Sanitary and Phytosanitary Measures: A game Theoretic Approach of Comparative Evaluation

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Introduction:

The issue of food safety and labeling is becoming important in the present decade. Consumers are increasingly incorporating the issue of safety measures in their buying decisions. They are willing to pay a higher price to get a higher quality product. Consumers with different preferences including the risk preference are rationally choosing different bundles. These choices will maximize their utility as long as their preferences for quality attribute is correct. On the other hand food producers will disclose the information of food quality if it is profitable for them or if they have to supply that information mandatory. In general the markets for food quality rarely work perfectly since the information provided is imperfect. Hence the government intervenes to regulate the market for food quality by imposing various safety measures. Sanitary and Phytosanitary (SPS) is one of those measures, which have been imposed by WTO to judge the quality in case of international marketing. The WTO induced Sanitary and Phytosanitary measure is restrictive and it is affecting the exports of the developing nations. This paper tries to assess the impact of Sanitary and Phytosanitary measures in the context of shrimp imports. A game theoretic model has been proposed to explore the impact of a restrictive SPS policy and to determine whether the policy in its current form generates mutually beneficial payoffs.

Trade and Environment : A Literature Review

The issue of protecting environment can be traced back to the decade of 1960s. The initial idea emerged with the view of protecting the domestic economy from pollution. Economists saw pollution as the consequence of an absence of prices for certain scarce

resources like clean air and water. They prescribed the introduction of unit taxes and effluent fees for protecting the environment from pollution. The evolution of environmental policy both in the US and other developed countries has brought economic issues into effect and involved the question of costs to push for pollution control.[3]The introduction of policy measures to protect the environment has potential not only for protecting the domestic economy but also for international trade. But it has been argued by economists that with pollution control measure there will be an increase in the cost which will eventually result in the loss of the export market and increase in the import of the products of polluting industries[4]. Developing countries in order to enhance their economic development rather than environmental protection tend to produce goods on which they have comparative advantage and at times they develop a comparative advantage in pollution intensive industries. They become the world's pollution haven for dirty industries. Earlier studies made by D'Arge and Kneese (1971) and Walter (1974) used the macro econometric model to estimate the likely magnitudes of these effects. They used the costs of pollution control programs on an industry basis to get an idea of the effects of these programs on trade and payment flows. Generally they found very little but measurable effect on the industries.

It is important to examine historically to what extent have environmental measures influenced the pattern of world trade or have LDCs' become the refuge for dirty industries. Two different studies ahs looked into this problem in a quite different character.

[3] Cropper L Maurren, Oates E. Wallace (1992), " Environmental Economics : A Survey", *Journal of Economic Literature*

[4] These trade effects have been studied by using the models of international trade by Kazumi Asako 1979; Baumol and Oates 1988; Anthony Koo 1974; Martin McGuire 1982; John Merrifield 1988; Rudiger pethig 1976; Horst Siebert 1974; James Tobey 1989; Ingo Walter 1975.

H .Jefferey Leonard (1988) has examined the foreign investment pattern of several industries and countries and found little evidence that pollution control measures have exerted a systematic effect on international trade and environment. He concluded by mentioning that “the differentials in the costs of complying with the environmental regulations and in the levels of environmental concern in industrialized and industrializing countries have not been strong enough to offset a larger political and economic forces in shaping aggregate international comparative advantage. Tobey (1989, 1990) has looked into the same issues in a large econometric study of international trade patterns in “pollution- intensive” goods. He cannot find any effects of the various measures of the stringent environmental policies after controlling for the effects of relative factor abundance and other trade effects. Tobey estimated two sets of equation explaining the patterns of trade in pollution intensive goods and changes in trade pattern from 1970 to 1984. None of the variables in the equations measuring the effect of environmental protection have any effect on trade patterns.

Kohn and Capen (2002) mentioned about the optimal volume of environmentally damaging trade. According to them it is highly controversial whether international trade enhances or degrades the environment. The model constructed by them shows that biodiversity is hampered due to trade liberalization, which includes commercialization of natural habitats, pollution and bio-invasion. They further stated that when both the countries engaged in trading internalize the costs of production and trade, environmental quality may be higher or lower as a result of trade. However the significant amounts of air and water pollution generated during the actual transport of goods from one country to the other should be internalized by the Pigouvian tax.

Benchekroun and Van Long (2001), differential game model on Transboundary fishery provides an interesting insight about conservation of endangered species. Migratory fish that travel along the coastline of several nations are subject to sequential catching. This has been a cause of disputes between US and Canada. The Canadian Salmon born in Canadian rivers have the habit of traveling across the Pacific Ocean and stay in the high sea areas for couple of years and they return to Canada for breeding. While returning the fisherman of Alaska has the first chance to catch them. If they catch all the Canadian Salmon then there will be no fish in the future. So there is an incentive to conserve the resources. Canadian fishers are the second movers, in this game pattern. The existence of a first mover results in more conservationist exploitation in the aggregate. In this model they have considered the implication of departure from the equilibrium. If the leader can decrease its fishing effort over a finite interval of time, then the follower may respond by increasing or decreasing its catch rate depending on the length of the commitment period.

From Bureau, Gozlan and Marette (2001), an idea about the quality signaling and international trade in food products can be developed. They have constructed a framework of repeated purchases under the scenario of imperfect competition on product quality. A northern firm can more easily detect tainted products than can a southern one. When imports are banned, the northern firm does not always signal the actual quality of its products. Competition from imports may lead the northern firm to test the quality of its products as a way to differentiate itself from foreign competitors. Consumers benefit from the disclosure of information on quality, even though borders are open to products of uncertain quality. However, competition from imports also increases the cost of signaling

high quality. This can be detrimental to the welfare of the importing country when the cost of detection is high.

The issue of political economy and trade liberalization is closely related. Trachtman (2002) has mentioned that the decision to relate trade with other linkages has been always a political decision and is not otherwise determined by the nature of the things. Government link trade concessions to the satisfaction of other non-trade policy interests either legally or politically whenever they find such linkage useful to achieve their goals.[5] This statement has not much empirical evidence in the economic literature. However, the issue of trade and environment from the perspective of international law justifies the above argument

Food Safety and Trade:

The issue of food safety and trade has become important after the WTO regulation on trade of processed food products. In 1994, SPS agreement has been signed to lay the foundation for strengthening multilateral discipline in the implementation of food safety standards. The exporting countries have to maintain the WTO specified standard.

For a decade WTO is mentioning about issues relating to trade, the environment and sustainable development. Environment is a horizontal issue that cuts across different rules and disciplines in WTO. Members both have considered the issue in terms of the impact of environmental policies on trade, and of the impact of trade on the environment.

Article 20 of the GATT allows government to act on trade to protect human animal or plant life or provided they do not discriminate or used this as disguised protectionism.[6] . A separate agreement on food safety and animal plant health sets out the basic rules. If the

[5] Trachtman P. Joel (2002), " Insitutional Linkage : Transcending " Trade and …", *The American Journal of International Law*

[6] http://www.wto.org/english/thewto_e/whatis_e/tif_e/agrm4_e.htm

trading countries are not complying with the set of rules then an embargo will be put on the commodities imported from the trading partner.

The International standards and recommendations for the SPS have facilitated trade through reducing transaction costs, and assuring consumers food safety. For the purpose of food safety, the Codex Alimentarius Commission establishes the standards, guidelines and recommendations. The recommendations are related to food additives, veterinary drug and pesticide residues, and contaminants, methods of analysis and sampling, for codes and guidelines of hygienic practice. In case of animal health and zoonoses, the standards, guidelines and recommendations developed under the auspices of the International Office of Epizootics. Similarly, in case of plant health the international standards, guidelines and recommendations are developed under the auspices of Secretariat of the International Plant Protection Convention in cooperation with regional organizations, international organizations and their subsidiary bodies, in particular, the Codex operating within the framework of the International Plant Protection Convention; and for matters which are not covered by the above organizations are appropriate standards, guidelines and recommendations is promulgated by the other relevant international organizations open for membership to all Members, as identified by the Committee[7].

The exporting countries have to follow the set of rules and regulations, which are specified by the regulatory WTO. In case of non-fulfillment of the exact specified regulations there is a high probability of rejection by the importing country.

It is argued by some economist that the Sanitary and Phytosanitary (SPS) measure is posing an absolute barrier to trade with some countries where certain plant pests and

[7] Haque Enamul, A.K, " Sanitary and Phytosanitary Barriers to Trade and its Impact on the Environment, *International Institute for Sustainable Development (April 2004)*

animal diseases require very stringent controls or eradication measures. Such absolute barriers are comparatively less common in relation to food safety measures, although the cost for meeting specified requirements maybe high for certain suppliers. In either case, however developing country suppliers rarely face all or no choices when determining the changes and investments needed to conform to emerging standards.

The has been a change in the trade pattern in the world economy over the years due to a change in the consumer tastes and preferences in production, transport and other supply chain technologies and methods. World exports of trade in fish and horticulture have increased from 19.7 % in 1980-81 to 31.1 % in 2000-01. (Table 1 gives a detail picture of the changing structure of agricultural trade in US). These products have higher income elasticities of demand and in most cases lower price volatility than many traditional developing country export commodities. The expansion of trade in fish, spices and horticulture products has been facilitated in part by comparatively low and declining tariff barriers as well as price pressure generated from the supply side. However the trade in these products has been governed by strict food safety and agricultural health standards that have been developed to address various risks including those associated with microbial pathogens, pesticides and veterinary pharmaceuticals, and environmental contaminants.

The past –decade has seen an expansion and strengthening of sanitary and phytosanitary (SPS) standards, in the public and private sector. These standards regime continues to evolve internationally, nationally and within individual supply chains.

Table 1: The Changing Structure of Agricultural Trade
(Percentage of Export Value)

	Total for developing Countries		**Total for industrialized countries**		**World Exports**	
	1980/81	**2000/01**	**1980/81**	**2000/01**	**1980/81**	**2000/01**
Traditional tropical products						
Coffee, cocoa, and tea	18.3	8.5	2.5	3.6	8.5	5.4
Natural Fibers	8.0	3.3	4.5	2.6	5.9	2.8
Sugar and Confectionery	10.5	4.3	3.9	2.3	6.4	3.1
Nuts and Spices	2.4	2.8	0.7	0.8	1.3	1.5
Subtotal	*39.2*	*18.9*	*11.6*	*9.3*	*22.0*	*12.7*
Temperate Products						
Meats, Fresh and processed	7.2	6.0	14.8	15.4	11.9	12.0
Dairy Products	0.3	1.1	7.9	7.6	5.0	5.2
Grains, raw and processed	9.3	7.0	21.6	11.6	16.9	9.9
Oilseeds + edible oil	4.6	5.5	4.8	4.4	4.7	4.8
Animal Feed	7.5	8.5	7.7	5.3	7.7	6.4
Subtotal	*28.8*	*28.1*	*56.9*	*44.2*	*46.3*	*38.3*
Fish and Horticulture						
Fish, fresh and processed	6.9	19.4	5.5	8.0	6.0	12.2
Fruits, Vegetables, and flowers	14.7	21.5	13.1	17.3	13.7	18.9
Subtotal	***21.6***	***40.9***	***18.6***	***25.3***	***19.7***	***31.1***
Other Products						
Tobacco and cigarettes	2.6	3.3	3.0	4.8	2.8	4.2
Beverages	1.1	3.6	6.9	11.5	4.7	8.6
Other Products/processed foods	6.7	5.2	3.0	5.0	4.4	5.1
Subtotal	*10.4*	*12.1*	*12.8*	*21.2*	*11.9*	*17.9*
	100	**100**	**100**	**100**	**100**	**100**

Source: UN COMTRADE

But the domestic consumption of shrimp has increased from 1996 onwards so in order to meet the growing demand, shrimp has to be imported .The low-priced shrimp imports from the developing countries, are threatening domestic shrimp producers. In 2004, shrimp fishermen in eight states plan to file petitions seeking increased tariffs on shrimp imports from Thailand, China, Vietnam, Ecuador and a handful of other nations that supply nearly 90 percent of the U.S. market.[8] .

[8] Kennedy P.Lyn , Lee Young jae, "Effects of Catfish, Crawfish, and Shrimp Imports on U.S. Domestic Prices" (Dept. of Agricultural Economics and Agribusiness, Louisiana State University AgCenter, Baton Rouge, Louisiana)

The issues related to trade and environment is giving rise to the question of conflict of interest between the developed nations and the developing nations. After the tuna dolphin debate of the late 80s the debate on shrimp import is gaining much importance in the US economy. Section 609 of Public law 101-102, enacted in 1989 by the United States stated that shrimps which are not harvested with turtle safe technology and does not meet the HACCP[9] criteria will not be imported by the US unless the harvesting nation was certified to have a regulatory program and an incidental take-rate comparable to that of the United States. In most of the cases the developing countries does not have a proper regulatory program, which is comparable to United States.

Trade pattern affects environmental standard. If we look into this debate from the partial equilibrium analysis it can be observed that an embargo on shrimp import will eventually hurt the domestic consumers. The partial equilibrium analysis is beyond the scope of this paper. In this paper, a basic game theoretic model for the problem has been proposed.

Model:

Let us assume there exists a set of players, $P = \{p^1, p^2, \ldots p^n\}$ with the strategy profile $S^i = \{s^i_j, s^i_{j+1}, s^i_{j+k}\}$ for each player i = 1, 2 ….n and $\forall$ j, k $\geq 0 \in R_+$. The strategy set is finite and bounded above to enable a non-empty solution set. Each player's strategy corresponds to a payoff derived from an interdependent payoff (utility) function,

$U_i = u(s^1, s^2, s^i \ldots. s^n)$. The equilibrium is defined (in the strict Nash sense) as the best response function for each individual player given all other's best responses. This implies $U^* = u(s^1, s^2, s^{i-1}, s^{i*}, s^{i+1}, \ldots s^n) > U = u(s^1, s^2, s^{i-1}, s^i, s^{i+1}, \ldots s^n)$ for any individual i. The

[9] Hazard analysis critical control point

equilibrium concept however need not be strict Nash and can take any form from pair wise stable to sequential equilibrium, depending on the modeling intricacy.

We begin with a simple example with 2-players two-strategy model. Let the two players be (developed countries) the importer and (developing country) the exporter. Let the strategies for the importer is deciding whether to impose high or low regulation on the basis of domestic health standard considerations whereas the strategy for the exporting country is to choose between farming practices (safe and unsafe). The Payoffs for importer is obtained from changes in health costs and welfare changes due to high regulations. The extra health cost is assumed to take care of possible health hazards from consuming low quality product of the exports arising out of unsafe farming. The welfare change is caused by the changes in domestic prices of the imported produce due to higher regulations. For the exporter adopting better technology involves learning cost or other associated investment for switching. This results in extra spending by the exporter, which reduces his net export revenue. On the other hand the losses in export revenue may also arise out of high regulation by the importing country (possibly in term of penalties or lower demands from the importer). The interdependency in decisiol making in such situations characterizes the appropriateness of exploring a game theoretic model. In the following simple example a simultaneous move single period game structure has been considered.

In the following diagram the row strategies are adopted by an exporter and the importer adopts the column strategy. For the actions set adopted by the importer, HR and LR represent High and Low Regulations respectively and for the exporter SF and UF denotes the safe and unsafe farming respectively. In the payoff matrix “w” denotes the total welfare out of trade, “h” denotes the health care cost and “λ” is the loss of welfare due to

high regulations. For the exporter "x_R" denotes the export income "c" denotes the technology/learning cost to adopt safe farming and "δ" denotes the loss in export revenue due to higher regulations imposed by the importer. The equilibrium outcome of the game will depend on the pay-off values of h, w, c and x_R. Depending on these parameter values it may be the case that even if a developing country is practicing safe farming but with high regulations from the importer (considering trade and other political reasons) the net income of the developing country (exporter) may diminish which makes the safe firming practices unsustainable in the long run. Similarly a country with high regulation may end up having a loss in welfare due to high price of the product in the domestic market. On the contrary with low regulation, the importing country may be placed in a high welfare zone comparing to the situation of high regulation if the exporting country is practicing safe farming.

Importer / **Exporter**	**HR**	**LR**
SF	$x_R - \delta - c$; $w - \lambda$	$x_R - c$; $h + w$
UF	$x_R - \delta$; $w - \lambda - h$	x_R; $-h + w$

When the importer is adopting safe farming and the exporter is imposing a high regulation, the net income of the exporter is given by $x_R - \delta - c$ and the net benefit of the importing country is $w - \lambda$. The value of $x_R - \delta - c$ will depend on the magnitude of c & δ & x_R If the cost of safe farming exceeds the export income then in that case the net income will be negative and if the cost of safe farming is balanced by the export income, then in that case their will be neither loss nor benefit. In developing countries the due to lack of

proper infrastructure, technology cost is very high. Producers hardly get any support from the government for practicing safe technology. The imposition of high regulation will make the export price more competitive hence the possibility of negative value of $c-x_R$ is very strong. If $c>x_R$ then there is a loss due to export and if $c- x_R <0$, then export is not beneficial if the producer practices safe farming.

With unsafe farming, the exporter is losing export income with high regulation and having a positive value of x_R with low regulation. The value of 'c' is zero in the case of unsafe farming since the exporter is not incurring any cost for improving its technology.

High regulation increases import price, which affects the consumers by paying higher unit price, thereby reducing consumer welfare. Net welfare effect of the importing country will depend on the magnitude of h&w. Even if the country is gaining health benefit but there is a loss of consumer's welfare due to high price. But it can be assumed that the strategy of safe farming is reducing the health care cost of the consumers.

With unsafe farming and high regulation the consumers in the importing country is both incurring a high cost of health due to consumption of shrimp, which is produced with unsafe farming and welfare loss due to high price of the imported good. In case of low regulation the possibility of health loss is same but there is welfare gain due to a controlled price.

The simple model explained above is further developed into a general structure involving the payoff functions of each player.

The consumer surplus (payoff) for the importer is given as :

$$U_m(P_m, X_m) = \int_{p_m}^{\infty} Q_m(P_m, R)\, dP_m - H(Q_m, T) \qquad (1)$$

where $\frac{\partial H}{\partial T} < 0 \; and \; \frac{\partial H}{\partial Q_m} \geq 0$ depending on the quality of imports and

$\frac{\partial Q_m}{\partial P_m} < 0 \; and \; \frac{\partial Q_m}{\partial R^*} < 0$

The domestic prices of imports and quantities imported is represented by P_m and X_m respectively, R^* denotes regulation and T denotes technology cost used by the exporter for farming. H(.) represents the health cost incurred by the importer.

The producer's surplus for the exporter is given as:

$$\pi_x \; (P_x, Q_x) \; = \; \int_0^{p_x} Q_x (P_x, \; R) \, d P_x \; - C (Q_x, \; T) \qquad (2)$$

where P_x is the price received by the exporters and Q_x denotes quantity exported. C(.) represents the associated cost of exports. The technology cost for safer farming technology is considered as T.

The decision making process for the exporter and the importer are interdependent on the parameters R and T. The condition for Nash equilibrium exists where the producer's surplus equates to the consumer's surplus. In other words the simultaneous solution of both the equations provide the Nash Equilibrium at $U_m(R^*,T^*) = \Pi_x(R^*,T^*)$. The deviance from the star strategy would induce the other player to defect and thus distort the equilibrium.

Conclusion:

The sanitary and phytosanitary measures of the WTO has mentioned about certain guidelines, which the exporting country should follow to protect the consumers from health hazards. Importing countries have so far restricted import of food products from the

developing countries on the grounds of non-compliance with food standards such as discovery of banned chemicals found in the shrimp and for not implementing HACCP (hazard analysis and critical control point). This kind of ban on imports (if the product is imported from developing countries) may result in decline in the exports of that country given the limited capacity of the developing country to implement the SPS measures at all levels. Driven by poverty and underdevelopment there can be a further aggravation of the existing problem**.** An appropriate policy should be adopted so that it benefits both the exporting and importing country. However one has to keep in mind that the expansion of the processed food –sector has a positive impact on employment generation of labor surplus developing countries.

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