

Risk Factors for Invasive Pest Introductions in Commodity Imports

Erik Lichtenberg and Lars J. Olson

Department of Agricultural and Resource Economics

University of Maryland

College Park, MD 20742-5535

Rationale and Objectives

Can we use information from surveillance screening to identify relative risks of invasive pest introductions?

Strategy:

- Theoretical characterization of import market equilibrium under optimal screening, alternative regulatory regimes.
- Empirical investigation using data from APHIS inspections, US Customs, other sources.

Theory—One exporter, one importer

Exporting country chooses quantity to export given cost structure:

$$\max_y p^* y - c(y, z, w, \beta)$$

p^* = world price

y = quantity exported

z = background pest infestation

w = input prices

β = factors affecting productivity

Importing country chooses inspection intensity to maximize sum of consumer and producer surplus less damage from exotic pest introductions:

$$\max_i \int_p^\infty D(\xi) d\xi + \int_0^p S(\xi) d\xi - H(\zeta)$$

i = inspection intensity

$D(\cdot)$ = quantity demanded

$S(\cdot)$ = quantity supplied

p = importing country price

ζ = exotic pest introductions

$H(\zeta)$ = damage from exotic pest introductions

Exporters charged for inspection.

k = unit cost of inspection

$m(p) = D(p) - S(p)$ = quantity imported

$\rho(z)$ = share of imports infested with exotic pests

$\phi(i)$ = share of imports with exotic pests detected

τ = import tariff

Material Balance and Arbitrage Conditions

I. Imports with exotic pests detected treated at unit cost t ; treatment eradicates share of pests $\eta(t)$:

$$m(p) = y(p^*, z, w, \beta)$$

$$p = p^* + ki + t\phi(i)\rho(z) + \tau$$

$$\zeta = \{[1-\phi(i)]\rho(z) + \phi(i)[1-\eta(t)]\rho(z)\}y(p^*, z, w, \beta)$$

II. Imports with exotic pests detected destroyed:

$$m(p) = [1-\phi(i)]y(p^*, z, w, \beta)$$

$$p = \frac{p^* + ki + \tau}{1 - \phi(i)\rho(z)}$$

$$\zeta = [1-\phi(i)]\rho(z)y(p^*, z, w, \beta)$$

Nash Equilibrium

Exporting country:
$$p^* - \frac{\partial c(y, z, w, \beta)}{\partial y} = 0$$

Importing country:
$$-H'(\cdot) \frac{\partial \zeta}{\partial i} = m \frac{dp}{di}$$

$$H' \sigma [\psi - \varepsilon \theta] = m \frac{dp}{di}$$

σ = exotic pest introductions per unit inspection intensity

ψ = elasticity of detections with respect to inspection intensity

$\varepsilon = pm'/m$ = elasticity of import demand

$\theta = (i/p)(dp/di)$ = elasticity of price with respect to inspection intensity

Importing country balances marginal reduction in damage from exotic pest introductions against loss in consumer welfare from higher import price.

Inspection intensity has two effects on damage avoidance:

1. Enhanced detection reduces rate of introductions.
2. Higher price reduces volume of introductions by reducing imports.

Implications: Detection rate should be influenced by

- Import volume.
- Import value.
- Background pest infestation rate.
- Treatability of pests.
- Treatment cost.

Data

APHIS Forms 264/280—all propagatable and non-propagatable plant material entering US during FY 2005-2007.

Type, port of entry, date of entry, volume.

Inspection result and disposition of cargo (includes pre-clearance, pre-treatment, etc.).

685,962 shipments inspected.

Actionable pests detected in 2.6% of shipments, 0.7% of shipment volume.

Disposition of shipments with actionable pests:

- Treated: 58.2% of shipments, 67.4% of shipment volume.
- Destroyed: 6.2% of shipments, 0.2% of shipment volume.
- Re-exported: 35.8% of shipments, 32.4% of shipment volume.

Top Commodities with Actionable Pests Detected

Commodity	Total Shipments	Shipments with Actionable Pests	Commodity	Total Shipment volume (kg)	Volume of Shipments with Actionable Pests (kg)
Basil	20995	1460	Pineapple	2,181,940,138	81,837,151
Thyme	13244	991	Grape	1,168,263,915	42,486,879
Rosemary	11637	917	Banana	12,768,115,575	13,064,962
Pepper	38051	792	Apple	369,848,608	12,369,554
Mint	13818	751	Orange	376,163,258	9,008,818
Pineapple	16045	706	Mango	997,971,000	6,059,316
Cilantro	10028	688	Pear	186,594,111	4,870,487
Oregano	11698	658	Onion	600,880,872	4,858,974
Tomato	22415	593	Watermelon	1,461,282,907	4,219,410
Lime, Sour	5543	590	Pepper	982,048,706	3,519,235
Green Bean	10957	480	Plum	84,582,062	3,494,614
Blackberry	7108	424	Plantain	796,608,123	3,408,397
Tarragon	9144	333	Lime, Sour	284,526,521	3,022,913
Total	685,962	18,117	Total	37,369,822,180	249,789,924

Top Commodities Treated for Invasive Pests

Commodity	Total Shipments	Shipments Treated	Commodity	Total Shipment Volume (kg)	Volume Treated (kg)
Basil	20995	824	Pineapple	2,181,940,138	78,116,700
Thyme	13244	773	Grape	1,168,263,915	33,348,326
Rosemary	11637	760	Banana	12,768,115,575	6,212,253
Mint	13818	646	Onion	600,880,872	4,734,669
Pineapple	16045	588	Orange	376,163,258	4,444,958
Oregano	11698	558	Plantain	796,608,123	2,808,489
Pepper	38051	524	Chayote	89,664,592	2,636,819
Tomato	22415	485	Pepper	982,048,706	2,293,265
Green Bean	10957	390	Cantaloupe	1,349,172,516	2,288,830
Cilantro	10028	281	Honeydew	575,236,714	1,941,339
Tarragon	9144	279	Watermelon	1,461,282,907	1,805,355
Lettuce	7299	263	Broccoli	243,549,467	1,724,118
Blackberry	7108	261	Green Onion	412,779,427	1,623,548
Marjoram	6404	244	Yam	102,088,501	1,313,352
Chayote	4956	170	Tomato	1,226,955,863	1,287,467
Dill	6796	163	Ginger Root	88,297,768	1,273,447
Broccoli	5035	157	Snow Pea	81,953,325	1,222,622
Total	685,962	10,510	Total	37,369,822,180	168,440,451

Top Commodities Destroyed Due to Invasive Pest Presence

Commodity	Total Shipments	Shipments Destroyed	Commodity	Total Shipment Volume (kg)	Volume Destroyed (kg)
Basil	20995	157	Rambutan	553,640	61,793
Oregano	11698	94	Sand Pear	18,594,460	58,500
Thyme	13244	93	Basil	17,561,879	45,118
Rosemary	11637	86	Onion	600,880,872	24,052
Tomato	22415	65	Persimmon	9,683,434	21,690
Mint	13818	60	Litchi	13,867,782	20,000
Marjoram	6404	47	Genip	2,334,317	19,431
Tarragon	9144	47	Water Chestnut	721,872	18,830
Eggplant	12456	35	Pepper	982,048,706	15,689
Pepper	38051	34	Bean Sprouts	275,158	15,046
Sage	5290	33	Papaya	438,644,265	12,678
Loroco	426	32	Tomato	1,226,955,863	12,650
Bean Sprouts	475	27	Ginger Root	88,297,768	11,459
Dill	6796	27	Cassava	133,279,609	10,800
Total	685,962	1127	Total	37,369,822,180	485,918

Top Commodities Re-Exported Due to Invasive Pest Presence

Commodity	Total Shipments	Shipments Re-Exported	Commodity	Total Shipment Volume (kg)	Volume Re-Exported (kg)
Lime, Sour	5543	562	Apple	369,848,608	11,876,579
Basil	20995	479	Grape	1,168,263,915	9,138,553
Cilantro	10028	398	Banana	12,768,115,575	6,852,708
Mango	10809	307	Mango	997,971,000	6,014,810
Pepper	38051	234	Pear	186,594,111	4,852,013
Grape	4156	199	Orange	376,163,258	4,563,860
Blueberry	8226	186	Pineapple	2,181,940,138	3,712,828
Squash	19745	176	Plum	84,582,062	3,340,997
Okra	7156	170	Lime, Sour	284,526,521	2,690,115
Blackberry	7108	161	Cilantro	111,493,495	2,437,161
Total	685,962	6	Total	37,369,822,180	80,863,554

Top Countries with Actionable Pests Detected

Country of Origin	Total Shipments	Shipments with Actionable Pests	Country of Origin	Total Shipment Volume (kg)	Volume with Actionable Pests (kg)
Mexico	226773	5001	Costa Rica	5,606,209,272	86,078,826
Colombia	48967	2785	Chile	1,855,651,802	58,140,525
Costa Rica	31804	1889	Mexico	13,797,645,712	22,847,315
Israel	44418	1666	Guatemala	4,399,790,514	11,478,818
Guatemala	45519	1297	Ecuador	3,856,908,048	9,432,517
Dominican Republic	53042	909	South Africa	276,628,114	8,812,317
Netherlands	36283	882	Panama	127,565,981	7,398,690
Peru	44729	870	Peru	553,373,429	7,271,205
Ecuador	18516	506	Honduras	2,561,893,634	6,710,498

Top Countries with Shipments Treated for Invasive Pests

Country of Origin	Total Shipments	Shipments Treated	Country of Origin	Total Shipment Volume (kg)	Volume Treated (kg)
Colombia	48967	2620	Costa Rica	5,606,209,272	79,427,682
Israel	44418	1302	Chile	1,855,651,802	35,244,185
Mexico	226773	1147	Guatemala	4,399,790,514	10,493,532
Guatemala	45519	1120	Ecuador	3,856,908,048	5,650,404
Costa Rica	31804	933	Mexico	13,797,645,712	5,403,809
Dominican Republic	53042	719	Honduras	2,561,893,634	5,248,410
Netherlands	36283	699	Australia	93,469,997	4,255,859
Peru	44729	695	Peru	553,373,429	4,196,823
Ecuador	18516	305	Colombia	1,734,065,390	3,905,217
Honduras	18275	194	Panama	127,565,981	3,255,965
Panama	3995	114	Dominican Republic	429,472,205	3,059,493

Top Countries with Shipments Destroyed Due to Invasive Pest Presence

Country of Origin	Total Shipments	Shipments Destroyed	Country of Origin	Total Shipment Volume (kg)	Volume Destroyed (kg)
Israel	44418	356	Costa Rica	5,606,209,272	77,531
Mexico	226773	157	Korea, South	33,311,313	75,432
Colombia	48967	154	Dominican Republic	429,472,205	57,396
Netherlands	36283	127	Mexico	13,797,645,712	49,307
Guatemala	45519	88	China	249,200,866	43,012
Dominican Republic	53042	78	Israel	30,391,905	33,037
New Zealand	3971	35	Guatemala	4,399,790,514	31,860
Costa Rica	31804	17	Netherlands	93,261,354	28,962
Japan	1996	10	Peru	553,373,429	24,672
Korea, South	1495	10	Ghana	8,395,368	9,005

Top Countries with Shipments Re-Exported Due to Invasive Pest Presence

Country of Origin	Total Shipments	Shipments Re-Exported	Country of Origin	Total Shipment Volume (kg)	Volume Re-Exported (kg)
Mexico	226773	3697	Chile	1,855,651,802	22,891,450
Costa Rica	31804	939	Mexico	13,797,645,712	17,394,200
Chile	39263	331	South Africa	276,628,114	8,798,706
Argentina	4712	311	Costa Rica	5,606,209,272	6,573,613
Ecuador	18516	200	Panama	127,565,981	4,142,704
Peru	44729	167	Ecuador	3,856,908,048	3,779,874
Brazil	6148	113	Peru	553,373,429	3,049,710
Dominican Republic	53042	112	Spain	260,443,802	2,230,432
South Africa	2972	104	Australia	93,469,997	1,942,150
Guatemala	45519	89	Brazil	196,628,657	1,605,234
Spain	6673	88	Argentina	181,014,646	1,562,037

Next Steps: Econometric Model

Pr{Actionable pest detected/treated/destroyed/re-exported from inspection of shipment j } = $f(a_0 + \sum_k a_{1k} \text{Commodity Type}_{jk} + \sum_m a_{2m} \text{Origin}_{jm} + \sum_n a_{3n} \text{Port}_{jn} + \sum_r a_{4r} \text{Regulation}_{jr} + \sum_t a_{5t} \text{Time}_{jt} + a_6 \text{Value}_j + a_7 \text{Volume}_j)$.

APHIS data:

- Share of shipments, volume with actionable pest detected/treated/destroyed/re-exported.
- Commodity.
- Origin.
- Port of entry.
- Season.

US Customs data:

- Unit value and tariff by commodity, country, month.