ for $s \in \sigma^{FT}$ and decreasing in τ for $s \in \sigma^P$. Also denote the total litigation cost by $c^{all} = c + c^*$. Now the efficiency loss of the empty contract with gap-filling DSB (D_g) is given by

$$L(D_g) = \int_{\sigma_L^{FT} \bigcup \sigma_L^P} \Gamma(\bar{\tau}(s), s) f(s) ds + \int_{\sigma_H^{FT}} [q(s)\Gamma(\tau^N(s), s) + c^{all}] f(s) ds + \int_{\sigma_H^P} [q(s)\Gamma(0, s) + c^{all}] f(s) ds \tag{3}$$

[14] There is no much doubt that the set σ_L^P will be very small and might be empty set in reality world. So it will be treated as a very small set throughout the paper.

Here σ_L^{FT} denote the set of state $s \in \sigma^{FT}$ and the importer policy is the low protection level $\bar{\tau}(s)$ and σ_H^{FT} denote the set of state $s \in \sigma^{FT}$ and the importer policy is the high protection level $\tau^N(s)$. Similarly for notation σ_L^P and σ_H^P. It is obvious that the total state set Σ is the disjoint union of the above four subsets and there is efficiency loss for all states.

From the above formula, the total efficiency loss associated with the institution D_g is consisted of three integrals: the first integral gives us the efficiency loss due to the low protection level $\bar{\tau}(s)$ in state subsets σ_L^{FT} and σ_L^P; the second and third integrals represents the loss due to the potential DSB ruling error and the dispute costs for both countries in state subspace σ_H^{FT} and σ_H^P. If $q(s)$ increase, notice that the integrand function increase and sets σ_H^{FT} and σ_L^P will get larger. That is, as the accuracy of the DSB ruling get worse, the cost associate with the wrong ruling will increase and the importer policy will be more far away from the first-best policy. As a result, the efficiency loss will be increasing as probability of DSB error increasing.[15]

Note $L(D_g)$ is positive as long as $c^* > 0$. That is, as long as there is litigation cost, no matter what the accuracy level of the DSB ruling, there would be the efficiency loss which comes from the positive protection level when the first-best policy is free trade.[16] That's because the exporter will tolerate the small protection level due to the litigation cost. To obtain the first-best efficiency, there should allow the transfers between the two governments depending on the results of DSB ruling. Say, the looser should bear all the litigation costs once the DSB is invoked. But it is beyond the scope of the paper and omitted here.

Now turn to the institution R_m which specifies the free trade rule and the DSB can allow exceptions if invoked. Notice the DSB will rule the same way as in the case of D_g. So the governments will react the same way in both cases. Therefore the efficiency loss will be the same. But there is a little contracting cost in the case of R_m. So D_g will dominate R_m.

Then consider the institution V_i where the crisp provision specified by the contract will be strictly carried out and ambiguous parts will be treated the same way as D_g. Denote the σ^{crisp} be the set of states where a crisp provision are specified in the contract. Notice for state $s \in \sigma^{crisp}$, V_i will achieve the first-best outcome although it incurs a little contracting cost.[17] When $q(s) \equiv 0$ for all s, D_g will induce state contingent trade policy $\bar{\tau}(s)$ for $s \in \sigma^{FT}$ and $\tau^N(s)$ for $s \in \sigma^P$ and DSB will not be invoked. In the meantime,V_i will achieve the same results as D_g except free trade for some state $s \in \sigma^{crisp} \bigcap \sigma^{FT}$. Thus D_g is strictly dominated by V_i for $q = 0$.[18] Notice $L(D_g)$ is increasing in $q(s)$ over σ^{crisp} while $L(V_i)$ is just the contracting fee over crisp provision part. Also for $s \in \Sigma \backslash \sigma^{crisp}$, both induce the same outcome. Then $L(D_g) - L(V_i)$ is increasing in $q(s)$. And by above arguments, we know for any $q \geq 0$, the efficiency loss is larger for D_g than V_i. Therefore V_i is preferred over D_g.[19]

Last compare the efficiency loss between V_i and nonactivist-DSB institutions D_n,V_n and R_n. Notice that $L(V_i)$ is increasing in $q(s)$ and $q(s)$ doesn't affect the efficiency loss of nonactivist-DSB institutions. So theoretically there exists a threshold and for q beyond that, V_i will be dominated by the nonactivist-DSB institution V_n or R_n.[20] We don't consider D_n because as we know it is dominated by V_n. Now we can summarize the results in the following proposition.

Proposition 2. *The results on optimal institution can be summarized as below:*

[15]By the Proposition 1 and the assumption of Γ, all integrand function will increase as $q(s)$ increase.

[16]Notice that for $q(s) \leq \frac{c^*}{\omega^*(0,s) - \omega^*(\tau^N(s),s)}$ for all $s \in \sigma^P$, the DSB will not be invoked and first-best policy will be achieved in state subset σ^P. But even though $q(s) \equiv 0$ for all s, positive protection level $\bar{\tau}(s)$ will be imposed in state subset σ^{FT}.

[17]For example, if $s \in \sigma^{crisp} \bigcap \sigma^{FT}$, then importer government will impose $\tau(s) = 0$ according to the trade agreement. Similarly for the states when the first-best policy is high protection.

[18]The contracting costs are supposed to the much smaller than the efficiency loss during the trade though out the paper

[19]The result is quite different from Maggi and Staiger(2011) where D_g dominate V_i for q below some threshold and reverse afterwards.

[20]Actually we require $q \in [0, 1]$ and it is possible the above threshold is beyond the upper boundary.

(1) Empty contract is dominated by vague contract in both activist and nonactivist DSB cases.
(2) There exists a threshold q^* such that

(i) for $q < q^*$, the vague contract with active interpretation role of DSB(V_i) is strictly preferred over nonactivist-DSB vague and rigid contracts(V_n and R_n)

(ii)for $q > q^*$, nonactivist-DSB vague contract(V_n) or rigid contract(R_n) dominate vague contract with a mandate for the DSB to interpret(V_i)

2.3. Selection of Dispute and Pro-Trade Bias

Here consider the bias in DSB ruling since it's well known that there is an apparent pro-trade bias in both GATT and WTO DSB ruling.[21] Assume that if disputes are randomly initiated, the outcome of DSB ruling will be unbiased. That is

$$\int_{\sigma^{FT}} f(s)ds = \int_{\sigma^P} f(s)ds = \frac{1}{2} \text{ and } \int_{\sigma^{FT}} q(s)f(s)ds = \int_{\sigma^P} q(s)f(s)ds$$

The first equation says that there is equal chance that the first best policy is free trade or high protection. The second equation says the conditional mean of probability of error ruling $q(s)$ is independent of the first best policy.Recall that the export will file complaint once the importer policy is the high level $\tau^N(s)$ at state s. Thus DSB is invoked for $s \in \sigma_H^{FT} \bigcup \sigma_H^P$. Now we consider D_g institution. Then the probability of DSB ruling is $\tau = 0$ conditional on DSB is invoked is given by

$$Pr(\tau^{DSB} = 0|\text{file}) = \frac{\int_{\sigma_H^{FT}}(1-q(s))f(s)ds + \int_{\sigma_H^P} q(s)f(s)ds}{\int_{\sigma_H^{FT}} f(s)ds + \int_{\sigma_H^P} f(s)ds}$$

From above equation, $Pr(\tau^{DSB} = 0|\text{file}) > \frac{1}{2}$ if and only if

$$\int_{\sigma_H^{FT}}(1-2q(s))f(s)ds > \int_{\sigma_H^P}(1-2q(s))f(s)ds$$

Next the question is to identify the region in (c, c^*) space where the above inequality holds. First notice that if DSB is invoked at every state s, there will be no bias. Thus it requires either $\bar{\tau}(s) \geq \tau^N(s)$ or $\bar{\tau}(s) < \tau^N(s)$ and $\tau^N(s)$ is the best choice for importer government for all state s. [22] Otherwise DSB is invoked in some states but not all states. Notice both sets σ_H^{FT} and σ_H^P are strictly decreasing set with respect to both c and c^*.[23] But it's hard to tell the boundary of the area in general.

Now we turn to the bias in the policy outcomes under institution D_g. From proposition 1, we know the outcome policy is choose from the set of three elements$(0, \bar{\tau}(s), \tau^N(s))$ for each state s. If there is free trade $\tau(s) = 0$ if and only if the exporter file complaint and the DSB ruling is free trade. If the policy induces a pro-trade bias, then $Pr(\tau(D_g) = 0) > \frac{1}{2}$ where $\tau(D_g)$ is the equilibrium policy induced by institution D_g.

$$Pr(\tau(D_g) = 0) = \int_{\sigma_H^{FT}}(1-q(s))f(s)ds + \int_{\sigma_H^P} q(s)f(s)ds$$

[21] According to the WTO(WTO, 2007, P273), 82% of complainants under GATT and 88% under WTO have won their cases. But there is very few cases where there is no protection policy especially if including the non-tariff barriers to trade.

[22] That is, either $c^* \geq \max\{\sup_{s\in\sigma^{FT}}(1-q(s))[\omega^*(0,s) - \omega^*(\tau^N(s),s)], \sup_{s\in\sigma^P} q(s)[\omega^*(0,s) - \omega^*(\tau^N(s),s)]\}$, or the conditions are $c^* < \min\{\inf_{s\in\sigma^{FT}}(1-q(s))[\omega^*(0,s) - \omega^*(\tau^N(s),s)], \inf_{s\in\sigma^P} q(s)[\omega^*(0,s) - \omega^*(\tau^N(s),s)]\}$ and $c < \min\{\inf_{s\in\sigma^{FT}}[(1-q(s))\omega(0,s) + q(s)\omega(\tau^N(s),s) - \omega(\bar{\tau}(s),s)], \inf_{s\in\sigma^P}[q(s)\omega(0,s) + (1-q(s))\omega(\tau^N(s),s) - \omega(\bar{\tau}(s),s)]\}$.

[23] Here it's different from Maggi and Staiger(2011) when each of σ_H^{FT} and σ_H^P depend on only one of c and c^*.

Then if there is pro-trade bias in policy outcome, then $Pr(\tau(D_g) = 0) > \frac{1}{2}$. Just simplify we obtain

$$\int_{\sigma_H^{FT}} (1 - 2q(s))f(s)ds > \int_{\sigma_H^P} (1 - 2q(s))f(s)ds + \int_{\sigma_L^{FT}} f(s)ds + \int_{\sigma_L^P} f(s)ds$$

Compare the two inequalities above. It's obvious that the pro-trade bias in policy outcome will imply the pro-trade bias in DSB ruling. But the converse might not be true except that the high protection level is imposed in every state, i.e.,both σ_L^{FT} and σ_L^P are empty sets. That does make sense in real world. Even there exists a pro-trading bias in DSB ruling by the real world data, we seldom see the dominance of free trade in reality.

3. Two-Period Precedent Model

Now consider the two-period dynamic model with precedent set by a DSB ruling. Here we are trying to answer the two important questions: whether the first period DSB ruling should set legal precedent for future ruling and if so,what's the optimal strength of precedent? For the second questions, the strength of precedent is defined as how the same DSB ruling can be applied to similar situations and whether the countries can appeal the DSB ruling when they are not satisfied. The comparison of the ex ante efficiency losses in these cases are made at the end of this section.

3.1. Dynamic Model Setup

This part is adapted from Maggi and Staiger(2011) except the strength of precedent. The two-period model is just the the repetition of the static game during the period 1 and period 2. Same as static game, the institution will be established during period 0. Assume the state s is *i.i.d.* across the two periods and let $\delta \geq 0$ denote the weight attached by governments to the second period payoff. Here the factor δ might be larger than 1 since it's possible interpreted that all future payoffs are collapsed into period 2. Denote τ_t and $\tau_t^{DSB}(t = 1, 2)$ as the importer government policy and the DSB ruling during period t. Since the states are *i.i.d.*, there is no dynamic in the contracting environment. Actually all dynamic comes from the precedent-setting authority of the DSB institution.

Now define the precedent formally. Due to the continuous state space,the probability of the recurrence of the same state is zero and precedent has no effect to consider. Thus we define the DSB ruling during period 1 will carry on to the states nearby. And it's natural for the countries to apply the DSB ruling in similar situations in the real world. If DSB is invoked during period 1 at state s' and its ruling is free trade i.e.$\tau_1^{DSB}(s') = 0$ for state s close to the given state s', then the ruling will be included in the contract and can not be modified in the future.[24] Thus the payoffs during period 1 just follow from the DSB ruling during first period. But there is a question whether the countries can appeal or not if they are not satisfied about the ruling results. In this paper, even though any country have the right to file complaint to the WTO DSB if the they're not satisfied about the ruling, I will only consider an ideal case that appeal will happen whenever there is ruling error.[25] If appeal is prohibited, then that's exactly the case in Maggi and Stager(2011) paper that the DSB ruling during period 1 should be carried out unconditionally during next period. In fact, appeal is another measure of the strength of precedent.

[24] A detailed description of the nearness will be given later when we define the strength of precedent.

[25] This is just a bench mark case to consider the maximal benefit can be achieved by appeal allowance. And also the WTO DSB is unaware that the appeal is due to their mistake and thus DSB make the second judge just like the first one.

There is a very special treatment for the strength of precedent.[26] Basically, the DSB ruling for state s' will be extended to the neighbors of the state,say, for $\| s - s' \| \leq \triangle (s')$ where $\triangle (s') > 0$ which depends on state s' is a measure of the precedent.[27] For simplicity, the distance $\triangle (s')$ is small and there exists positive number $p(s')$ such that we can get $\int_{\|s-s'\| \leq \triangle(s')} g(s)ds \approx p(s')g(s')$ for any integrable function $g(\cdot)$.[28] Here, the number $p(\cdot)$ is the measure of strength of precedent instead of $\triangle (\cdot)$ and to make the calculations easier, we will just use the approximation for the integral.[29]

Also assume that if the same state occurs and the DSB is invoked in both periods(which is possible when absence of precedent or appeal is allowed), then the DSB use only the period 2's signal information to make the ruling. That's to say, there is no learning process in the DSB ruling. So the DSB will behavior exactly as in the static game, no matter which period it is. And the probability of wrong ruling is still $q(s)$ in state s. It is obvious that without precedent the equilibrium will be exactly the same as in the static game in each period. Also the precedent setting has no effect with the nonactivist-DSB institutions(D_n, V_n, R_n). And same as before, R_m is outcome-equivalent to D_g and dominated by the later. So we only need to consider the cases of V_i and D_g.

3.2. Pure Strategy Subgame Perfect Equilibrium for V_i and D_g with Precedent

It's true that the institute D_g will induce the same outcome as the ambiguous parts of V_i. And that part of V_i is exactly what we are interested. So for simplicity, we only consider the pure strategy subgame perfect equilibrium induced by D_g.Same as in Maggi and Staiger(2011), Denote by $B_p^E(s')$ (or $B_p^M(s')$)the expected period-2 value of the filing complaint during period 1 to the exporter (or importer) conditional on the realized period-1 state s' but the period-1 ruling is unknown. If DSB is not invoked during period 1, the period 2 results are exactly the same as those of static game which are summarized in Proposition 1.[30] That is, the importer will just choose policy $\bar{\tau}(s)$ for state $s \in \sigma_L^{FT} \bigcup \sigma_L^P$ and policy $\tau^N(s)$ for state $s \in \sigma_H^{FT} \bigcup \sigma_H^P$. And exporter will file complaint to DSB for state $s \in \sigma_H^{FT} \bigcup \sigma_H^P$. Then discuss the formula of $B_p^E(s')$ and $B_p^M(s')$ based on the four different cases of the state s'.

3.2.1. Institutions with Precedent but NO Appeal

Here we consider the strong precedent case that the DSB ruling during the first period can not be appealed during the second period. Then this precedent is the same as the case discussed in Maggi and Staiger(2011). The detailed calculation can be found in appendix and it's based on the discussions of the state s' belonging to which state subspace, say, σ_L^{FT}, σ_H^{FT}, σ_L^P, σ_H^P. The reason is that the second period will proceed exactly as the static game if the dispute is not invoked in the period 1.

Now we will briefly talk about the computation process. For each state s' in each of the four state subset, given the importing policy $\tau_1(s')$, the expected benefit of the dispute for the second

[26]Due to the continuous distribution of the state s, probability of repetition of the same state is 0. That's the main reason we need to consider the strength issue of the precedent of DSB ruling.

[27]Notice for $\triangle (\cdot) \equiv 0$ can be treated as no precedent in the continuous states space and it is different from the case considered in Maggi and Staiger(2011) where, even though $\triangle (\cdot) \equiv 0$, the precedent is still well established due to the positive repetition of the same state in the discrete state space. The good thing here is that we can choose the optimal size of the interval to measure the optimal choice of the strength of precedent.

[28]Generally $p(\cdot)$ should depend on $\triangle (\cdot)$ and integrand function $g(\cdot)$. In this paper $g(\cdot)$ refer to about a handful of functions so we would like to denoted as $p(s)$ for simplicity.

[29]If $\triangle (s)$ is small, we consider the Taylor expansion of the integral,then $p(s) \approx 2 \triangle (s)$ and the righthand side is the first three term, i.e. the error is up to $O(p^3)$. But be aware that we don't need to require $\triangle (\cdot)$ to be small at all if we only consider the same integrand function.

[30]Without the DSB ruling in period 1, the importing policy are free to change in the period 2.

period $(B_p^E(s'), B_p^M(s'))$ can be calculated.[31] Then the exporting country will file complaint to WTO DSB if and only if

$$Pr(\tau_1^{DSB}(s') = 0|s')[\omega^*(0, s') - \omega^*(\tau_1(s'), s')] + \delta B_p^E(s') > c^*$$

It's easy to get the left hand side is increasing of $\tau_1(\cdot)$ so we can get the cut off protection level $\tilde{\tau}_1(\cdot)$ such that the exporting country will file complaint if and only if $\tau_1(\cdot) > \tilde{\tau}_1(\cdot)$. To make $\tilde{\tau}_1(\cdot) \geq 0$, the restriction on the strength of precedent should be imposed such that $0 \leq p(\cdot) \leq \bar{p}(\cdot)$.[32]Then the problem of the importing country is to choose between the cutoff policy $\tilde{\tau}_1(\cdot)$ and the high protection level $\tau^N(\cdot)$ by comparing the expected payoffs. That is, the high protection policy will be imposed if and only if

$$Pr(\tau_1^{DSB}(s') = 0|s')\omega(0, \cdot) + [1 - Pr(\tau_1^{DSB}(s') = 0|s')]\omega(\tau^N, \cdot) - c + \delta B_p^M(\cdot) > \omega(\tilde{\tau}_1, \cdot)$$

Then we will divide each state subset into two smaller disjoint subsets depend on the importing policy decision made by importing country. For example, for the state subset when the low protection level policy is imposed in static game, $\sigma_L^{\cdot} = \tilde{\sigma}_{LL}^{\cdot} \bigoplus \tilde{\sigma}_{LH}^{\cdot}$. Now we will have eight proper state subsets.

For any state, no matter which state subset is, the reserved importing policy $\tilde{\tau}_1(\cdot) < \bar{\tau}(\cdot)$ and is a decreasing function of the strength of the precedent($p(\cdot)$), the weight put on the future payoffs(δ), and the frequency of the repetition of the state($f(\cdot)$). It's straight forward to interpret the relation with the cutoff policy level in stationary game that due to the expected benefit for the second period, the exporting country will be more likely to file complaint than in the static game without precedent. Also all the factors such as the strength of precedent, the weight on the future payoffs and the frequency of the current state will increase the expected benefit of the precedent for the future. Therefore, the exporting country will be more willing to file complaint once any of the above factors get larger. For the state when the first-best policy is free trade and the high importing policy will be imposed without disputes, the reservation policy will decrease as the dispute error increase.[33] But for the state when the first-best policy is protection and the high importing policy will be imposed without disputes($s' \in \sigma_H^P$), the exporting country are more likely to file complaint as the accuracy of the DSB ruling improves. The reasons is simply the relative change of the benefit due to the accuracy changes. For the states when the first-best policy is free trade and the low protection policy will be imposed without disputes(σ_L^{FT}), the exporter's reservation policy decreases as the accuracy of the DSB ruling improves when the ruling error is small or large. Otherwise, the exporting country is more willing to file complaint as the ruling error increases. For for the last case(σ_L^P), the results are opposite to those in the previous one. For details, see the related materials in Appendix.

Now we will do the comparative analysis for the importing country's decisions thus derive the relative change of the subsets division responding to the the parameters. First the importing country is more likely to impose the high protection policy as the increases of the strength of the precedent($p(\cdot)$), the weight put on the future payoffs(δ), and the frequency of the repetition of the state($f(\cdot)$). That's mainly due to the decrease of the exporting country's reserve policy thus the decrease of the exporting country's alternative payoff. Therefore, the subsets $\sigma_{\cdot H}^{\cdot}$ will increase as the above three parameters increase. For the states when the first-best policy is free trade, the exporting country will be more willing to impose high protection level as the DSB ruling error increases. That's because the exporting country are more likely to try their luck as the chance of the "success" increases. Thus the subsets $\sigma_{H\cdot}^{FT}$ are getting larger as ruling

[31]Be aware that the DSB ruling will only effect the state $\| s - s' \| \leq \triangle$ (s'). Also there is no doubt that sometimes each of the two terms might be negative.

[32]If $p(\cdot) = 0$, there is no precedent and $B_p^{\cdot}(\cdot) = 0$. But if $p(\cdot) = \bar{p}(\cdot)$, then $\bar{\tau}_1(\cdot) = 0$. That is, the export will file complaint whenever there is no free trade. It's called "zero tolerance" rule in this paper.

[33]That is, $\tilde{\tau}_1(\cdot)$ is a decreasing function of the ruling error $q(\cdot)$. Similarly to interpret the following statement.

error $q(\cdot)$ increases. But for the opposite cases when the first-best policy is protection, the exporting country are more likely to impose high protection level as the accuracy of the DSB ruling improves. That's because the exporting country are more "confident" to choose the high importing policy due to the fact that the DSB are less likely to make mistakes in ruling the disputes. So the subsets $\sigma^P_{H\cdot}$ are getting larger as the ruling error $q(\cdot)$ decreases.

3.2.2. Institutions with Precedent and Appeal

Here we consider the weak precedent case that the DSB ruling during the first period can be appealed during the second period. Notice the payoff during the first period is according to the results of the DSB ruling. But the second period payoff will be the same as period 1 if neither of the two countries appeal the DSB ruling. If there is no additional cost for appeal,due to the positive chance of winning appeal, each of the two countries will appeal whenever the ruling outcome is against itself.

To reduce the efficiency loss due to the abuse of appeal by the two countries, we assume there are "proper" appeal costs to the two countries such that the extra gain from appeal exceeds the appeal cost if and only if the DSB ruling follows the first-best policy . For example, if the DSB ruling is free trade which is exactly the optimal policy, the importing country will not appeal due to the dominance of the cost over the benefit. But if the ruling is not free trade, then the exporting country will definitely appeal the ruling results. In addition, if the appeal costs are not "proper"(might be very small), WTO DSB can manipulate the appeal costs. For instance, the country need to deposit some money to the WTO DSB to ask for the DSB make the ruling again under the condition that they can only get the money back if they win the appeal. Since the winning probability for the "bad" party (which is the loosing chance for "good" party) is exactly the probability the DSB makes the wrong ruling $q(\cdot)$ which is,for most cases, strictly less than the loosing probability $1 - q(\cdot)$. So the optimal outcome for appeal can be achieved by imposing a "proper" amount of deposit. Here the really costs of appeal to the system can not exceed the dispute costs thus should be small. Hence,for simplicity, we assume there is no efficiency loss due to the appeal. Here I want to make it clear that there is no such "deposit"for appeal in real life such that only the proper appeal is invoked in real world. But it's definitely true that the "proper" appeal is more likely to happen than the "improper" ones. Also the WTO DSB can not tell whether the appeal country is "innocent " or not. Thus the DSB ruling process is the same as the first period. Therefore this part with the assumption of no abuse of appeal can be treated as benchmark model for analysis.

The "proper" appeal to the period 1 DSB ruling will improve the accuracy of the period 2's ruling results. In fact, the period 2's ruling error is $q^2(s)$ for state s compared with the period 1's ruling error is $q(\cdot)$ because only the appeal is invoked whenever the ruling is wrong. No doubt, the expected benefit of the precedent will be improved due to the reduced ruling error in period 2 compared with the previous part without appeal. Actually the expected benefit for exporting country($B^E_p(\cdot)$) becomes larger if the first-best policy is free trade and shrinks if not. The same results hold for importing country that the expected benefit of precedent($B^M_p(\cdot)$) gets larger if the first-best policy is protection and shrinks if not. Due to the change of the expected benefit of the precedent, we can obtain that the cut-off policy level becomes less than the previous section without appeal, i.e., $\hat{\tau}(\cdot) \leq \tilde{\tau}(\cdot)$ if the first-best policy is free trade. The other side also holds, i.e., $\hat{\tau}(\cdot) \geq \tilde{\tau}(\cdot)$ if the first-best policy is protection. Therefore, comparing with the previous section, the exporting country are more willing to file complaint whenever that's the best for the whole system and less willing to trigger the dispute if not. Also the importing country are more likely to impose the high protection policy only if it's the first-best policy. If we divide the state subset the same way as previous section and add the hat to the notation of the subsets.[34]Then we can conclude that $\hat{\sigma}^{FT}_{L\cdot} \supseteqq \tilde{\sigma}^{FT}_{L\cdot}$ and $\hat{\sigma}^{P}_{H\cdot} \supseteqq \tilde{\sigma}^{P}_{H\cdot}$. The results of the

[34]For example, we can divide $\sigma^{\cdot}_{L}$ as $\sigma^{\cdot}_{L} = \hat{\sigma}^{\cdot}_{LL} \bigoplus \hat{\sigma}^{\cdot}_{HL}$.

comparative analysis of the cut-off policy($\hat{\tau}$) and the division of the state subsets ($\hat{\sigma}^{\cdot}_{\cdot\cdot}$) respect to the strength of precedent, the weight on the future payoff, the frequency of the current state, and the WTO DSB ruling error are quite similar to the previous section. For details, see the appendix.

The comparison about results on the subgame perfect equlibrium between the institutions with precedent and appeal and with precedent but without appeal can be summarized in the following propositions.

Proposition 3. *The comparison of key variables are as below:*
(1)If the first-best policy is free trade, we get the cut-offs satisfy $0 \leq \hat{\tau}(\cdot) \leq \tilde{\tau}(\cdot) \leq \bar{\tau}(\cdot)$. *If not, we get* $0 \leq \tilde{\tau}(\cdot) \leq \hat{\tau}(\cdot) \leq \bar{\tau}(\cdot)$.
(2) The relation between the state subsets divided according to the outcome is given by $\hat{\sigma}^{FT}_{L\cdot} \supseteqq \tilde{\sigma}^{FT}_{L\cdot}$ *and* $\hat{\sigma}^{P}_{H\cdot} \supseteqq \tilde{\sigma}^{P}_{H\cdot}$.
(3)The institutions with precedent and appeal will dominate the institutions with precedent but no appeal given part (1) and (2).

In fact, the "proper" appeal with precedent exactly the case that the WTO will give two rulings for each period and the ruling error will be reduced for the second period than the first period. It can be treated as a learning process in the DSB ruling decision making. Without doubt, the efficiency of the system will be greatly improved due to the two decision rulings setting up. And it could be a option considered by the WTO DSB designers.

3.3. Precedent or Not?

First we want to make it clear about the notations on state subsets used before. For example, denote by $\hat{\sigma}^{FT}_{LH}$ the set of states such that the importer government will choose low level($\hat{\tau}(s)$)during period 1 and high level($\tau^N(s)$) for period 2 if the dispute is not invoked in period 1 for the institution with precedent and appeal when the first best policy is free trade ($\tau = 0$). Similarly we have the sets $\tilde{\sigma}^{FT}_{LH}$ for the corresponding institution with precedent but no appeal. Then we will get the sets $\hat{\sigma}^{FT}_{LL}, \tilde{\sigma}^{FT}_{HL}; \hat{\sigma}^{P}_{LH}, \tilde{\sigma}^{P}_{LL}, \ldots$,etc. For each institution with precedent, we can get eight state subsets. Notice that for institutions without precedent settings, the $\sigma^{\cdot}_{L}$ is the set of states in which both periods will have the same low protection policy and there are four state subsets like that. By construction, the relation between the state sets of institutions with precedent and not are simple. For example,σ^{FT}_{L} is the disjoint union of $\hat{\sigma}^{FT}_{LL}$(or $\tilde{\sigma}^{FT}_{LL}$) and $\hat{\sigma}^{FT}_{HL}$(or $\tilde{\sigma}^{FT}_{HL}$). Also by section 3.2.2, we can get $\hat{\sigma}^{FT}_{L,\cdot} \supseteq \tilde{\sigma}^{FT}_{L,\cdot}$ and $\hat{\sigma}^{P}_{H,\cdot} \subseteq \tilde{\sigma}^{P}_{H,\cdot}$. Now consider the institution D_g. Denote $\hat{D}^P_g$(or $\tilde{D}^P_g$) be the D_g with precedent and appeal(or without appeal). And the efficiency loss of $\hat{D}^P_g$ (or $\tilde{D}^P_g$) is denoted by $L(\hat{D}^P_g)$ (or $L(\tilde{D}^P_g)$). Since without precedent, the two period game is just a repetition of the static game. Thus the efficient loss is just the discount sum of the loss in section 2.

$$L(D_g) = (1+\delta)\int_{\sigma^{FT}_L \bigcup \sigma^P_L} \Gamma(\bar{\tau}(s), s) f(s) ds + (1+\delta)\int_{\sigma^{FT}_H} [q(s)\Gamma(\tau^N(s), s) + c^{all}] f(s) ds$$
$$+ (1+\delta)\int_{\sigma^P_H} [q(s)\Gamma(0, s) + c^{all}] f(s) ds \quad (4)$$

Now consider the ex ante efficiency loss $L(\tilde{D}^P_g)$ by discussing about the state subsets.

(i) for $s \in \tilde{\sigma}^{FT}_{LL} \bigcup \tilde{\sigma}^{P}_{LL}$, we know import policies are $\tilde{\tau}(s)$ and $\bar{\tau}(s)$ for corresponding period 1 and 2. Then there is no dispute and no litigation cost. Then we can get the efficiency loss are given by

$$\int_{\tilde{\sigma}^{FT}_{LL} \bigcup \tilde{\sigma}^{P}_{LL}} [\Gamma(\tilde{\tau}(s), s) + \delta\Gamma(\bar{\tau}(s), s)] f(s) ds$$

(ii) for $s \in \tilde{\sigma}_{LH}^{FT} \bigcup \tilde{\sigma}_{LH}^{P}$, there is no disputes during period 1 but at period 2. The good point is that there is no effect of precedent. So we can get the efficiency loss easily

$$\int_{\tilde{\sigma}_{LH}^{FT} \bigcup \tilde{\sigma}_{LH}^{P}} \Gamma(\tilde{\tau}(s), s) f(s) ds + \delta \int_{\tilde{\sigma}_{LH}^{FT}} [q(s)\Gamma(\tau^N(s), s) + c^{all}] f(s) ds + \delta \int_{\tilde{\sigma}_{LH}^{P}} [q(s)\Gamma(0, s) + c^{all}] f(s) ds$$

(iii) for $s \in \tilde{\sigma}_{HL}^{FT} \bigcup \tilde{\sigma}_{HL}^{P}$, we know import policies will be $\tau^N(s)$ in period 1 and $\bar{\tau}(s)$ for corresponding period 2 without precedent. Then DSB will be invoked only in period 1. First we consider $s \in \tilde{\sigma}_{HL}^{FT}$. Then the first period expected payoffs for exporter and importer are $(1-q(s))\omega^*(0,s) + q(s)\omega^*(\tau^N(s), s) - c^*$ and $(1-q(s))\omega(0,s) + q(s)\omega(\tau^N(s), s) - c$ respectively. Now we need to derive the expected payoff for each state in period 2. Notice that by continuity of the state and its density function, the DSB ruling will also continuous for the small $\triangle\ (s)$. Also notice that, due to precedent, the outcome for period 2 for the state s' will ex ante be influenced by the DSB rulings for states nearby, i.e. $\parallel s - s' \parallel \leq \triangle\ (s')$.[35] Then the expected period-2 payoff for exporter at state s' is

$$\begin{aligned}\int_{\|s-s'\| \leq \triangle(s')} [(1-q(s))\omega^*(0,s') + q(s)\omega^*(\tau^N(s'), s')] f(s) ds + \int_{\|s-s'\| > \triangle(s')} \omega^*(\bar{\tau}(s'), s') f(s) ds \\ = p(s')f(s')[(1-q(s'))\omega^*(0,s') + q(s')\omega^*(\tau^N(s'), s')] + (1 - p(s')f(s'))\omega^*(\bar{\tau}(s'), s')\end{aligned}$$

By symmetry, we can easily get the expected period-2 payoff at state s' for importing country and the payoffs for state $s' \in \tilde{\sigma}_{HL}^{P}$.[36] Now the efficiency loss is

$$\begin{aligned}\int_{\tilde{\sigma}_{HL}^{FT}} \Big[[q(s)\Gamma(\tau^N(s), s) + c^{all}] + \delta[p(s)f(s)q(s)\Gamma(\tau^N(s), s) + [1 - p(s)f(s)]\Gamma(\bar{\tau}(s), s)]\Big] f(s) ds + \\ \int_{\tilde{\sigma}_{HL}^{P}} \Big[[q(s)\Gamma(0, s) + c^{all}] + \delta[p(s)f(s)q(s)\Gamma(0, s) + [1 - p(s)f(s)]\Gamma(\bar{\tau}(s), s)]\Big] f(s) ds\end{aligned} \tag{5}$$

(iv)for $s' \in \tilde{\sigma}_{HH}^{FT} \bigcup \tilde{\sigma}_{HH}^{P}$, there will be disputes in only first period and the import policy is $\tau^N(s')$ for both period if exporter country loose the dispute. The expected period 1 payoffs for exporter and importer are exactly the same as in part(iii). Now we consider the expected period 2 payoff for exporter when $s' \in \sigma_{HH}^{FT}$

$$\begin{aligned}\int_{\|s-s'\| \leq \triangle(s')} \Big[(1-q(s))\omega^*(0,s') + q(s)\omega^*(\tau^N(s'), s')\Big] f(s) ds + \\ \int_{\|s-s'\| > \triangle(s')} [(1-q(s'))\omega^*(0,s') + q(s')\omega^*(\tau^N(s'), s') - c] f(s) ds \\ = (1-q(s'))\omega^*(0,s') + q(s')\omega^*(\tau^N(s'), s') - (1 - p(s')f(s'))c^*\end{aligned}$$

Similarly we can get the expected period-2 payoff at state s' for importing country and by symmetry, the expected payoff vector for exporter and importer for states $\hat{\sigma}_{HH}^{P}$ can by obtained. Then we can write down the efficiency loss as below

$$\begin{aligned}\int_{\tilde{\sigma}_{HH}^{FT}} \Big[(1+\delta)[q(s)\Gamma(\tau^N(s), s) + c^{all}] - \delta p(s)f(s)c^{all}\Big] f(s) ds + \\ \int_{\tilde{\sigma}_{HH}^{P}} \Big[(1+\delta)[q(s)\Gamma(0, s) + c^{all}] - \delta p(s)f(s)c^{all}\Big] f(s) ds\end{aligned} \tag{6}$$

[35]Here we need to consider all the state s which are close to s' so that the DSB ruling at s can also affect s'. In addition, if we assume there is symmetry between states during DSB ruling,i.e., ruling at state s affect state s' if vice versa, then the integral domain should be $\triangle\ (s')$. Otherwise, the integral domain radius would be difference. Even so, we can still get the same integral formula by the strong assumption about $p(\cdot)$.

[36]Just replace the probability pair $(q(\cdot), 1-q(\cdot))$ with the probabilities pair$(1-q(\cdot), q(\cdot))$ to get the payoffs when first-best policy is P.

Now consider choosing the optimal strength of precedent($p(\cdot)$) to minimize the efficiency loss ($L(\tilde{D}_g^P)$) especially the terms in equations (5) and (6). For equation(6), it's straight forward to choose the upper bound for the stength of precedent $p(\cdot)$ since the efficiency loss is a decreasing function of the variable $p(\cdot)$.[37] This will make the exporter file complaint whenever there is tariff no matter what the first-best policy is. Or we can say the exporting country now uses the "zero-tolerance" strategy. That result is consistent with the setting ups in Maggi and Staiger (2011). In their paper, the exporting country will file complaint except free trade if the litigation cost is small enough. But here the optimality of the "zero-tolerance" can be derived rigorously from the efficiency analysis. In equation(9), we need to compare the relative size of the efficiency loss due to the ruling error($q(s)\Gamma(\tau^N(s),s)$ or $q(s)\Gamma(0,s)$) and the efficiency loss due to the low-protection level($\Gamma(\bar{\tau}(s),s)$). If the ruling error q is large, the former is larger then the optimal strength $p=0$. Otherwise, that $p(\cdot)$ reaches its right boundary is optimal. That is, $p(s)=\frac{1-q(s)}{\delta f(s)}$ for $s\in\sigma_L^{FT}$ and $p(s)=\frac{q(s)}{\delta f(s)}$ for $s\in\sigma_L^P$. This way will bring in the "zero-tolerance" rule again. It does make sense that if the accuracy of the DSB ruling is very high then it will be efficient if the exporting country file complaint whenever there is protection. If the accuracy of DSB ruling is very low then the precedent will be harmful due to the ruling errors. So the optimal one is to get rid of the precedent by setting $p(\cdot)=0$. Through out the paper, we assume that the efficiency loss due to the DSB ruling error dominates the loss when there is no dispute. Thus here the paper choose strength of precedent $p(\cdot)=0$, i.e., there is no precedent if the dispute will not be invoked during period 2.

First we can write down $L(\tilde{D}_g^P)$

$$
\begin{aligned}
L(\tilde{D}_g^P) = & \int_{\tilde{\sigma}_{LL}^{FT}\bigcup\tilde{\sigma}_{LL}^{P}} [\Gamma(\tilde{\tau}(s),s)+\delta\Gamma(\bar{\tau}(s),s)]f(s)ds + \int_{\tilde{\sigma}_{LH}^{FT}\bigcup\tilde{\sigma}_{LH}^{P}} \Gamma(\tilde{\tau}(s),s)f(s)ds + \\
& \delta\int_{\tilde{\sigma}_{LH}^{FT}}[q(s)\Gamma(\tau^N(s),s)+c^{all}]f(s)ds + \delta\int_{\tilde{\sigma}_{LH}^{P}}[q(s)\Gamma(0,s)+c^{all}]f(s)ds + \\
& \int_{\tilde{\sigma}_{HL}^{FT}}[[q(s)\Gamma(\tau^N(s),s)+c^{all}]+\delta\Gamma(\bar{\tau}(s),s)]f(s)ds + \\
& \int_{\tilde{\sigma}_{HL}^{P}}[[q(s)\Gamma(0,s)+c^{all}]+\delta\Gamma(\bar{\tau}(s),s)]f(s)ds + \\
& \int_{\tilde{\sigma}_{HH}^{FT}}\left[(1+\delta)[q(s)\Gamma(\tau^N(s),s)+c^{all}] - \frac{c^*c^{all}}{q(s)[w^*(0,s)-w^*(\tau^N(s),s)]+c^*}\right]f(s)ds + \\
& \int_{\tilde{\sigma}_{HH}^{P}}\left[(1+\delta)[q(s)\Gamma(0,s)+c^{all}] - \frac{c^*c^{all}}{(1-q(s))[w^*(0,s)-w^*(\tau^N(s),s)]+c^*}\right]f(s)ds \qquad (7)
\end{aligned}
$$

Compare the efficiency losses of precedent without appeal with that of the institutions without

[37] It should be $p(s)=\frac{c^*}{\delta f(s)[q(s)(w^*(0,s)-w^*(\tau^N(s),s))+c^*]}$ for state subset $\tilde{\sigma}_{HH}^{FT}$ and $p(s)=\frac{c^*}{\delta f(s)[(1-q(s))(w^*(0,s)-w^*(\tau^N(s),s))+c^*]}$ for state subset $\tilde{\sigma}_{HH}^{P}$

precedent by take difference between $L(\tilde{D}_g^P)$ and $L(D_g)$.

$$
\begin{aligned}
L(\tilde{D}_g^P) - L(D_g) = \int_{\tilde{\sigma}_{LL}^{FT} \bigcup \tilde{\sigma}_{LL}^{P}} [\Gamma(\tilde{\tau}(s), s) - \Gamma(\bar{\tau}(s), s)] f(s) ds + \\
\int_{\tilde{\sigma}_{HL}^{FT}} [[q(s)\Gamma(\tau^N(s), s) + c^{all}] - \Gamma(\bar{\tau}(s), s)] f(s) ds + \int_{\tilde{\sigma}_{HL}^{P}} [[q(s)\Gamma(0, s) + c^{all}] - \Gamma(\bar{\tau}(s), s)] f(s) ds + \\
\int_{\tilde{\sigma}_{LH}^{FT}} [\Gamma(\tilde{\tau}(s), s) - q(s)\Gamma(\tau^N(s), s) - c^{all}] f(s) ds + \int_{\tilde{\sigma}_{LH}^{P}} [\Gamma(\tilde{\tau}(s), s) - q(s)\Gamma(0, s) - c^{all}] f(s) ds \\
- \int_{\tilde{\sigma}_{HH}^{FT}} \frac{c^* c^{all}}{q(s)[w^*(0, s) - w^*(\tau^N(s), s)] + c^*} f(s) ds \\
- \int_{\tilde{\sigma}_{HH}^{P}} \frac{c^* c^{all}}{(1 - q(s))[w^*(0, s) - w^*(\tau^N(s), s)] + c^*} f(s) ds
\end{aligned} \tag{8}
$$

By the monotone of the efficiency loss function $\Gamma(\cdot)$ and $\tilde{\tau}(\cdot) \leq \bar{\tau}$, it's easy to conclude that the institution $\tilde{D}_g^P$ did much better than the original D_g in all cases except state subsets $\sigma_L^P \bigcup \tilde{\sigma}_{HL}^{FT}$. Be aware that the state subset σ_L^P is very small. That is, it's very rare for the importing country to impose low protection policy when the first-best policy is high protection. So we only need to worry about the case where the dispute will be invoked due to the high policy imposed when the first-best policy is free trade. By the results in section 3.2.1, we know the subset $\tilde{\sigma}_{HL}^{FT}$ will increase as the increase of the strength of precedent($p(\cdot)$), the weight on the future payoff(δ) and frequency of state($f(\cdot)$). So our choice of no precedent is indeed optimal in the sense to reduce such cases. To reduce the weight on the weight on the future payoff, we can imagine there are more than two period game and the all future payoff claps to the second period. In this sense, we need to make the precedent weak such that it just lasts for fewer periods.

It worth pointing out that the precedent will save the litigation costs in the subsets $\tilde{\sigma}_{HH}^{FT} \bigcup \tilde{\sigma}_{HH}^{FT}$ and reducing the efficiency loss by avoiding the dispute and the dispute mistake in the state subspace $\tilde{\sigma}_{LH}^{FT} \bigcup \tilde{\sigma}_{LH}^{P}$. We summarize the optimal design of the precedent of the DSB ruling in the following proposition.

Proposition 4. *To minimize the efficiency loss, there is optimal choice of strength of precedent if the dispute is invoked in period 1.*
(1)If there will be disputes anyway during period 2, it is optimal to choose maximal strength of precedent. That is, $p(s) = \frac{c^*}{\delta f(s)[q(s)[w^*(0,s) - w^*(\tau^N(s),s)] + c^*]}$ *for state* $s \in \sigma_H^{FT}$ *and* $p(s) = \frac{c^*}{\delta f(s)[(1-q(s))[w^*(0,s) - w^*(\tau^N(s),s)] + c^*]}$ *for state* $s \in \sigma_H^P$*. Then the dispute will be invoked whenever there is no free trade, i.e., the exporter will apply "no tolerance" strategy.*
(2)If the disputes would not happen during period 2, i.e., for state $s \in \sigma_L^{FT} \bigcup \sigma_L^P$*, it's optimal to set* $p(s) = 0$*,that is, there is no precedent if the accuracy of the DSB ruling is low; otherwise choose* $p(s) = \frac{1-q(s)}{\delta f(s)}$ *for* $s \in \sigma_L^{FT}$ *and* $p(s) = \frac{q(s)}{\delta f(s)}$ *for* $s \in \sigma_L^P$*. In the latter case, the exporter will file complaint whenever there is protection of any level("No Tolerance" strategy again).*
(3)If WTO DSB chooses the optimal strength of the precedent and the set $\tilde{\sigma}_L^P$ *is very small,* $\tilde{D}_g^P$ *will dominate* D_g *if the DSB ruling error or the weight on the future payoff is small.*

The last part can be easily derived by considering reducing the efficiency loss when the first-best policy is free trade,especially the second term in the integration. As mentioned above, the decrease of the weight on the future payoff can be achieved by limiting the total number of period the precedent applied. That will decrease the cases for subset $\tilde{\sigma}_{HL}^{FT}$ when the importing country will take the chance to impose the high protection policy due to the extra benefit of precedent. Also as the accuracy of the DSB ruling improves, the efficiency loss due to the DSB ruling error will be reduced. Thus the precedent will become strictly optimal.

Now we need to calculate the efficiency loss $L(\hat{D}_g^P)$ for institution with precedent and appeal. Similarly we discuss on the state s'.
(i) for $s' \in \hat{\sigma}_{LL}^{FT} \bigcup \hat{\sigma}_{LL}^{P}$, we know import policies are $\hat{\tau}(s')$ and $\bar{\tau}(s')$ for corresponding period 1 and 2. Then there is no dispute and no litigation cost. Then we can get the efficiency loss are given by

$$\int_{\hat{\sigma}_{LL}^{FT} \bigcup \hat{\sigma}_{LL}^{P}} [\Gamma(\hat{\tau}(s), s) + \delta\Gamma(\bar{\tau}(s), s)] f(s) ds$$

(ii) for $s' \in \hat{\sigma}_{LH}^{FT} \bigcup \hat{\sigma}_{LH}^{P}$, there is no disputes during period 1 but at period 2. The good point is that there is no effect of precedent. So we can get the efficiency loss easily

$$\int_{\hat{\sigma}_{LH}^{FT} \bigcup \hat{\sigma}_{LH}^{P}} \Gamma(\hat{\tau}(s), s) f(s) ds + \delta \int_{\hat{\sigma}_{LH}^{FT}} [q(s)\Gamma(\tau^N(s), s) + c^{all}] f(s) + \delta \int_{\hat{\sigma}_{LH}^{P}} [q(s)\Gamma(0, s) + c^{all}] f(s)$$

(iii) for $s' \in \hat{\sigma}_{HL}^{FT} \bigcup \hat{\sigma}_{HL}^{P}$, we know import policies are $\tau^N(s')$ for period 1 and $\bar{\tau}(s')$ without precedent. Then DSB will be invoked only in period 1 and period 2 importing policy will be determined by the DSB ruling during period 1 and the appeal result. First we consider $s' \in \hat{\sigma}_{HL}^{FT}$. Then the first period expected payoffs for exporter and importer are $(1 - q(s'))\omega^*(0, s') + q(s')\omega^*(\tau^N(s'), s') - c^*$ and $(1 - q(s'))\omega(0, s') + q(s')\omega(\tau^N(s'), s') - c$ respectively. Similarly by continuity of the state and its density function, the DSB ruling will also continuous for the small $\triangle\ (s)$. Then the expected period-2 payoff for exporter at state s' is

$$\int_{\|s-s'\| \le \triangle(s')} [(1 - q^2(s))\omega^*(0, s') + q^2(s)\omega^*(\tau^N(s'), s')] f(s) ds + \int_{\|s-s'\| > \triangle(s')} \omega^*(\bar{\tau}(s'), s') f(s) ds$$
$$= p(s')f(s')[(1 - q^2(s'))\omega^*(0, s') + q^2(s')\omega^*(\tau^N(s'), s')] + (1 - p(s')f(s'))\omega^*(\bar{\tau}(s'), s')$$

Similarly the expected payoff for importer government at state s' is obtain by replacing the payoff function $\omega^*(\cdot)$ with $\omega(\cdot)$.

$$p(s')f(s')[(1 - q^2(s'))\omega(0, s') + q^2(s')\omega(\tau^N(s'), s')] + (1 - p(s')f(s'))\omega(\bar{\tau}(s'), s')$$

Also for $s' \in \sigma_{HL}^{P}$, by symmetry, the expected payoffs are $pf(s')[q^2(s')\omega^*(0, s') + (1 - q^2(s'))\omega^*(\tau^N(s'), s')] + (1 - pf(s'))\omega^*(\bar{\tau}(s'), s')$ and $pf(s')[q^2(s')\omega(0, s') + (1 - q^2(s'))\omega(\tau^N(s'), s')] + (1 - pf(s'))\omega(\bar{\tau}(s'), s')$ for the exporter and importer government respectively. Then we can write down the efficiency loss as below

$$\int_{\hat{\sigma}_{HL}^{FT}} \Big[[q(s)\Gamma(\tau^N(s), s) + c^{all}] + \delta[p(s)f(s)q^2(s)\Gamma(\tau^N(s), s) + [1 - p(s)f(s)]\Gamma(\bar{\tau}(s), s)] \Big] f(s) ds +$$
$$\int_{\hat{\sigma}_{HL}^{P}} \Big[[q(s)\Gamma(0, s) + c^{all}] + \delta[p(s)f(s)q^2(s)\Gamma(0, s) + [1 - p(s)f(s)]\Gamma(\bar{\tau}(s), s)] \Big] f(s) ds \tag{9}$$

(iv)for $s' \in \hat{\sigma}_{HH}^{FT} \bigcup \hat{\sigma}_{HH}^{P}$, there is dispute in period 1 and can not be avoided in the second period without precedent since the importing policy is $\tau^N(s')$ for both periods. The expected period 1 payoffs for exporter and importer are exactly the same as in part(iii). Now we consider the expected period 2 payoff for exporter when $s' \in \sigma_{HH}^{FT}$

$$\int_{\|s-s'\| \le \triangle(s')} [(1 - q^2(s))\omega^*(0, s') + q^2(s)\omega^*(\tau^N(s'), s')] f(s) ds +$$
$$\int_{\|s-s'\| > \triangle(s')} [(1 - q(s'))\omega^*(0, s') + q(s')\omega^*(\tau^N(s'), s') - c] f(s) ds$$
$$= \omega^*(0, s') - [1 - p(s')f(s') + p(s')f(s')q(s')]q(s')[\omega^*(0, s') - \omega^*(\tau^N(s'), s')] - (1 - p(s')f(s'))c^*$$

Just replace ω^*, c^* with ω, c, we can obtain the expected period 2 payoff for importer government. Also by symmetry between σ_{HH}^{FT} and σ_{HH}^{P},just replace $q(s'), 1 - q(s')$ with $1 - q(s'), q(s')$, we can obtain the expected payoffs for exporter and importer government for $s' \in \sigma^P_{HH}$. Therefore the efficiency loss for the two subsets of states are given by

$$\int_{\hat{\sigma}^{FT}_{HH}} [q(s)\Gamma(\tau^N(s), s) + c^{all}]f(s)ds + \int_{\hat{\sigma}^{P}_{HH}} [q(s)\Gamma(0, s) + c^{all}]f(s)ds$$

$$\int_{\hat{\sigma}^{FT}_{HH}} \delta[[1 - p(s)f(s) + p(s)f(s)q(s)]q(s)\Gamma(\tau^N(s), s) + [1 - p(s)f(s)]c^{all}]f(s)ds+$$

$$\int_{\hat{\sigma}^{P}_{HH}} \delta[[1 - p(s)f(s) + p(s)f(s)q(s)]q(s)\Gamma(0, s) + [1 - p(s)f(s)]c^{all}]f(s)ds \qquad (10)$$

Similarly to the previous part, we only need to consider cases (iii) (iv). If disputes are invoked for the states when the low importing policy will be imposed during the second period (i.e. state subsets $\hat{\sigma}^{FT}_{HL}$ and $\hat{\sigma}^{P}_{HL}$), which is similar to previous part, the optimal choice of the strength of precedent $p(s)$ will just depend on the comparison of the efficiency loss due to error of the DSB rulings of appeal and the efficiency loss due to the exporting country keep silent. That is, we need to compare $q^2(\cdot)\Gamma(\tau^N)$ for state subset $\hat{\sigma}^{FT}_{HL}$(or $q^2(\cdot)\Gamma(0)$ for subset $\hat{\sigma}^{P}_{HL}$) with $\Gamma(\bar{\tau})$. The result is the same as before: if the efficiency loss due to appeal error dominate the second term, then the optimal choice of strength of precedent $p(\cdot) = 0$; otherwise, choose maximal strength $p(\cdot) = \frac{1-q(\cdot)}{\delta f(\cdot)}$ (or $\frac{q(\cdot)}{\delta f(\cdot)}$). Notice that the efficiency loss due to the appeal error here is much less then the efficiency loss due to the wrong ruling precedent in previous part. So it's more likely the upper bound of strength to be chosen than before. But here, to be consistent with previous part when appeal is not allowed, we still assume the efficiency loss due to appeal error dominate the second case. So absent of precedent is optimal.

By equation (10) in case (iv), we will get the same results that the optimal choice of strength is the upper bound. The reason is the precedent with appeal will not only save litigation costs but also the reduced efficiency loose due to the improvement of the DSB ruling by the assumption of appeal. For example, if the first-best policy is free trade and the high importing policy will be imposed during period 2(i.e. state $s \in \hat{\sigma}^{FT}_{HH}$), the optimal strength of the DSB ruling is $p(s) = \frac{c^*}{\delta f(s')[q(s')(\omega^*(0,s') - \omega^*(\tau^N(s'),s')) + c^*]}$. Similarly for the other case when state $s \in \hat{\sigma}^{P}_{HH}$. In both cases, the DSB ruling will make the exporting file complaint whenever there is no free trade. In other world, the importing country is using the "No Tolerance" strategy.

In the case when free-trade is optimal(state $s \in \sigma^{FT}$), it's very interesting that the choice here require that the strength of the precedent is inversely related with the probability of occurrence of the state and the weight put onto the future payoff and the the DSB ruling error. That is, the strength of precedent should be low when the chance of the state is high or the weight of the future payoff is large or the DSB ruling error is low. One interpretation is that if the frequency of the state is high,then the neighboring states are also of high frequency. Thus low strength of precedent will prevent the future efficiency loss due to the current potential ruling error. Similar interpret also works for the weight on the future payoffs. If the accuracy of the DSB ruling is high, then the neighboring states will be probably the same by continuity of $q(s)$. So the high strength of the precedent which means the ruling can be applied to larger neighborhood of the current state will reduce the efficiency loss by reducing potential disputes. In this sense, our choice is optimal.[38] Then we can write down the efficiency loss for $L(\hat{D}_g^P)$.

$$
\begin{aligned}
L(\hat{D}_g^P) = \int_{\hat{\sigma}_{LL}^{FT}\bigcup\hat{\sigma}_{LL}^{P}} [\Gamma(\hat{\tau}(s),s)+\delta\Gamma(\bar{\tau}(s),s)]f(s)ds + \int_{\hat{\sigma}_{LH}^{FT}\bigcup\hat{\sigma}_{LH}^{P}} \Gamma(\hat{\tau}(s),s)f(s)ds+ \\
\delta\int_{\hat{\sigma}_{LH}^{FT}}[q(s)\Gamma(\tau^N(s),s)+c^{all}]f(s)+\delta\int_{\sigma_{LH}^{P}}[q(s)\Gamma(0,s)+c^{all}]f(s)+ \\
\int_{\tilde{\sigma}_{HL}^{FT}}[[q(s)\Gamma(\tau^N(s),s)+c^{all}]+\delta\Gamma(\bar{\tau}(s),s)]f(s)ds+\int_{\tilde{\sigma}_{HL}^{P}}[[q(s)\Gamma(0,s)+c^{all}]+\delta\Gamma(\bar{\tau}(s),s)]f(s)ds+ \\
\int_{\hat{\sigma}_{HH}^{FT}}[[1+\delta][q(s)\Gamma(\tau^N(s),s)+c^{all}]]f(s)ds+\int_{\hat{\sigma}_{HH}^{P}}[[1+\delta][q(s)\Gamma(0,s)+c^{all}]]f(s)ds \\
-\int_{\hat{\sigma}_{HH}^{FT}}\frac{c^*}{q(s)[w^*(0,s)-w^*(\tau^N(s),s)]+c^*}][(1-q(s))q(s)\Gamma(\tau^N(s),s)+c^{all}]f(s)ds+ \\
-\int_{\hat{\sigma}_{HH}^{P}}\frac{c^*}{(1-q(s))[w^*(0,s)-w^*(\tau^N(s),s)]+c^*}][(1-q(s))q(s)\Gamma(0,s)+c^{all}]f(s)ds
\end{aligned}
\tag{11}
$$

Now compare $L(\hat{D}_g^P)$ and $L(D_g)$.

$$
\begin{aligned}
L(\hat{D}_g^P)-L(D_g) = \int_{\hat{\sigma}_{LL}^{FT}\bigcup\hat{\sigma}_{LL}^{P}} [\Gamma(\hat{\tau}(s),s)-\Gamma(\bar{\tau}(s),s)]f(s)ds+ \\
\int_{\tilde{\sigma}_{HL}^{FT}}[[q(s)\Gamma(\tau^N(s),s)+c^{all}]-\Gamma(\bar{\tau}(s),s)]f(s)ds+\int_{\tilde{\sigma}_{HL}^{P}}[[q(s)\Gamma(0,s)+c^{all}]-\Gamma(\bar{\tau}(s),s)]f(s)ds+ \\
\int_{\tilde{\sigma}_{LH}^{FT}}[\Gamma(\tilde{\tau}(s),s)-q(s)\Gamma(\tau^N(s),s)-c^{all}]f(s)ds+\int_{\tilde{\sigma}_{LH}^{P}}[\Gamma(\tilde{\tau}(s),s)-q(s)\Gamma(0,s)-c^{all}]f(s)ds \\
-\int_{\hat{\sigma}_{HH}^{FT}}\frac{c^*}{q(s)[w^*(0,s)-w^*(\tau^N(s),s)]+c^*}[(1-q(s))q(s)\Gamma(\tau^N(s),s)+c^{all}]f(s)ds+ \\
-\int_{\hat{\sigma}_{HH}^{P}}\frac{c^*}{(1-q(s))[w^*(0,s)-w^*(\tau^N(s),s)]+c^*}[(1-q(s))q(s)\Gamma(0,s)+c^{all}]f(s)ds
\end{aligned}
\tag{12}
$$

By the above equation, it is obvious that the institutions with precedent setting will do a strictly better job in reducing the efficiency loss for state subsets σ_H^{FT} and σ_H^P when the high protection policy will be imposed without precedent. Same as previous part, the only case that $\hat{D}_g^P$ did worse job we need to consider is for state set $\hat{\sigma}_{HL}^{FT}$. But we know, the subset $\hat{\sigma}_{HL}^{FT}$ is less than the subset $\tilde{\sigma}_{HL}^{FT}$. Together with the fact that it's more likely for the institution to have positive strength at this subset and thus reduce the efficiency loss. So we can find the institution with precedent and appeal will strictly dominate the institution without appeal.

Also by the last two term in the equation(12), they are increasing in DSB ruling error $q(\cdot)$. Also as the ruling error increases, the "no tolerance" rule will become optimal for all cases. Then it's more likely that the institution with precedent and appeal will dominate the ones without precedent.

Those results also hold for vague contract $\hat{V}_i^P$ and V_i. That's because the behavior of the importer and exporter are the same for states which are in the vague part and the DSB will act the same way in empty contract(D_p). Now we can summarize the results as below

Proposition 5. *The results for the institutions with precedent and appeal:*
(1) The optimal choice of precedent are the same as institutions with precedent but no appeal. But for the situations when the low importing policy will be imposed without precedent, the

[38] Notice that the division of subset spaces also depends on the strength of the precedent $p(\cdot)$. Thus the optimal choice of $p(\cdot)$ here doesn't necessarily mean the minimization of the total efficiency loss $L(D_g^P)$.

institution $\hat{D}_g^P$(or $\hat{V}_i^P$) will more likely to choose the upper boundary for the strength than the institutions without appeal.
(2) As mentioned above, the institution with appeal $\hat{D}_g^P$(or $\hat{V}_i^P$) will strictly dominate the ones without appeal.
(3) As DSB ruling error increases, it's more likely that the institution $\hat{D}_g^P$(or $\hat{V}_i^P$) will dominate the institutions without precedent.

It's easy for the DSB to impose the optimal strength which depends on the ruling error and the importing policy in the next period. In the real world, it's better for the DSB to ask the importing country's future plans before making the ruling. Also be aware that the "proper" appeal here is equivalent to the case that the DSB will make multi period ruling and the accuracy are improving with time. So it's recommend that the DSB should reconsider the same case and improve the ruling decision. It's not hard since the more information will be collected and the DSB will improve themselves too.

4. Conclusion

This paper exploits the effect of WTO Dispute Settlement Body in the trade agreement between two countries when there are continuous state space and the importing country can choose any importing policy from an interval. Both static and dynamic models are considered in a similar way as in Maggi and Staiger (2011). In both static and dynamic models, this paper explains why there is no free trade without WTO DSB rulings due to the existence of the filing complaint cost for the exporting country. Especially in static model, we find the empty contract in dominated by vague contract in both activist and nonactivist DSB cases. That's a much tighter conclusion compared with the ones in Maggi and Staiger (2011). Also the vague contract with active interpretation role of DSB is strictly preferred over nonactivist-DSB vague and rigid contracts when the DSB ruling error is below a threshold. After that threshold, the conclusion reverse.

Another contribution of this paper is the innovative way to model the effects of precedent with continuous state space. Meanwhile the optimal design of DSB are also covered. By this method, we can analysis the expected efficiency loss for two different precedent settings depending on whether the "appeal" is allowed or not. Then we derive an optimal degree of precedent for both cases. There is a very nice property on the optimal precedent strength that it should either make the exporting country adopt the "No Tolerance" strategy or get rid of the precedent which depend on the ruling accuracy and the exporting country's future plans. If the high importing policy will be imposed in the future, it's optimal to maximize the precedent to make the exporting country choose "No Tolerance" strategy. If not and the ruling error is not very small, it's optimal to get rid of precedent,i.e, the optimal precedent strength is zero. We also compare the efficiency losses of both setting ups with the institutions when the precedent is absent.

Currently the paper is still preliminary and some work need to be done. In particular, the comparison between the different institutions such as the vague contract, empty contract and the rigid contract with precedent setting ups are missing in the dynamic model. Also further assumptions might be needed to sharpen the conclusions and derive more results.

Appendix

A. Subgame Perfect Equilibrium with Precedent but NO Appeal

The detailed calculation of the subgame perfect equlibrium in section 3.2.1 is based on the discussions of the state s'.

(i) Consider state $s' \in \sigma_L^{FT}$. Let $\tau_1(s')$ be importer's policy during first period. Then DSB ruling $\tau_1^{DSB}(s) = 0$ with probability $1 - q(s')$ and $\tau_1^{DSB}(s) = \tau_1(s')$ with probability $q(s')$ for state $\| s - s' \| \leq \triangle\ (s)$. So for those states the expected period-2 payoff is given by $(1 - q(s'))\omega^*(0, s) + q(s')\omega^*(\tau_1(s'), s)$. Without filing complaint to DSB, exporter's expected payoff in those states is $\omega^*(\bar{\tau}(s), s)$. Then expected value of filing complaint in period 1 is

$$B_p^E(s') = \int_{\|s-s'\| \leq \triangle(s)} [(1 - q(s'))\omega^*(0, s) + q(s')\omega^*(\tau_1(s'), s) - \omega^*(\bar{\tau}(s), s)]f(s)ds$$
$$= p(s')f(s')\big[- q(s')[\omega^*(0, s') - \omega^*(\tau_1(s'), s')] + \frac{c^*}{1 - q(s')}\big]$$

Then exporter will file complaint if and only if

$$Pr(\tau_1^{DSB}(s') = 0|s')[\omega^*(0, s') - \omega^*(\tau_1(s'), s')] + \delta B_p^E(s') > c^*$$

Plug $B_p^E(s')$ into above inequality and simplify

$$\tau(s') > (\omega_{s'}^*)^{-1}(\omega^*(0, s') - \frac{c^*(1 - q(s') - \delta p(s')f(s'))}{(1 - q(s'))(1 - q(s') - q(s')\delta p(s')f(s'))}) \equiv \tilde{\tau}(s')$$

To make $\tilde{\tau}(\cdot) \geq 0$ to require that $p(s) \leq \frac{1-q(s)}{\delta f(s)}$ for all $s \in \sigma_L^{FT}$. Also we can get $0 < \tilde{\tau}(s') < \hat{\tau}(s') < \bar{\tau}(s') < \tau^N(s')$ for all $s' \in \sigma_L^{FT}$. Same as the previous section 3.2.1(i), the cutoff point of the trade policy($\hat{\tau}(s')$) is a decreasing function of the strength of the precedent of the DSB ruling($p(s')$)and the weight of the future payoff(δ). Thus the exporter government are more likely to file complaint if the strength of the precedent of the DSB ruling or the weight put on future is larger is improved for $s' \in \sigma_L^{FT}$. But it is an increasing function of probability of ruling error($q(s')$)when the error is small or large but becomes decreasing as the error lies in the middle.[39] That makes sense that the exporter will more likely complain when the DSB ruling error decrease if the ruling is either very accurate or very likely to be wrong. For example, the ruling error is large and is decreasing, the benefit of filing complaint ($B_p^E(s')$) is getting larger. Also by comparing the cutoff point with the previous section, we can find precedent without appeal will make the exporter more likely to file complaint than previous section case. The reason is obvious that exporter will take the chance since no appeal available in the next period.

Now the importer will just choose between the cutoff point $\tilde{\tau}(s')$ and full protection level$\tau^N(s')$. The expected period-2 value to importer of the precedent when the importing policy is the latter one

$$B_p^M(s') = p(s')f(s')[(1 - q(s'))\omega(0, s') + q(s')\omega(\tau^N(s'), s') - \omega(\bar{\tau}(s'), s')]$$

Same as before, the importer government choose $\tau^N(s')$ over $\tilde{\tau}(s')$ if and only if

$$D = [1 - q(s')]\omega(0, s') + q(s')\omega(\tau^N(s'), s') + \delta B_p^M(s') - \omega(\tilde{\tau}(s'), s') - c > 0$$

[39] That is, $\tilde{\tau}(\cdot)$ is increasing in $q(\cdot)$ for $q(\cdot) < 1 - \delta p(\cdot)f(\cdot)(1 + \sqrt{\frac{\delta p(\cdot)f(\cdot)}{1+\delta p(\cdot)f(\cdot)}})$ or $q(\cdot) > 1 - \delta p(\cdot)f(\cdot)(1 - \sqrt{\frac{\delta p(\cdot)f(\cdot)}{1+\delta p(\cdot)f(\cdot)}})$. And it becomes decreasing in $q(\cdot)$ when $q(\cdot)$ lies in between the two boundaries.

Notice the expected period-2 value of the precedent for importer country is greater than the institution with precedent and appeal. Also the cutoff protection level is lower than the previous section case. Therefore the function D is greater here and the importer country are more likely choose high protection level. It's not hard to get $\frac{dD}{dq(s)} > 0$ if the litigation cost c^* is small enough. That is, the importing country will more likely to choose high protection level $\tau^N(s)$ rather than $\tilde{\tau}(s)$ when the DSB ruling error is increasing.

(ii) Similarly consider state $s' \in \sigma_L^P$. The expected value of precedent for exporter is given

$$B_p^E(s') = p(s')f(s')\big[-(1-q(s'))[\omega^*(0,s') - \omega^*(\tau_1(s')] + \frac{c^*}{q(s')}\big]$$

The cutoff point can be calculated the same way and the exporter file complaint if and only if

$$\tau(s') > (\omega_{s'}^*)^{-1}(\omega^*(0,s') - \frac{c^*(q(s') - \delta p(s')f(s'))}{q(s')[q(s') - (1-q(s'))\delta p(s')f(s')]}) \equiv \tilde{\tau}(s')$$

Similarly we require that $p(s) \leq \frac{q(s)}{\delta f(s)}$ for all $s \in \sigma_L^P$. Also $0 < \tilde{\tau}(s') < \hat{\tau}(s') < \bar{\tau}(s') < \tau^N(s')$ for all $s' \in \sigma_L^P$. Still the cutoff level $\tilde{\tau}(s')$ is a decreasing function of the strength of the precedent and the discount factor. So the exporter country will more likely to file complain while the strength of the precedent and the weight put on the future payoff increase. And the cutoff $\tilde{\tau}_1(s')$ is decreasing as the ruling error increases while the accuracy is very low or large. Otherwise the cutoff policy level will be an increasing function of the ruling error.[40] That is, the exporter will take the chance to file complaint to increase expected payoff.

Same as above, the importer country will choose between the cutoff protection level $\tilde{\tau}(s')$ and the Nash protection level $\tau^N(s')$. The expected period-2 value of the precedent for the importer when the Nash importing policy is imposed in period 1.

$$B_p^M(s') = p(s')f(s')[q(s')\omega(0,s') + (1-q(s'))\omega(\tau^N(s'),s') - \omega(\bar{\tau}(s'),s')]$$

Then the expected value of the precedent for the next period is much greater than the case where the appeal is allowed. Then the Nash policy will be imposed if and only if

$$D = q(s')\omega(0,s') + [1-q(s')]\omega(\tau^N(s'),s') + \delta B_p^M(s') - \omega(\tilde{\tau}(s'),s') - c > 0$$

Notice the cutoff policy which will get rid of the dispute is lower than the appeal case, so the Nash policy will more likely dominate the low cutoff policy. Similarly, we can show $\frac{\partial D}{\partial q(\cdot)} < 0$ if the litigation cost c^* is small or the weight on the future is large. Therefore, the high importing policy $\tau^N(\cdot)$ is more likely to imposed if the accuracy of the DSB ruling is larger.

(iii) Consider state $s' \in \sigma_H^{FT}$. Let $\tau_1(s')$ be importer's policy during first period. So for those neighboring states the expected period-2 payoff is given by $(1-q(s'))\omega^*(0,s)+q(s')\omega^*(\tau_1(s'),s)$. Without filing complaint to DSB, exporter's expected payoff in those states is $(1-q(s'))\omega^*(0,s)+ q(s')\omega^*(\tau^N(s),s) - c^*$. Then expected period-2 value of filing complaint in period 1 is

$$\begin{aligned} B_p^E(s') &= \int_{\|s-s'\|\leq\triangle(s)} [q(s')[\omega^*(\tau_1(s'),s) - \omega^*(\tau^N(s),s)] + c^*]f(s)ds \\ &= p(s')f(s')\big[q(s')[\omega^*(\tau_1(s') - \omega^*(\tau^N(s'),s')] + c^*\big] \end{aligned}$$

Then exporter will file complaint if and only if

$$Pr(\tau_1^{DSB}(s') = 0|s')[\omega^*(0,s') - \omega^*(\tau_1(s'),s')] + \delta B_p^E(s') > c^*$$

[40]The cutoff policy $\tilde{\tau}_1(\cdot)$ is increasing if and only if $\delta p(\cdot)f(\cdot)(1 - \sqrt{\frac{\delta p(\cdot)f(\cdot)}{1+\delta p(\cdot)f(\cdot)}}) \leq q(\cdot) \leq \delta p(\cdot)f(\cdot)(1 + \sqrt{\frac{\delta p(\cdot)f(\cdot)}{1+\delta p(\cdot)f(\cdot)}})$.

Then simplify the above inequality,

$$\tau(s') > (\omega^*_{s'})^{-1}\left[\frac{(1-q(s'))\omega^*(0,s') - q(s')\delta p(s')f(s')\omega^*(\tau^N(s'),s') - c^*(1-\delta p(s')f(s'))}{1-q(s')-q(s')\delta p(s')f(s')}\right] \equiv \tilde{\tau}(s')$$

To make $\tilde{\tau}(s') \geq 0$, the strength of precedent satisfies $p(s') \leq \frac{c^*}{\delta f(s')\left[q(s')(w^*(0,s')-w^*(\tau^N(s),s'))+c^*\right]}$.[41] Here the cut-off level $\tilde{\tau}(s') \leq \hat{\tau}(s')$ still holds under condition that the litigation cost c^* is much smaller compared with the difference between the free trade payoff $\omega(0,s')$ and the Nash protection payoff $\omega(\tau^N(s'),s')$. The interpretation is straight forward, i.e. the exporter country will more likely to file complaint to DSB if the extra gain from the free-trade DSB ruling is much larger than litigation cost and there is no chance of appeal to the results of the DSB ruling. Same as previous two parts, the cut-off level is decreasing function of the discount factor and the strength of the precedent of the DSB ruling. Also notice the cut-off level $\tilde{\tau}(s')$ is a decreasing function of the the error probability $q(s')$. That is, with the accuracy of the DSB ruling increases, the exporting country will less likely to file the complaint against the importing country. That's because the extra gain from the dispute is less than the cost.

Then the importer will just choose the cut-off protection level $\tilde{\tau}(s')$ and the Nash protection level $\tau^N(s')$. If the latter is imposed, the expected period-2 value of the precedent for importer country

$$B^M_p(s') = p(s')f(s')c$$

That's to say, the precedent just save the litigation cost for the importer. If compared with the case where the appeal is allowed, the expected period-2 value of the precedent for exporter is greater. That is, the extra benefit of the precedent for the exporter during the second period will induce the exporter more likely to impose high protection level during first period when,without a DSB ruling in period 1, the high protection level will be imposed in period 2(for state $s' \in \sigma^{FT}_H$). Then construct the the decision function by comparing the Nash level and the cut-off level:

$$D = [1-q(s')]\omega(0,s') + q(s')\omega(\tau^N(s'),s') + \delta B^M_p(s') - \omega(\tilde{\tau}(s'),s') - c > 0$$

Same as before, due to the better extra benefit of the precedent and the lower alternative no-dispute payoff level(due to the lower cut-off point $\tilde{\tau}(s')$), the high protection level will be more likely to be imposed than the in the appeal-allowed institution case. Now we do the comparative analysis.

$$\frac{\partial D}{\partial q(\cdot)} = -w(0,s) + w(\tau^N(s),s) - \frac{w'(\tilde{\tau}(s))}{(w^*)'(\tilde{\tau}(s))}\frac{\delta p(s)f(s)[w^*(0,s)-w^*(\tau^N(s),s)] - c^*[1-(\delta p(s)f(s))^2]}{[1-q(s)-q(s)\delta p(s)f(s)]^2}$$

The partial derivative is positive when the litigation cost c^* is small enough.[42] Thus the importing country will choose high protection policy $\tau^N(s)$ when the DSB ruling error is large.

(iv) Consider state $s' \in \sigma^P_H$. Let $\tau_1(s')$ be importer's policy during first period. So for those neighboring states, the expected period-2 payoff is given by $q(s')\omega^*(0,s)+(1-q(s'))\omega^*(\tau_1(s'),s)$. Without filing complaint to DSB, exporter's expected period-2 payoff in those states is $q(s')\omega^*(0,s)+(1-q(s'))\omega^*(\tau^N(s),s)-c^*$. Then the expected period-2 value of the precedent for exporter

$$\begin{aligned} B^E_p(s') &= \int_{\|s-s'\|\leq\triangle(s)} [(1-q(s'))[\omega^*(\tau_1(s'),s) - \omega^*(\tau^N(s),s)] + c^*]f(s)ds \\ &= p(s')f(s')[(1-q(s'))[\omega^*(\tau_1(s') - \omega^*(\tau^N(s'),s')] + c^*] \end{aligned}$$

[41] When the strength $p(\cdot)$ reach the right boundary,the cut-off level $\tilde{\tau}(\cdot) = 0$.And when $p(\cdot) = 0$, then it follows that $\tilde{\tau}(\cdot) = \bar{\tau}(\cdot)$

[42] By the domain of the strength of precedent, we get $\delta p(s)f(s) \leq \frac{c^*}{q(s')(w^*(0,s')-w^*(0,s'))+c^*}$.

Then exporter will file complaint if and only if

$$Pr(\tau_1^{DSB}(s') = 0|s')[\omega^*(0, s') - \omega^*(\tau_1(s'), s')] + \delta B_p^E(s') > c^*$$

Simplify and get the cut-off protection level

$$\tau(s') > (\omega_{s'}^*)^{-1}\Big[\frac{q(s')\omega^*(0, s') - (1 - q(s'))\delta p(s')f(s')\omega^*(\tau^N(s'), s') - c^*(1 - \delta p(s')f(s'))}{q(s') - (1 - q(s'))\delta p(s')f(s')}\Big] \equiv \tilde{\tau}(s')$$

Similarly, the requirement for strength of precedent is $p(\cdot) \leq \frac{c^*}{\delta f(\cdot)\big[(1-q(\cdot))(w^*(0,\cdot)-w^*(\tau^N,\cdot))+c^*\big]}$. Also the cut-off level $\tilde{\tau}(s') \leq \hat{\tau}(s')$ still holds under condition that the litigation cost c^* is much smaller compared with the difference between the free trade payoff $\omega(0, s')$ and the Nash protection payoff $\omega(\tau^N(s'), s')$. Same as before the cut-off protection is decreasing with the increase of the strength of the precedent and the weight put onto the future payoff. The critical level $\tilde{\tau}(s')$ is an increasing function of the DSB ruling error($q(s')$). That is, as the accuracy of the DSB ruling improving, the exporter will more likely to file complaint against the exporter.

Now the importer will just choose the cut-off protection level $\tilde{\tau}(s')$ and the Nash protection level $\tau^N(s')$. If the latter is imposed, the expected period-2 value of the precedent for importer country

$$B_p^M(s') = p(s')f(s')c$$

That's to say, the precedent just save the litigation cost for the importer. If compared with the case where the appeal is allowed, the expected period-2 value of the precedent for exporter is greater. Then consider

$$D = q(s')\omega(0, s') + (1 - q(s'))\omega(\tau^N(s'), s') + \delta B_p^M(s') - \omega(\tilde{\tau}(s'), s') - c > 0$$

Same as before, the exporter will more likely to choose the high protection level than in the case where appeal is allowed. Like before we can calculate the partial derivative

$$\frac{\partial D}{\partial q(\cdot)} = w(0, s) - w(\tau^N(s), s) + \frac{w'(\tilde{\tau}(s))}{(w^*)'(\tilde{\tau}(s))}\frac{\delta p(s)f(s)[w^*(0, s) - w^*(\tau^N(s), s)] - c^*[1 - (\delta p(s)f(s))^2]}{[q(s) - (1 - q(s))\delta p(s)f(s)]^2}$$

The partial derivative is negative when the litigation cost c^* is small enough.[43] Thus the importing country will choose high protection policy $\tau^N(s)$ when the DSB ruling error is small.

B. Subgame Perfect Equilibrium with Precedent and Appeal

Similar to the previous part, the calculation is based on the discussion of the state. But the calculation of the benefit of the prcedent $B_p^{\cdot}(\cdot)$ will be changed due to the setting up of appeal.

(i) for $s' \in \sigma_L^{FT}$, given the period 1 policy $\tau_1(s')$, then the result of DSB ruling in the period 1 is $\tau_1^{DSB}(\tau_1) = 0$ with probability $1 - q(s')$ and remain as τ_1 with probability $q(s')$ for states $\| s - s' \| \leq \triangle(s)$. But when the DSB ruling is to keep the current policy, the exporting country will appeal the ruling. And the results of the appealed ruling will be exactly like the first ruling. That's to say, for those state s, the expected payoff of period 2 to exporter is $(1 - q^2(s')\omega^*(0, s) + q^2(s')\omega^*(\tau_1(s))$. Without filing complaint to DSB, the expected payoff is $\omega^*(\bar{\tau}(s), s)$ since DSB will not be invoked then. The expected value of filing complaint during period 1 is

$$B_p^E(s') = \int_{\|s-s'\| \leq \triangle(s)} [(1 - q^2(s'))\omega^*(0, s) + q^2(s')\omega^*(\tau_1(s) - \omega^*(\bar{\tau}(s))]f(s)ds$$
$$= p(s')f(s')\big[- q^2(s')[\omega^*(0, s') - \omega^*(\tau_1(s'), s')] + \frac{c^*}{1 - q(s')}\big]$$

[43]By the domain of the strength of precedent, we get $\delta p(s)f(s) \leq \frac{c^*}{q(s')(w^*(0,s')-w^*(0,s'))+c^*}$.

Suppose the importing policy is $\tau(s')$ at period 1. Then exporter will file complaint if and only if

$$Pr(\tau_1^{DSB}(s')=0|s')[\omega^*(0,s')-\omega^*(\tau_1(s'),s')]+\delta B_p^E(s')>c^*$$

Plug $B_p^E(s')$ into above inequality and simplify

$$\tau(s')>(\omega^*_{s'})^{-1}(\omega^*(0,s')-\frac{c^*(1-q(s')-\delta p(s')f(s'))}{(1-q(s'))(1-q(s')-q^2(s')\delta p(s')f(s'))})\equiv\hat{\tau}(s')$$

To make $\hat{\tau}(s')\geq 0$, we require that $p(s)\leq\frac{1-q(s')}{\delta f(s)}$ for all $s\in\sigma_L^{FT}$. So $\hat{\tau}(s')<\tilde{\tau}(s')$ for all $s'\in\sigma_L^{FT}$. It's easy to observe that the cutoff point of the trade policy($\hat{\tau}(s')$) is a decreasing function of the strength of the precedent of the DSB ruling($p(s')$), the weight of the future payoff(δ) and the frequency of the state($f(\cdot)$) but an increasing function of probability of ruling error($q(s')$) if the ruling error is small. Thus the exporter government are more likely to file complaint if the strength of the precedent of the DSB ruling or the weight put on future is larger or the accuracy of the DSB ruling is improved for $s'\in\sigma_L^{FT}$.

Like the static case, the importer just need to choose between policy $\hat{\tau}(s')$ and $\tau^N(s')$.[44] Denote $B_p^M(s')$ be the expected period-2 value to importer of the precedent for period-1 state s'. Similar to $B_p^E(s')$, we can get

$$B_p^M(s')=p(s')f(s')[(1-q^2(s'))\omega(0,s')+q^2(s')\omega(\tau_1(s'),s')-\omega(\bar{\tau}(s'),s']$$

So importer government choose $\tau^N(s')$ over $\hat{\tau}(s')$ if and only if[45]

$$D=[1-q(s')]\omega(0,s')+q(s')\omega(\tau^N(s'),s')+\delta B_p^M(s')-\omega(\hat{\tau}(s'),s')-c>0$$

First it's obvious that D is an decreasing function of importer government's dispute cost c. So higher the dispute cost, the importer will be more likely to choose low protection level. Then calculate the derivatives of the difference function $D(\cdot,\cdot,\cdot,\cdot)$ with respect to its variables.

First notice $\frac{\partial D}{\partial\delta}=\frac{\partial B_p^M(\cdot)}{\partial\delta}-w'(\hat{\tau})\frac{\partial\hat{\tau}(\cdot)}{\partial\delta}$. For c^* is small enough, the sign of the derivative is determined by the first item. When the first item is positive, i.e. $B_p^M>0$, we get the derivative is positive. Otherwise, it's negative. Similarly for the partial derivative for $p(\cdot)$ and $f(\cdot)$. That is, the more weight the importer put on the future payoff, the less likely the high protection level will be imposed and the DSB will be less likely invoked if the current expected benefit of the disputes on importing country is negative. The reason is that potential period-2 damage due to the dispute cost and the precedent effect of the correct ruling during period 1 will exceed the extra benefit by imposing high protection level during first period. Similar interpolation can be applied to other variables($p(\cdot),f(\cdot)$) and other cases of the sign of the expected payoff of the dispute on importing country.

$$\frac{\partial D}{\partial q(\cdot)}=-\omega(0)+\omega(\tau^N(\cdot))+\delta p(\cdot)f(\cdot)[2q(\cdot)(\omega(\tau^N(\cdot))-\omega(0))-\omega'(\bar{\tau})\frac{\partial\bar{\tau}}{\partial q}]-w'(\hat{\tau})\frac{\partial\hat{\tau}(\cdot)}{\partial q}$$

When the litigation is small enough then the last two idems will be very small. Thus the term $\frac{\partial D}{\partial q(s)}$ is positive, i.e. as the probability of error ruling increase, the importer will change from low protection $\hat{\tau}(s)$ to high level $\tau^N(s)$.

(ii) Similarly consider state $s'\in\sigma_L^P$. The expected value of precedent for exporter is given

$$B_p^E(s')=p(s')f(s')\big[-(1-q^2(s'))[\omega^*(0,s')-\omega^*(\tau_1(s')]+\frac{c^*}{q(s')}\big]$$

[44] Just like the precedent without appeal, the expected payoff function of importing country is increasing over $[\hat{\tau}(\cdot),\tau^N(\cdot)]$ when the dispute will be invoked.

[45] Substitute $\tau^N(\cdot)$ for $\tau_1(\cdot)$ in $B_p^M(\cdot)$ in the following inequality.

The cutoff point can be calculated the same way and the exporter file complaint if and only if

$$\tau(s') > (\omega^*_{s'})^{-1}(\omega^*(0,s') - \frac{c^*(q(s') - \delta p(s')f(s'))}{q(s')[q(s') - (1-q^2(s'))\delta p(s')f(s')]}) \equiv \hat{\tau}(s')$$

Similarly we require that $p(s) \leq \frac{q(s)}{\delta f(s)}$ for all $s \in \sigma^P_L$. Also $0 < \tilde{\tau}(s') < \hat{\tau}(s')$ for all $s' \in \sigma^P_L$. Still the cutoff level $\tilde{\tau}(s')$ is a decreasing function of the strength of the precedent and the discount factor. So the exporter country will more likely to file complain while the strength of the precedent and the weight put on the future payoff increase. And the cutoff $\tilde{\tau}_1(s')$ is decreasing as the ruling error increases while the accuracy is very low or large. Otherwise the cutoff policy level will be an increasing function of the ruling error. That is, the exporter will take the chance to file complaint to increase expected payoff.

Same as above, the importer country will choose between the cutoff protection level $\hat{\tau}(s')$ and the Nash protection level $\tau^N(s')$. The expected period-2 value of the precedent for the importer when the Nash importing policy is imposed in period 1.

$$B^M_p(s') = p(s')f(s')[q^2(s')\omega(0,s') + (1-q^2(s'))\omega(\tau^N(s'),s') - \omega(\bar{\tau}(s'),s')]$$

Then the Nash policy will be imposed if and only if

$$D = q(s')\omega(0,s') + [1-q(s')]\omega(\tau^N(s'),s') + \delta B^M_p(s') - \omega(\hat{\tau}(s'),s') - c > 0$$

Similarly, we can show $\frac{\partial D}{\partial q(\cdot)} < 0$ if the litigation cost c^* is small or the weight on the future is large. Therefore, the high importing policy $\tau^N(\cdot)$ is more likely to imposed if the accuracy of the DSB ruling improves. Also the partial derivative of D respect to p(or δ,$f(\cdot)$) is positive. So the larger the strength of precedent, the weight on the future payoff, or the frequency of the states, the more likely is the high protection policy imposed.

(iii) Consider state $s' \in \sigma^{FT}_H$. Let $\tau_1(s')$ be importer's policy during first period. So for those neighboring states the expected period-2 payoff is given by $(1-q^2(s'))\omega^*(0,s) + q^2(s')\omega^*(\tau_1(s'),s)$. Without filing complaint to DSB, exporter's expected payoff in those states is $(1-q(s'))\omega^*(0,s) + q(s')\omega^*(\tau^N(s),s) - c^*$. Then expected period-2 value of filing complaint in period 1 is

$$\begin{aligned} B^E_p(s') &= \int_{\|s-s'\|\leq\triangle(s)} [q(s')[\omega^*(0,s) - \omega^*(\tau^N(s),s)] - q^2(s')[\omega^*(0,s) - \omega^*(\tau_1(s'),s)] + c^*]f(s)ds \\ &= p(s')f(s')\left[q(s')[\omega^*(0,s') - \omega^*(\tau^N(s'),s')] - q^2(s')[\omega^*(0,s') - \omega^*(\tau^N(s'),s')] + c^*\right] \end{aligned}$$

Then exporter will file complaint if and only if

$$Pr(\tau^{DSB}_1(s') = 0|s')[\omega^*(0,s') - \omega^*(\tau_1(s'),s')] + \delta B^E_p(s') > c^*$$

Then simplify the above inequality,

$$\tau(s') > (\omega^*_{s'})^{-1}\left[\omega^*(0) - \frac{c^*(1-\delta p(s^\cdot)f(s^\cdot)) - q(\cdot)\delta p(\cdot)f(\cdot)[\omega^*(0) - \omega^*(\tau^N)]}{1 - q(s') - q^2(s')\delta p(\cdot)f(\cdot)}\right] \equiv \hat{\tau}(s')$$

To make $\tilde{\tau}(s') \geq 0$, the strength of precedent satisfies $p(s') \leq \frac{c^*}{\delta f(s')\left[q(s')(w^*(0,s') - w^*(\tau^N(s),s')) + c^*\right]}$.[46] Here the cut-off level $\hat{\tau}(s') \leq \tilde{\tau}(s')$. The interpretation is straight forward, i.e. the exporter country will more likely to file complaint to DSB if the extra gain from the free-trade DSB ruling is much larger due to the chance of appeal the wrong ruling results. Same as previous two parts, the cut-off level is decreasing function of the discount factor, the strength of the

[46]When the strength $p(\cdot)$ reach the right boundary,the cut-off level $\tilde{\tau}(\cdot) = 0$.And when $p(\cdot) = 0$, then it follows that $\tilde{\tau}(\cdot) = \bar{\tau}(\cdot)$

precedent of the DSB ruling and the frequency of the states. Also notice the cut-off level $\tilde{\tau}(s')$ is a decreasing function of the the error probability $q(s')$. That is, with the accuracy of the DSB ruling increases, the exporting country will less likely to file the complaint against the importing country. That's because the extra gain from the dispute is less than the cost.

Then the importer will just choose the cut-off protection level $\tilde{\tau}(s')$ and the Nash protection level $\tau^N(s')$. If the latter is imposed, the expected period-2 value of the precedent for importer country

$$B_p^M(s') = p(s')f(s')[(q(\cdot) - q^2(\cdot))(\omega(0) - \omega(\tau^N)) + c]$$

That's to say, the precedent will save the litigation cost but incur potential loss for the importer due to the accuracy of DSB ruling improving for period 2. If the ruling error is very small, the expected benefit for importer is positive. Otherwise, the precedent can hurt the importing country. If compared with the case where the appeal is not allowed, the expected period-2 value of the precedent for importer is much less. That is, the less benefit of the precedent for the importer during the second period will induce the exporter more likely to impose low protection level during first period when,without a DSB ruling in period 1, the high protection level will be imposed in period 2(for state $s' \in \sigma_H^{FT}$). Then construct the the decision function by comparing the Nash level and the cut-off level:

$$D = [1 - q(s')]\omega(0, s') + q(s')\omega(\tau^N(s'), s') + \delta B_p^M(s') - \omega(\hat{\tau}(s'), s') - c > 0$$

Same as before, the monotonicity of the decision function in variable $\delta, p(\cdot), f(\cdot)$ will depend on the sign of the expected benefit of the precedent. So if the precedent will hurt the exporting country, which is very likely when the ruling error is large,then the less likely the high importing policy is imposed, the larger the weight on the future or the strength of the precedent or the frequency of the state. Now we do the comparative analysis.

$$\frac{\partial D}{\partial q(\cdot)} = -w(0, s) + w(\tau^N(s), s) + \delta p(\cdot)f(\cdot)\frac{\partial B_p^M}{\partial q(\cdot)} - \omega'(\hat{\tau})\frac{\partial \hat{\tau}}{\partial q}$$

The partial derivative is positive when the litigation cost c^* is small enough.[47] Thus the importing country will choose high protection policy $\tau^N(s)$ when the DSB ruling error is large.

(iv) Consider state $s' \in \sigma_H^P$. Let $\tau_1(s')$ be importer's policy during first period. So for those neighboring states, the expected period-2 payoff is given by $q^2(s')\omega^*(0, s) + (1 - q^2(s'))\omega^*(\tau_1(s'), s)$. Without filing complaint to DSB, exporter's expected period-2 payoff in those states is $q(s')\omega^*(0, s) + (1 - q(s'))\omega^*(\tau^N(s), s) - c^*$. Then the expected period-2 value of the precedent for exporter

$$B_p^E(\cdot) = p(\cdot)f(\cdot)[(1 - q(\cdot))[\omega^*(0) - \omega^*(\tau_1)] - (1 - q^2(\cdot))[\omega^*(0) - \omega^*(\tau^N)] + c^*]$$

The expected benefit of the dispute for exporting country is less than that in the case without appeal. It could be negative when the ruling error is large.[48] Then exporter will file complaint if and only if

$$Pr(\tau_1^{DSB}(s') = 0|s')[\omega^*(0, s') - \omega^*(\tau_1(s'), s')] + \delta B_p^E(s') > c^*$$

Simplify and get the cut-off protection level

$$\tau(s') > (\omega_{s'}^*)^{-1}\left[\omega^*(0) - \frac{c^*(1 - \delta p(s^{\cdot})f(s^{\cdot})) - (1 - q(\cdot))\delta p(\cdot)f(\cdot)[\omega^*(0) - \omega^*(\tau^N)]}{q(s' - [1 - q^2(s')]\delta p(\cdot)f(\cdot)}\right] \equiv \hat{\tau}(s')$$

[47] By the domain of the strength of precedent, we get $\delta p(s)f(s) \leq \frac{c^*}{q(s')(w^*(0,s') - w^*(0,s')) + c^*}$. So the last two terms can be dominated by the first two terms.

[48] Notice $B_p^E(\cdot)$ is a decreasing function of the ruling error $q(\cdot)$.

Similarly, the requirement for strength of precedent is $p(\cdot) \leq \frac{c^*}{\delta f(\cdot)\left[(1-q(\cdot))(w^*(0,\cdot)-w^*(\tau^N,\cdot))+c^*\right]}$. Also the cut-off level $\tilde{\tau}(s') \leq \hat{\tau}(s')$ due to the expected benefit of the dispute with appeal is less than that when appeal is prohibited. If the expected benefit is positive(when q is small), the cut-off protection is a decreasing function of the strength of the precedent, the weight put onto the future payoff and the frequency of the states. Otherwise, it's an increasing function. The critical level $\tilde{\tau}(s')$ is an increasing function of the DSB ruling error($q(s')$). That is, as the accuracy of the DSB ruling improving, the exporter will more likely to file complaint against the exporter due to the increase of the expected benefit for period 2 dominating the potential loss of period 1.

Now the importer will just choose the cut-off protection level $\tilde{\tau}(s')$ and the Nash protection level $\tau^N(s')$. If the latter is imposed, the expected period-2 value of the precedent for importer country

$$B_p^M(s') = p(s')f(s')\left[(q(\cdot) - q^2(\cdot))[\omega(\tau^N) - \omega(0)] + c\right]$$

That's to say, the precedent will save the litigation cost and extra benefit the importer from the correct ruling in period 2 due to the appeal of the wrong ruling in period 1. If compared with the case where the appeal is not allowed, the expected period-2 value of the precedent for importer is greater. Then consider

$$D = q(s')\omega(0,s') + (1-q(s'))\omega(\tau^N(s'),s') + \delta B_p^M(s') - \omega(\tilde{\tau}(s'),s') - c > 0$$

Because of the greater expected benefit of precedent, the exporter will more likely to choose the high protection level than in the case where appeal is not allowed. Also it's easy to obtain the function D is an increasing function of the strength of precedent, the weight on future payoff and the frequency of current state. Like before we can calculate the partial derivative

$$\frac{\partial D}{\partial q(\cdot)} = [w(0,s) - w(\tau^N(s),s)][1 - (1 - 2q(\cdot)\delta p(\cdot)f(\cdot))] - \omega'(\hat{\tau})\frac{\partial \hat{\tau}}{\partial q}$$

The partial derivative is negative when the litigation cost c^* is small enough. Thus the importing country will choose high protection policy $\tau^N(s)$ when the DSB ruling error is small.

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