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Welfare Assessment of SPS Standards: An Empirical Study of Indo-US Mango Trade Dispute

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Welfare Assessment of SPS Standards: An Empirical Study of Indo-US Mango Trade Dispute

Siddhartha K. Rastogi*

Abstract

As trade quotas have been eliminated under GATT and tariffs have been rationalized under WTO; the focal point of disputes and negotiations in international trade has shifted to non-tariff barriers (NTBs), particularly Sanitary and Phytosanitary (SPS) standards. However, in the absence of any past experience and concrete scientific or empirical evidence, standards are usually kept at prohibitively high levels, thereby inducing sub-optimal outcomes. One such case is the mango trade dispute between India and USA. India ranks first in mango production worldwide, supplying about 40 per cent of world mangoes; whereas, USA is world's biggest mango importer accounting for 32.7% of the total imports worldwide during 2003-05. However, USA imposed a ban on import of Indian mangoes between 1989 and 2006 due to high pesticide levels and incidence of pests. The US permitted import of mangoes from India in 2006 under high standards and strict inspection norms. This study examines the impact of various standard regimes on the two trading partners and explores if the benefit from a higher standard regime is worth the marginal effort.

As the importing nation, US has four policy options – 1) a complete ban on mango trade, which was in application between 1989 and 2006; 2) Hot Water Treatment (HWT), the policy advocated by India; 3) nuclear irradiation, the policy favored by US and presently in force, and; 4) free trade, policy regime with no SPS standards in place. Welfare impact of mango trade on both, India and US, under all four different policy regimes is estimated using partial equilibrium framework with stylized microeconomic models for different components.

The results suggest that policy choices of both the nations are consistent with their respective payoff estimates. However, if India undertakes to compensate the US for any losses from a policy change in favor of India, both the nations may reach a Kaldor-Hicks efficient outcome. A brief sensitivity analysis is performed, indicating that the developed north can afford to be more flexible in adopting SPS standards. This study also underscores that the impact of risks arising out of invasive species cannot be studied in terms of science alone but it has to be wedded to the economic implications.

JEL Classification: F13, F14, F51, Q17

Key words: SPS, India - USA Trade, Mango Trade, Cost-Benefit Analysis, Harberger Triangles, Microeconomic Stylized Model.

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Welfare Assessment of SPS Standards: An Empirical Study of Indo-US Mango Trade Dispute

1. Introduction

Agricultural trade has become liberated to a great extent under the General Agreement on Tariff and Trade (GATT) and then under the auspices of World Trade Organization (WTO). However, as the incidence of quotas and tariffs declined, non-tariff barriers (NTBs) became the focal point of trade negotiations among trading partners. WTO member countries have adopted two multilateral agreements to deal with NTBs, namely Agreement on Sanitary and Phytosanitary (SPS) measures and Agreement on Technical Barriers to Trade (TBT). A country can adopt SPS measures to protect human, animal, and plant health and life from the risks arising from invasive species of pests, weeds, disease causing organisms, and toxins present in imported foods and/or agricultural products.

According to the agreement, SPS standards are commodity specific standards backed by scientific evidence and shall be kept at a minimal level. However, near absence of empirical basis and over-cautiousness on technical grounds often result in SPS standards more stringent than necessary. According to Rodriguez et al (2000), under the agreement, a member has the sovereign right to determine the level of protection it deems appropriate against bona fide risks. Thus SPS agreement also provides a potent tool for prohibiting trade, protectionism, and discrimination among trading partners. Such standards adversely affect allocative efficiency within the economy and reduce the comparative advantage of the nation. Roberts (2000) assert that "any SPS restriction that increases the price of an imported good is, in effect, a tax on all exports, raising the price of tradable goods bids resources away from other industries."

The rationale of SPS agreement emerges from the economic implications that the occurrence of invasive species may entail, if not checked by the SPS agreement.

There are four vectors for the spread of invasive species - travel, transport, trade, or tourism. The pertinence of SPS measures has increased with the extent of globalization and the ensuing increase in volumes of international trade and tourism. Margolis (2007) quote Invasive Species Specialist Group (ISSG) figures to show the number of invasive aquatic species in Europe only has increased exponentially, as it was 183 only in 100 years from 1800 to 1899, 497 in next forty years between 1900 to 1939, reached 1611 during subsequent forty years from 1940 to 1979, and then within next 19 years between 1980 to 1998, reached a number of 2214.

The rest of the paper is arranged as follows - in section 2, we take a background look at the case of mango trade dispute between India and USA. Section 3 presents dataset along with estimation for various scenarios. Section 4 represents a brief sensitivity analysis. Section 5 concludes with policy implications, contributions, and limitations of this study.

2. The Case of Mango Trade between India and USA

India ranks first in mango production worldwide, supplying about 40 per cent of world mangoes. With almost two million hectares under mango cultivation, it is India's top valued horticulture crop. However, India's mango exports have been about only one percent of the total production (Table 1). This is primarily due to huge domestic demand; however, it is also due to lack of export supply chain, high transport costs, and non-exportable quality of Indian mangoes (Mattoo et al. 2007). Mango export is insignificant even in value terms at less than INR 1.5 billion (30 million US$) for 2006-07 (or approximately INR 18 per kg).

Table 1: Indian mango production and trade (MT)

Year	Production	Import	Export
2000	10,503,500	6.08	107,015.39
2001	10,056,800	12.96	94,413.20
2002	10,020,200	0.26	121,164.51
2003	12,733,200	90.65	134,110.75
2004	11,490,000	0	60,551.32

Table 1: Indian mango production and trade (MT) (contd)

Year	Production	Import	Export
2005	11,605,200	38.3	53,480.02
2006	12,663,100	0.80	69,606.60

Source: CMIE Indian Harvest

The top export destinations for Indian mangoes are United Arab Emirates, Nepal, Bangladesh, United Kingdom, and Saudi Arabia. These markets fetch a lot lesser price (Table 2) than the US market, which appears to be a much lucrative market, fetching Indian suppliers a price between INR 180 to 240 per kilogram.

Table 2: Indian mango export – top destinations

	2005-06			2006-07			2007-08		
Country	**Quantity**	**Value**	**INR /KG**	**Quantity**	**Value**	**INR /KG**	**Quantity**	**Value**	**INR /KG**
UAE	26,533.8	7,30.4	27.5	22,045.5	6,58.1	29.9	22,469.6	6,32.1	28.1
UK	839.9	53.8	64.0	1,883.2	1,14.1	60.6	2,575.4	1,98.2	76.9
Bangladesh	32,770.9	2,76.6	8.4	42,887.5	3,99.5	9.3	17,063.6	1,59.5	9.4
Nepal	4,116.0	32.3	7.9	8,055.7	70.7	8. 8	7,550. 9	63.6	8.4
S. Arab	1,564.2	44.2	28.3	1,323.6	42.2	31.9	1,488.9	45.9	30.9

Source: APEDA Trade Junction (2008); Quantity in MT, Value in Million INR.

On the other hand, US production of mangoes is quite insignificant, not exceeding 3000 MT per annum (Table 3).

Table 3: US mango production and trade

Year	Production	Import (MT)	Import Value (Mn US$)
2000	NA	235,098.33	164.562
2001	3,000	237,933.97	183.540
2002	3,000	263,347.50	153.009
2003	2,300	278,421.94	192.891
2004	2,600	276,344.91	180.351

Table 3: US mango production and trade (contd)

Year	Production	Import (MT)	Import Value (Mn US$)
2005	2,800	260,841.85	169.117
2006	3,000	292,376.63	209.650

Source: USDA ERS (2008), FAOSTAT

Florida is the major mango producing state of US with over 80 per cent production occurring in Miami-Dade County (Mossler and Nasheim, 2002). However, US is world's largest mango importer accounting for 32.7% of the total imports during 2003 to 2005 (Evans, 2008). In 2006, US imported mangoes worth $233 million out of which mangoes worth $138 million (or about 60 per cent) were imported from Mexico. The top mango exporters to US are given in Table 4. Evidently, India has exported negligible quantity of mango in that period under special permits only. This is due to the ban on mango import from India imposed by US between 1989 and 2006. The ban was lifted in 2006; however, the SPS standards and inspection norms enforced still remain controversial and under negotiation.

Table 4: Top mango exporters to USA, 2002-2006 (million US$)

Rank		2002	2003	2004	2005	2006
0	World	163.40	176.14	168.56	195.25	233.05
1	Mexico	82.80	93.07	88.28	107.32	137.98
2	Brazil	28.69	28.37	16.69	18.22	18.90
3	Peru	19.89	16.81	21.19	21.52	23.77
4	Ecuador	10.43	13.70	14.41	13.48	19.03
5	Philippines	5.36	8.83	11.69	16.69	12.50
6	Haiti	5.50	4.48	5.48	7.34	8.65
7	Thailand	3.06	3.43	4.23	4.31	4.63
8	Guatemala	4.79	3.64	2.90	2.67	3.40
9	Nicaragua	1.24	2.01	1.35	1.35	1.74
10	Costa Rica	1.10	1.14	1.07	1.09	1.17
16	India	0.06	0.08	0.13	0.04	0.04

Source: World Trade Atlas. Ranking is based on total exports of mangoes by the respective countries to US during 2002 to 2006.

The US banned import of Indian mango in 1989 on account of excessive usage of pesticides and fear of invasion of fruit flies and stone weevils. India offered to reduce pesticide levels and offered Hot Water Treatment (HWT) as a viable measure of pest control. In 2006, after prolonged negotiations, US permitted import of Indian mangoes with nuclear irradiation and strict inspection. The inspection norms were prohibitively strict as inspection in India by US inspectors increases the cost of mango manifold and renders it uncompetitive (Sen, 2007; Rabinowitz, 2007). However, after further negotiations, US agreed for nuclear irradiation and routine inspection only.

India has tried arguing for HWT as an effective SPS measure reducing probability of fruit fly infestation by 80 per cent (OISAT, 2009). The process includes desapping, washing, immersion in hot water, and fungicide. If coupled with bagging of mango fruit or pre-harvest sanitation treatment. HWT provides a completely fruit fly free crop (Verghese et al, 2006). Initial costs of HWT comes to INR 200 thousand for a life of 8 years, a fraction of irradiation plants with substantially lower operational costs.

3. Estimation for Alternative Scenarios

US, as an importing nation, has four policy options to chose from – 1) a complete ban on mango trade, which was in application between 1989 and 2006; 2) HWT, a policy favored by India; 3) nuclear irradiation, the policy favored by US and presently in force, and; 4) free trade, a policy regime with no SPS standards in place. In the nuclear irradiation of mangoes, the fruit cartons are exposed to gamma ray for about 10 minutes. After irradiation, the fruit is kept in cold storage for at least a day. The irradiation process delays ripening of fruit, thereby, increasing the shelf-life of the fruit by about a week. The process also inactivates fruit flies and stone weevil, the two pests of concern. However, the irradiation process is costly and technically sensitive. An irradiation plant requires an initial investment of approximately INR 100 million with a life of 10 years, in addition to maintenance, safety, and operation costs. HWT, on the other hand, requires very low initial investments and is a simpler process. The process involves desapping of the fruit, washing, immersion in the hot water, fungicide, and washing again before placing the fruit in cold storage for at least a day. Countries in Middle-East and EU as well as China, UK, Bangladesh etc. accept HWT as an effective treatment against all mango pests.

Welfare impact of mango trade on both, India and US, under the four different policy regimes is estimated. Welfare impact is defined as the net of consumer surplus, producer surplus, SPS compliance cost for the exporting nation, and control and spillover costs for the importing nation. Market clearing conditions are imposed. The steps in analysis under every policy option are shown in the following figure, whereas respective assumptions and theoretical justifications are provided in the respective sections.

Figure 1: Steps in Analysis

Part 1 - Payoffs to India	**Part 2 - Payoffs to USA**	**Part 3 - Sensitivity Analysis**
1.1 Estimate Consumer Surplus	2.1 Estimate Consumer Surplus	3.1 Assume no loss from HWT
1.2 Estimate Producer's Surplus	2.2 Estimate Producer's Surplus	3.2 Assume marginal loss from nuclear irradiation
1.3 Estimate cost of respective treatments	2.3 Estimate Pest losses	3.3 Assume no loss to US producers
1.4 Sum-up all the estimated figures	2.4 Sum-up all the estimated figures	3.4 Assume all 3 simultaneously

In the sensitivity analysis part, all the three assumptions are taken first independent of each other (i.e. *Ceteris Paribus*) and then simultaneously in order to understand their respective as well collective impact.

3.1 Estimates for Mango Trade – India

The consumer surplus to Indian mango consumers due to export of mangoes to US under different trade regimes is measured by estimating the Harberger's Triangle (see Appendix 1). To measure the consumer surplus, equation 3.1 is estimated for different scenarios. The equation can be estimated easily, if the benchmark dataset includes the three required parameters under all the four possible scenarios - mango demand elasticity of Indian mango consumers, quantity demanded of Indian mangoes, and domestic price of mangoes. With this information, an estimate of consumer surplus of Indian mango consumers under all the four scenarios is derived. The consumer surplus under alternate scenarios is compared with that under trade ban scenario for assessing the impact of the policy change.

The quantity traded under different scenarios is arrived at in different ways. According to the Director of Agricultural and Processed Food Products' Export Development Authority (APEDA), India is expected to export 8,000-10,000 MT of mangoes to the US every year under nuclear irradiation regime (Business Line, 2007). This provides the expected quantity of exports to the US under irradiation regime. For the expected export quantity under free trade regime, it is assumed that the top price export of Indian mangoes would all be diverted to the US, since US is the most premium market. Therefore, top quality mango that is presently exported to European or Middle-East countries is expected to be exported to US. This assumption controls for the quality of mangoes as well, which is much inferior in case of low price exports to Bangladesh and Nepal. As HWT, as a policy, stands somewhere in between the two alternate policy regimes of irradiation and free trade, the expected quantity of export under HWT regime would be somewhere in between the two regimes; hence, a simple average of the export quantity under two regimes is taken as a fair estimate of the export quantity under HWT regime.

The elasticity estimate (e_d) for the baseline scenario is drawn from Mittal (2006), which is all India uncompensated elasticity of demand for fruits and vegetables group. Since mango is the largest horticulture crop for India, the number is taken as a close approximation. As the purpose here is to capture the change in utility as a result of change in consumption, the Marshallian or uncompensated elasticity of demand is considered. Rest of the demand elasticity estimates are derived by a simple linear approximation with demand elasticity under trade ban regime and HWT regime. The mango demand elasticity estimate under the HWT regime is derived by comparing the total available quantity of consumption to the

Indian consumers and the price the Indian consumers pay at the beginning and at the end of the benchmark period under trade ban scenario. HWT is used for approximation and thereafter for linear extrapolation and interpolation instead of any other policy regime for the elasticity estimate under the remaining two policy regimes, as that was the prevailing policy for all the other countries during the benchmark period.

Prices under different scenarios are worked out by a simple estimation of elasticity of demand equation, where all the values except that of Δp are known. The baseline price (P) is adjusted for inflation with the Consumer Price Index - Industrial Worker (food group) for four months between April to July (RBI, 2009), which are the four months of mango season in India. All these prices are FOB prices, which are the relevant benchmark for the Indian mango producers. The benchmark dataset thus compiled is depicted in Table 5 a, b, and c.

Table 5a: Benchmark dataset for different SPS regimes - Prices INR/MT

Year	Trade Ban	Irradiation	HWT	Free Trade
2004	15409.00	15419.38	15425.96	15431.89
2005	16644.66	16656.99	16668.86	16679.55
2006	16680.71	16693.18	16702.46	16710.82

Source: APEDA Trade Junction (2008) and author's own calculations.

Table 5b: Benchmark dataset for different SPS Regimes - quantity MT (production + import – export)

Year	Trade Ban	Irradiation	HWT	Free Trade
2004	11,429,448.68	11,420,448.68	11,413,939.43	11,407,430.19
2005	11,551,758.28	11,541,758.28	11,531,070.13	11,520,381.98
2006	12,593,494.20	12,582,494.20	12,573,262.69	12,564,031.18

Source: APEDA Trade Junction (2008) and author's own calculations.

Table 5c: Benchmark dataset for different SPS regimes – price elasticity

Trade Ban	Irradiation	HWT	Free Trade
0.98	1.169	1.234	1.299

Source: Mittal (2006) and author's own calculations.

The gain to Indian producers is estimated by assessing the value differential between the domestic market and export to US market. The domestic prevailing price, as depicted in Table 5a, under different scenarios is compared with the FOB price the Indian producers would get upon exporting to US. A simple estimation of the value gain to Indian mango producers under different policy regimes is compared to the same under the baseline scenario and any excess over and above the baseline scenario is assigned as the cumulative producers' gain to India. The estimates for cost of compliance are collected from the facilities directly. HWT and allied costs were collected through visits to Central Institute of Sub-tropical Horticulture (CISH) in Kakori, Uttar Pradesh and two mango pack-house facilities in Kakori and Lucknow, Uttar Pradesh. The irradiation cost estimates were collected from Kay Bee Exports of Mumbai, Maharashtra, one of India's largest mango exporters to USA. These costs were verified with figures from APEDA. The cost of irradiation is shown in Table 6a and 6b and that of HWT in Table 7.

Table 6a: Post-harvest irradiation cost estimates for mango (INR per kg)

<table>
<tr><th>Expenditure</th><th>APEDA</th><th>Kay Bee Fresh</th></tr>
<tr><td>Transport - Farm to Pack House</td><td rowspan="3">8.79</td><td>2.00</td></tr>
<tr><td>Processing at Pack House (Fungicide)</td><td>5.00</td></tr>
<tr><td>Pack House to Irradiation Plant</td><td>1.00</td></tr>
<tr><td>Irradiation + Handling</td><td>6.59</td><td>7.00</td></tr>
<tr><td>Irradiation Plant to Mumbai Airport</td><td rowspan="2">1.83</td><td>1.00</td></tr>
<tr><td>Clearance Charges at Mumbai Airport</td><td>1.00</td></tr>
<tr><td>Air-freight to USA</td><td>109.89</td><td>110.00</td></tr>
<tr><td>Total</td><td>127.10</td><td>127.00</td></tr>
</table>

Source: Primary data from APEDA, CISH Kakori, Mango Packhouse Kakori, and KayBee Fresh

Table 6b: Other Costs for Exporting Irradiated Mangoes to USA

Cost of new plant and facilities	INR 100 Million
Life of Plant	10 years
Cost of farm certification (once)	US$ 750
Farm Infrastructure cost (first year only)	US$ 2,500
Cost of farm inspection (per annum)	US$ 300

Source: Hindu (2008), Bourquin and Deepa Thiagarajan (2007)

Table 7: Cost of HWT treatment of Mangoes (INR/KG)

Transport (Farm to Pack-house)	2.00
Pack-house(Desapping, HWT, Fungicide)	2.50
Cold storage	2.13
Total per kg	**6.63**
Cost of Plant - (Life – 8 years)	200,000

Source: CISH Kakori, Mango Packhouse Kakori, and KayBee Fresh

The estimates for all the four scenarios were summed up and averaged for annual estimates after conversion into US$ with relevant exchange rates. The compiled results are shown in Table 8. The trade ban scenario shows all zeros, since all the other numbers are over and above this baseline scenario. Notably, the cost of compliance under free trade is also zero, as there may not be any standards in force under this scenario. Further, Indian suppliers always gain from access to the high premium market of US. However, Indian consumers also benefit due to overall production rise and probable improvements in quality due to the rush to export to the high premium US market.

Table 8: Estimates for impact of mango trade on India (US$ p.a.)

	Trade Ban	Irradiation	HWT	Free Trade
Impact on Consumers	0	376,550,527	532,432,404	682,715,087

Table 8: Estimates for impact of mango trade on India (US$ p.a.) (contd)

	Trade Ban	Irradiation	HWT	Free Trade
Impact on Producers	0	46,472,628	46,398,347	34,071,311
Cost of Compliance	0	-3,733,295	-2,698,807	0
Total	**0**	**419,289,859**	**576,131,945**	**716,786,399**

Source: Author's own calculations.

The payoff estimates in Table 8 clearly indicate that the most well paying strategy for India is free trade of mangoes. However, India has been demanding for HWT perhaps with the view of minimizing the potential loss to US due to mango pests. Since the negotiation strategy of India would depend not only on its own payoff but also on that of US, an estimation exercise for scenario-wise payoff to US follows.

3.2 Estimates for Mango Trade – USA

According to APHIS (Federal Register, 2006), permission for mango imports from India would have minimal impact on the US mango producers and the benefits of opening up the market to Indian mangoes would outweigh any expected costs to the US domestic producers. However, going by the conservative principle, we estimate the impact on US producers by assigning proportionate loss of market to them. For example, if Indian mangoes acquire 10 per cent of US mango market share, it is assumed that US producers would lose a proportionate share of their market, thereby pegging the loss to US producers at a higher end. To estimate the loss to US mango producers, the quantity exported from India under different scenarios is compared with the total US mango consumption and the proportionate loss of market is assigned to US mango producers. The US market share of Indian mangoes over the years and the supposed equal share loss to US producers is given in Table 9.

Table 9: Indian export as a proportion to total US consumption (%)

Year	Trade Ban	Irradiation	HWT	Free Trade
2004	0	3.311	5.707	8.10
2005	0	3.908	8.085	12.263
2006	0	3.814	7.014	10.215

Source: USDA ERS (2008) and author's own calculations.

For the impact on consumers, due to data unavailability, an alternate method is employed to measure the 'willingness to pay'. Instead of comparing the reserve price and market price of Indian mangoes for US consumers, the price of Indian mangoes is compared with the prevailing market price of a comparable variety. The prevailing market price of domestic US mangoes and the highest of the prevailing price of other imported mangoes are taken as a benchmark to compare the price received by Indian mangoes. The underlying assumption is that if US consumers are paying a premium to Indian mangoes over and above the other available varieties, that premium must indicate their gain in satisfaction derived from Indian mangoes. This measure simply captures willingness to pay as an indicator of consumers' gain in value. A detailed theoretical justification for this approach lies in the *Theory of Revealed Preference*.

Since irradiation is the most restrictive regime, quantity of export remains low and confined to choicest of mangoes. These mangoes have received a very high premium in US. Therefore, the price received by irradiated Indian mangoes is compared with that of domestically produced US mangoes that fetch the highest price after Indian mangoes. The price of irradiated Indian mangoes is derived by considering the cost escalations over and above the domestic price of Indian mangoes under the irradiation regime. These cost escalations include the costs of transportation, irradiation, other treatments, packaging, export cargo, customs, and a margin for mango importing parties.

Under HWT and free trade regimes, the quantity of export is expected to increase significantly, whereas the quality may not be as consistently high as in the case of mangoes under irradiation regime. Therefore, the price received by Indian mangoes under HWT and free trade regimes is compared with the price of equivalent Mexican mangoes (Gallo, 2009). The Mexican mangoes have about 60 per cent market share in US mango market and fetch the highest price among all imported mangoes barring the Indian premium mangoes. The Mexican mangoes had to compete so far against mangoes from Brazil, Haiti, Peru, and Ecuador (Evans, 2008), which are usually lower in quality but higher in prices due to inefficient supply chains and high transportation cost. With bulk import of Indian mangoes under HWT or free trade regimes, it s expected that a large market share will go to Indian mangoes due to quality as well as preference of the Indian diasporas. The estimates of prices received by Indian mangoes are arrived at by topping the domestic price of Indian mangoes under the respective regime with the costs of transportation, treatment, packaging, duties, and a margin to importing parties.

The highest price received by the benchmark variety among all the non-Indian mango varieties and the expected price received by Indian mangoes are compared and the difference is multiplied by the quantity traded for an estimate of perceived value gain to US consumers. The price estimates under irradiation, HWT, and free trade also include cost of transportation within India, cost of relevant treatment, cost of transportation between India and USA, charges for customs and duties in USA, and margin for US mango importers. All this information is sought through first-hand interaction with the government agencies (APEDA and CISH) and mango exporters (Nawab Pack House, Kakori and Kay Bee Fresh, Mumbai). The consolidated price estimate thus derived and the comparable benchmark mango prices are shown in Table 10.

Table 10: Price of mangoes under different conditions (US$/MT)

Year	US Domestic	Mexican	Irradiation	HWT	Free Trade
2004	7000	5000	10,000.00	5,707.72	4,554.93
2005	5500	3500	9,748.88	5,776.65	4,604.03
2006	7500	5500	9,647.91	5,991.63	4,714.20

Source: USDA ERS (2008) and author's own calculations.

The most important estimate for the impact on US is that of potential loss from invasive species and cost of their elimination. Indian mangoes carry twenty pests of concern for US, including fourteen insects, five fungi, and one bacterium (USDA APHIS, 2006). The estimates for cost of control and elimination of pests are directly adopted and adjusted for current prices from Andrew et al. (1978). The study considers loss by pest infestation to the entire citrus industry at the higher end of ten per cent. The loss figure is adjusted with GDP Deflator for the benchmark period and taken to be the cost to US in case of free trade. GDP deflator is used as it flexibly captures changed expenditure patterns. Therefore, by reflecting up to date expenditure patterns, GDP deflator better accounts for price rise as well as the expansion in the size of the industry.

Since, HWT can reduce the potential damage by eighty per cent (OISAT, 2009), the free trade loss figure is reduced by 80 per cent for trade of mangoes under HWT regime. However, since USDA APHIS claims irradiation to be completely effective against all these pests, there is a zero control and elimination cost assumed. The estimates for US thus arrived are averaged for annual numbers and are compiled in Table 11. As is evident from estimate of net welfare gains, nuclear irradiation is the only policy regime with positive impact for US. When India was not ready to offer the best choice to US for eighteen years, US chose the second best policy of trade ban. In remaining two scenarios, loss from pest infestation erodes completely the comparatively small gain to consumers.

Table 11: Estimates for impact of mango trade on USA (US$ p.a.)

	Trade Ban	Irradiation	HWT	Free Trade
Impact on Consumers	0	31,038,611	22,674,112	11,546,755
Impact on Producers	0	-687,612	-1,287,436	-1,887,260
Cost of Control	0	0	-41,772,169	-208,860,847
Total	0	30,350,999	-20,385,494	-199,201,353

Source: Author's own calculations.

Although free trade of mangoes is the best policy option for India, in no way US can be convinced to choose free trade of mangoes due to high loss figures for US under that policy regime. The US considers its own payoffs and chooses the policy option of nuclear irradiation of mangoes, which is clearly a dominant strategy and exceeds the payoff to US from any other strategy by a substantial margin.

4. Sensitivity Analysis

Since the estimates above are conservative in nature, there is a possibility of some margin of error while passing the estimates. Therefore, a sensitivity analysis is performed. The payoffs to India are decisively clear with huge differences of magnitude across scenarios. Further, there is not any theoretical basis to suggest that the value or the direction of these payoffs might substantially differ from the value derived above. However, the impact of mango trade on US is not substantially different under different scenarios. Therefore, an assumption that is in conflict with the actual scenario or a partially correct observation may affect the outcomes to such a degree, where a change in magnitude or direction of payoffs is possible. Hence, a sensitivity analysis for impact of mango trade on USA is in order to bring more robustness to the results of this study.

The payoff to USA is within a small range under three of the four scenarios, namely trade ban, irradiation, and HWT. This is seemingly valid as the first strategy was a US policy for 18 years, the second strategy is a US policy for the past 3 years, and the third strategy has been a request by India during all these years; whereas the fourth policy option of free trade exists as a hypothetical possibility. For the sensitivity analysis, the values that may actually be different from the ones assumed for this study include the pest risk estimate under different scenarios and the impact on US producers. These are the two variables for which there exists some theoretical justification or claim, which is different from the assumptions taken for this study so far. Therefore, only these two variables are discussed under varying possibilities for alternate values.

While urging and negotiating with the US to adopt HWT as the applicable standards for import of mangoes, India has maintained that HWT is an effective control measure. Due to emphasis on conservative estimation, the analysis above assumes that the pest losses can be reduced by 80 per cent with HWT. However, there are various studies to suggest that the risk is completely mitigated even with HWT. According to OISAT (2009), HWT is an effective treatment against fruit fly damage, anthracnose, and stem-end rot infestations. According to Waskar (2005), HWT coupled with post-harvest fungicidal treatment reduces disease risk as well as increases shelf life. According to a study commissioned by National Mango Board of USA, few improvements in the mango HWT process maximize the mango quality, such as - hydro-cooling the fruit after HWT and immediate packaging of the fruit without breaking the cold-chain (Mitcham and Yahia, 2009). However, the study distinctly notes that HWT is not effective against the mango seed weevil, which is one of the pests of concern to US. Buganic et al. (2005) suggests that pre-harvest bagging of mango fruits and post-harvest HWT accompanied by fungicidal treatment effectively cures all the disease of mango and reduce the fruit-fly damage by 80 per cent. Most importantly, Dr. Hernani Golez of National Mango Research and Development Center, Guimaras, Philippines, suggest that HWT can be made more effective by extending the treatment time till the pulp reaches a temperature level of 46 degree centigrade, which effectively cures all the problems faced by mango crops (ABW, 2009).

Since the estimate of potential losses to US stands on the leanest grounds, the same is changed first for the sensitivity analysis. If it is assumed that there are no losses from HWT (accompanied with pre-harvest bagging, fumigation, and appropriate cold chain maintenance), the loss to US of US$ 41 million is nullified. Therefore, the gain to US under HWT regime increases by the same amount. The total payoff to US from mango trade under HWT regime now stands at a positive figure of US$ 21 million. Since this figure is still lower than the comparable numbers under nuclear irradiation regime, irradiation remains the dominant policy option for the US, albeit with a much smaller margin if US$ 9 million only.

As a logical next step to the above, the 'no loss to US' under nuclear irradiation regime is put to test. A study by Iowa State University distinctly notes that "as in the heat pasteurization of milk, the irradiation process greatly reduces but does not eliminate all bacteria" and that irradiated food helps the product only when all other protocols are followed in the most appropriate manner (Iowa, 2006). If irradiation is not a perfect and leak-proof policy option, it may lead to some losses to US. Therefore, as the next adjustment, the US is assigned a small loss figure of a tenth of the normal loss figure under the free trade regime. This implies that although irradiation is an effective process, there remains a chance of 10 per cent that the pests of concern may affect US. This leads to assigning an additional amount of loss to the US to the tune of US$ 20 million. In isolation, this adjustment would not affect the policy choice and irradiation still remains the preferred policy choice of the US with over a US$ 30 million positive margin over HWT regime. However, if this second adjustment is taken into account in continuation to the previous one, the policy choices are seriously affected. An additional loss of US$ 20 million from irradiation regime and an elimination of the loss of US$ 41 million under the HWT regime make the latter a more attractive policy option for the US.

If the above line of argument is further extended and the study by APHIS is fully accepted, there would not be any loss of market share to US mango producers (Federal Register, 2006). The study comments that if the import of mangoes from India is permitted, the effect on US mango producers would be minimal and the benefits of opening up the market to Indian mangoes would outweigh any expected cost to the domestic producers. This would further increase the gain to US under different regimes by the respective figures of loss to US producers. However, since the loss to US producers is so small in magnitude, not crossing a US$ 2 million mark under any circumstances, this is almost insignificant in the decision making scheme.

If all of the above three adjustments are assumed to be valid, the policy choices for US may completely change and may not remain as clear as before under the conservative approach. The effect of these adjustments is represented in a summarized tabular form in Table 12a through d. The payoffs affected by the respective adjustments are shown in bold.

Table 12a: Total payoffs to US - no loss from HWT

		USA			
INDIA		Trade Ban	Nuclear Irradiation	HWT	Free Trade
	Trade Ban	0	30	**21**	-199
	MB	1100	1130	**1121**	901
	Free Trade	1127	1157	**1148**	928

Source: ABW (2009) and author's own calculations.

Table 12b: Total payoffs to US - marginal loss from irradiation

		USA			
INDIA		Trade Ban	Nuclear Irradiation	HWT	Free Trade
	Trade Ban	0	**9**	-20	-199
	MB T	1100	**1109**	1080	901
	Free Trade	1127	**1136**	1106	928

Source: IOWA (2006) and author's own calculations.

Table 12c: Total payoffs to US - no loss to US producers

		USA			
INDIA		Trade Ban	Nuclear Irradiation	HWT	Free Trade
	Trade Ban	0	31	-19	**-197**
	MB T	1100	1131	1081	**903**
	Free Trade	1127	1158	1108	**929**

Source: Federal Register (2006) and author's own calculations.

Table 12d: Total payoffs to US - all adjustments simultaneously

		USA			
INDIA		Trade Ban	Nuclear Irradiation	HWT	Free Trade
	Trade Ban	0	**10**	**22**	**-197**
	MB T	1100	**1110**	**1123**	**903**
	Free Trade	1127	**1137**	**1149**	**929**

Source: Author's own calculations.

If all the three adjustments are made simultaneously, or as noted earlier, only the first two adjustments are considered as valid due to the insignificance of the loss amount to US producers and the policy choices demand a substantial rethink. If the payoffs in Table 12d are considered to be valid, the US has a clear case of deviating from the present policy regime of nuclear irradiation and opting for HWT. Although the difference in magnitude of payoffs is again low, these payoffs represent the lower limit of gains and imply that the difference in payoffs cannot be squeezed any further.

5. Concluding Remarks

As observed through detailed estimation process, the policy choices of both the nations are consistent with their respective payoff estimates. However, the policy emphasis and demands are not in sync with the best outcomes possible. The request by India for HWT regime in mango import by USA is not the most lucrative option for the US and entails small losses. The demand of India for HWT can be justified only in the case if India may undertake to compensate the US for any losses emanating from a policy change in favor of India. This shall not be much difficult for India; as the regime change increases the benefit to India by over US$ 157 million, whereas the consequential loss borne by US is about US$ 50 million only. Therefore, India may offer to compensate the US mango producers directly in lieu of a more favorable policy regime. This would keep the US at the same welfare level and at the same time, would increase the gain to India by more than US$ 100 million. Through this exchange, both the nations may reach a Kaldor-Hicks efficient outcome.

The present study is the first of its kind, which seeks to attach an economically justifiable value on the welfare impact on the two nations as a result of the trade of two commodities. This study underscores another important point; i.e. - the impact of risks arising out of invasive species cannot be studied in terms of science alone but it has to be wedded to the economic implications. This is underlined with a clear separation of direct impact on consumers and producers from indirect impact on environment and other indirect stakeholders. By spelling out the pest losses specifically as purely environmental externalities, the separation of direct and indirect impact of SPS standards is clearly underlined. As shown in the estimation process, the major costs of trade are not the market shares but the costs of pest infestation and control, it is clear that SPS standards is the central issue in these disputes. Therefore, a traditional analysis with enumeration of trade gains or losses would not suffice.

Finally, empirical estimates are subject to data availability limitations and are as strong as the assumptions made. This study indicates many levels, where more systemic efforts are required for robust data generation. These areas include precise estimation of economic impact of all the relevant pests of concern for both the countries. Introduction of economies of scale and scope can also alter some of the assumptions. Although Indian mangoes do not get substantial premium from top price importers, the demand competition from the US may lead to increased price offers from other countries as well, thereby reducing gains to India from US trade but enhancing overall gain from mango exports to other countries.

This research has tried to account for spillover costs of the trade; however, many of the roundabout effects have been ignored. For example, the gain to USA due to the supply of machinery for irradiation has not been taken into consideration. From a policy point of view, incorporating transaction costs would be critical for policy decisions and a value add dimension for future research, as suggested by Abla and Nugent (1996).

Appendix

Harberger Triangles give the lowest estimate for consumer surplus as against the other two measures of consumer surplus, namely equivalent variation and compensating variation (Henderson and Quandt, 2003). The Harberger triangle is depicted graphically in Figure 1. Equation 3.1 is derived and explained next for the measurement of consumer surplus under the four scenarios.

In Figure 1, CD is the initial demand curve for mangoes, with demand q_1 at price p_1. If the price changes due to a policy change, the new price and quantity are p_2 and q_2 respectively. The consumer surplus is given by the triangle CR_1p_1, which is similar to the triangle R_1R_2R. The underlying assumption of linear demand is valid as the actual elasticity of demand in this case is -0.98 (Mittal, 2006), which is almost linear.

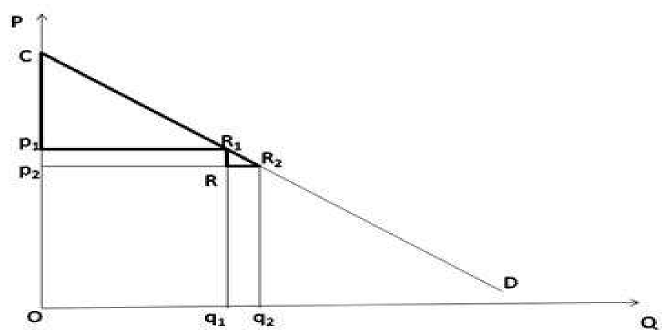

Fig 1: Harberger Triangle depicting consumer surplus

$$e_d = elasticity\ of\ demand = \frac{\Delta Q/Q}{\Delta P/P}$$

$$= \frac{q_1q_2}{p_1p_2} X \frac{Op_1}{Oq_1}$$

$$= \frac{p_1R_1}{Cp_1} X \frac{Op_1}{Oq_1} \qquad \text{Since, } [\Delta CR_1p_1 \sim \Delta R_1R_2R]$$

$$= \frac{Op_1}{Cp_1} \qquad \text{Since, } [R_1p_1 = Oq_1]$$

$$=> Cp_1 = \frac{Op_1}{e_d} \qquad \text{= Price / Elasticity of demand}$$

$$(3.1) \qquad \textbf{Consumer Surplus} = \frac{1}{2}\ X\ \frac{\textbf{Price}}{\textbf{elasticity of demand}}\ X\ \textbf{Quantity}$$

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