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Illicit Agricultural Trade

Peyton Ferrier

Agricultural and wildlife trade is subject to sudden, disruptive import restrictions arising from concerns over sanitary and phytosanitary safety and the conservation of natural resources. These restrictions can create significant international price differences that encourage the smuggling of goods across borders. This article presents an equilibrium model of smuggling where the supply and demand for smuggled goods depend on interregional price disparities in the presence of a trade ban. In this model, smuggling is more prevalent when demand and supply among trade partners is more inelastic or when there are fewer total trade partners at the time a trade ban is enacted. Applications are presented for regionalization, destruction of goods in government eradication programs, price support, stockpiling, and the development of substitutes. Regionalization may increase smuggling under certain production and consumption patterns.

Key Words: illicit trade, invasive species, smuggling, SPS Agreement, CITES, Endangered Species Act, regionalization

These traffickers haul more than 1,000 contraband chickens a day into Lang Son, one of six Vietnamese provinces along the Chinese border, flouting a chicken import ban. Do Van Duoc, director of animal health in Lang Son, explained that the huge difference in prices on opposite sides of the border makes for a flourishing business despite the ban on poultry imports from China. Prices fluctuate, but on average, chicken that sells for 30 cents per pound or less in China can fetch a dollar or more in Vietnam

— Alan Sipress, *The Washington Post*

In 2005, citrus canker became fully established in Florida and is expected to cause damages of approximately \$169 million annually (Zansler, Spreen, and Muraro 2005). A similar establishment in California would likely cost between \$173 and \$890 million (U.S. Customs and Border Patrol 2005). So when, in August of 2005, U.S. Customs and Border Protection intercepted express mail shipments from Japan to California that contained 450 citrus cuttings that later tested positive for citrus canker, it was quick to prosecute and convict the first felony under the 2002 Plant Protection Act.

This event illustrates that the potential consequences of smuggling are far from innocuous or even self-contained. Extending back to Adam

Smith, economists have addressed smuggling primarily as an effort to circumvent protectionist trade restrictions. As these restrictions distort competitive and efficient markets, smuggling either enhances economic efficiency or has no effect (Bhagwati and Hensen 1973, Lawrence and Panagariya 1984, Thursby, Jensen, and Thursby 1991). However, import restrictions now commonly address externalities, and multilateral trade agreements, such as GATT, NAFTA, and CITES, limit the ability of countries to erect trade barriers arbitrarily or out of protectionism.

These externalities can be significant, along with the consequences of smuggling. Tobacco smuggling compromises laws safeguarding public health (Thursby, Jensen, and Thursby 1991, Goel 2004, Saba, Beard, and Ekelund 1995). The illegal seafood trade threatens sustainability in wildlife stocks [Kattoulas 2002, Kurlansky 1997 (Chapter 9), Rosenthal 2008]. Counterfeit goods, including high-value wine (Meichtry 2006), erode the value of intellectual property and diminish investment. Trade in ivory and exotic animal products endangers species survival (Kremer and Morcom 2000, Fischer 2004, van Kooten 2006, Heltberg 2001). Goods carrying invasive species have the potential to diminish biodiversity, reduce agricultural productivity, jeopardize a nation's trade status, and threaten the public health.

This paper considers the smuggling of agricultural goods into the United States, with specific

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emphasis on trade bans arising over sanitary and phytosanitary (SPS) risk and resource risk. Most previous economic analysis of smuggling has focused on the welfare effects that result when smuggling circumvents a comprehensive tariff on all products but produces no other externalities. Generally, this literature addresses whether smuggling reduces or increases total domestic welfare of the receiving country when it coexists with legal trade (Smith 1776, Bhagwati and Hensen 1973, Sheick 1974, Pitt 1981, Martin and Panagariya 1984).¹ Similarly, most empirical work on smuggling has examined tax avoidance, specifically on specific goods where tax and tariff differentials are high (Thursby, Jensen, and Thursby 1991, Goel 2004, Norton 1988, Fisman and Wei 2004). In contrast, this article addresses smuggling when it results from a directed trade ban on a specific country or region, but also allows for the possibility of replacement in supply from other unrestricted trade partners.

This paper presents an equilibrium model of smuggling as a function of the difference in prices between trade regions similar in character. Because agricultural trade bans² are often comprehensive and sudden, these price differences are significant. The demand curve for smuggled goods is developed from trade theory, while the supply curve is developed from the economic model of crime by Becker (1968). In this manner, the risk profile of firms exporting smuggled goods is characterized.³ This paper then finds that the smuggling is likely to be larger when the demand and supply for prohibited goods is less elastic and

when there are fewer trade partners. Regionalization is also found to encourage smuggling under specific patterns of consumption and production.

The Market for Smuggled Agricultural Goods

In the United States, agricultural trade bans and restrictions commonly arise to address sanitary and phytosanitary (SPS) risk (the risk that invasive species and diseases may become established domestically) and resource risk (the risk of depleting a natural resource to inefficient levels). These restrictions affect prices dramatically, as witnessed in the discoveries of bovine spongiform encephalopathy (BSE) in Canadian and U.S. cattle and avian influenza in south Asian poultry flocks. Smuggling to avoid these restrictions is not uncommon, and significant resources are devoted to intercepting prohibited items. The U.S. Customs and Border Patrol now employs over 2,400 agricultural specialists to inspect goods for SPS threats. The Smuggling, Interdiction and Trade Compliance (SITC) group of USDA APHIS⁴ recovered approximately \$1.2 million worth of smuggled goods in 2,000 seizures in fiscal year 2006. Interpol estimates that the illegal wildlife trade in endangered species alone ranges between \$7 and \$20 billion annually and represents a major threat to many species (Interpol 2006). SPS and resource risk may not be mutually exclusive, either, as illegally imported wild animals and plants are not subject to inspection for disease risk. Williamson (1999) cites competition with invasive species as the second largest factor threatening U.S. species biodiversity.

Commercial smuggling, as opposed to non-commercial smuggling by tourists for personal use,⁵ typically occurs through regular cargo shipping channels. To conceal the banned contents, smuggling typically involves *trans-shipping*, where cargo is re-routed through a legal country from a prohibited country, or *mis-manifesting*, where the cargo manifest simply misidentifies the material, its origins, or its prior treatments. For example, Reed (2005, p. 757) notes that

... hundreds of "captive-bred" Pacific Island boa constrictors (Candoia) and yellow anacondas (Eunectes no-

¹ Adam Smith (1776, p. 381) has this to say about smuggling: "Not many people are scrupulous about smuggling when, without perjury, they can find any easy and safe opportunity of doing so. To pretend to have any scruple about buying smuggled goods ... would be regarded as one of those pedantic pieces of hypocrisy which, instead of gaining credit with anybody, serve only to expose the person who affects to practise them to the suspicion of being a greater knave than most of his neighbours. By this indulgence of the public, the smuggler is often encouraged to continue a trade which he is thus taught to consider as in some measure innocent...."

² An organized table of fruits and vegetables prohibited for U.S. import based on country of origin is available at the USDA's Economic Research Service website at <http://www.ers.usda.gov/Data/fruitvegphyto>.

³ This contrasts with the crime-theoretic model of Martin and Panagariya (1984), where a representative agent firm engages in both legal and illegal trade because the probability of detection is dependent on the proportion of the firm's total trade that is illegal. Norton (1988) calls this "camouflaging" and notes that it implies that all competitive firms must smuggle to some extent. In his model, the probability of detection also depends on the distance exported, which is heterogeneous across firms.

⁴ The Animal and Plant Health Inspection Service division of the U.S. Department of Agriculture.

⁵ Deflem and Henry-Turner (2001) refer to this as "petty smuggling."

taeus) [are] imported despite an absence of popular knowledge of large scale commercial breeding operations in the countries of origin.

Reed notes that this affects both SPS and resource risk, as captured wildlife is more likely to carry pathogens and deplete wildlife stocks. Similarly, Franklin (1997) describes the “laundering” of wild-caught or restricted-origin birds that have their countries misrepresented at the time of importation. Because only a small percentage of agricultural cargo is inspected, and because the intensity of inspection varies within that percentage, the probability of preventing the entry of *trans-shipped* or *mis-manifested* goods is small.

Fisman and Wei (2004) find strong evidence that mis-manifesting is used to evade high import tariffs of goods through Hong Kong into China. In particular, they find that smuggling (as measured by the discrepancy in reported imports and exports) increases when a good’s tariff rate is larger, when there are more similar products with which the good might be easily mis-classified, and when the disparity in tariff rate with those similar goods is larger. Alternatively, Thursby, Jensen, and Thursby (1991) find evidence of camouflaging where both legal and illegal goods are sold simultaneously to obscure the illicit portion of trade. Fischer (2004) argues that limited legal ivory importation from certain countries, as opposed to blanket trade bans, will encourage camouflaging and laundering (a term somewhat synonymous with either mis-manifesting or trans-shipment).

With regard to applications to SPS risk, analysis of smuggling is sparse. Deflem and Henry-Turner (2001) provide a synopsis of smuggling from an interdisciplinary background with a link to the larger body of historical work.⁶ Ameden, Cash, and Zilberman (2007) develop models showing the tendency of firms to adjust their ports-of-entry and pest-treatment practices when ports vary in the rigor of inspections, although they do not address smuggling specifically. In application to resource risk, the empirical literature is much deeper, especially regarding the wildlife trade (Fischer 2004, Henry 2004), due to the notable efforts of conservation groups such as the World Wildlife Fund to draw attention to the issue.

Regulation of SPS and Resource Risk

Estimates of the economic cost of invasive species vary significantly, but all agree that the cost is large and has historically been overlooked. Pimentel et al. (2000) estimate that invasive species cost the United States approximately \$137 billion annually (approximately one percent of U.S. GDP), while the Office of Technology Assessment (OTA) estimates that figure more modestly at \$4.9 billion (OTA 1993). Specific outbreaks can be extremely costly. The Office of Technology Assessment (OTA 1993) has estimated that the Russian wheat aphid caused \$600 million worth of crop damage between 1987 and 1989. During the 1990s, APHIS spending on emergency eradication programs increased twenty-fold—\$232 million to \$10.4 billion—indicating a heightened awareness of the problem by the government (Lynch and Lichtenberg 2006).

To some extent, states, local, and federal governments all regulate the hunting, harvesting, and trade of fish and wildlife resources as a general management practice. Outright trade bans typically arise when species are endangered or threatened. Domestically, the Endangered Species Act of 1973 severely prohibits trade in endangered or threatened species, as well as restricts the uses of habitats on which threatened species survive. Internationally, the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) specifically designates species to have trade restrictions. Within CITES, three appendices list species granted differing levels of protection. Wild-caught Appendix I species are endangered, and no part or derivative product of them can be traded commercially. Export and import permits for non-commercial trade are required from both the origin and destination countries. Appendix II species have restricted movement across all trading countries and require an export permit and export certificates documenting that trade is not detrimental to the species’ survival. (Appendix II species include Appendix I species shown to have been raised in captivity.) Appendix III species are listed by participating countries. Once a country adds a species to its Appendix III list, all trading countries must provide certificates of origin to export that species (but do not have to show whether trade is detrimental). Notably, CITES lacks any authority over domestic trade or habitat preservation.

⁶ See Matthieu DeFlem’s website at <http://www.cas.sc.edu/socy/faculty/deflem/zsmugbib.htm>.

There is little consensus or empirical guidance on the costs of generic illicit trade. Resource and SPS risk and costs are measured with substantial uncertainty even when addressing specific threats or goods. With SPS risk, assessments of specific threats are frequently performed to assess if trade prohibitions or other regulations are justified [see Paarlberg and Lee (1998) for beef and Peterson and Orden (2006) for avocados]. Many policy choices, such as the optimal number of inspections, are oriented towards preventing a generic SPS or resource risk that represents the probability weighted sum of all possible individual risks that might be prevented.⁷ Inspection, interdiction, and other enforcement mechanisms are designed to address all import risks across all goods simultaneously.

Quantifying the damage of such generic risks is daunting. Costello et al. (2007) develop a measure of the marginal risk of invasion from all trade by relating maritime trade flows from different maritime regions to historical data on the number of invasions in the San Francisco Bay. They then find the marginal invasion cost to trade by multiplying the marginal risk of a generic invasive species introduction by the average cost of an invasion as inferred from Pimentel, Zuniga, and Morrison (2005)⁸ and other sources. Costello and McAusland (2003) show that damages from invasive species introductions might be exacerbated if a tariff (or trade ban) induces substantial expansion of the production of the good which an invasive species might damage, a substantial concern if trade bans are so comprehensive as to spur large-scale domestic substitution. In their model, freer trade can reduce damage by reducing the platform for which an invader takes hold, although their analysis does not incorporate ecological damage. Because of these obstacles to quantification of the cost of smuggling, this model uses the volume of smuggling as a general metric of analysis and leaves the challenge of quantifying the damage of smuggling to future work.

In the modeling section of this paper, I assume that the underlying demand for goods is unaf-

fected by the extent to which goods are acquired by being smuggled or prohibited from trade. For specific goods, this is clearly not the case due to stigma and health effects. Stigma effects occur as consumers associate the purchase of a good prohibited from trade with a negative social consequence or externality and social pressures cause them to reduce their demand for goods known to be smuggled. Fischer (2004), Fischer (2003), van Kooten (2006), and Heltberg (2001) have all modeled stigma effects in the case of ivory and other products from endangered wildlife. Fischer (2004) argues that stigma effects will be larger for goods on display than for consumed goods⁹ and finds evidence of market separation as illegal ivory sells at a significant discount in Japan. Health effects, on the other hand, occur when goods known to be smuggled are viewed as more dangerous to the health of consumers and are likely to transact at a discount to legal goods.

In most cases, agricultural goods are oriented towards consumption rather than display, which suggests a limited role for stigma effects. Health effects, however, are likely to occur with goods prohibited for both trade and health reasons, including beef from countries with BSE and poultry from countries with avian influenza. The size of health effects is debatable. For example, the discovery of BSE in both U.S. and Canadian cattle herds had a limited effect on beef demand despite causing dramatic trade bans. Moreover, many banned agricultural goods often have no significant health effect. For example, banned Szechuan pepper that can potentially carry citrus canker and banned beef that can potentially carry hoof-and-mouth disease pose very little human health risk.

Trade Restrictions, Regionalization, and Smuggling

The remainder of the paper shows that the equilibrium level of smuggling is determined by the interaction of demand and supply curves for smuggled goods. The demand curve is derived from trade theory and the supply curve is developed from the economic model of crime first de-

⁷ The problem is further complicated by the fact that U.S. Customs and Border Patrol inspections address security and narcotics risks as well.

⁸ The authors acknowledge the likely disparity between marginal and average damage and that their results are very sensitive to the parameters used.

⁹ Fischer (2004) also notes that creating legal markets also allows ivory poachers to hide illegal sales easier (i.e., camouflaging) and to launder illegally acquired goods as legal (i.e., mis-manifesting or transshipping).

veloped by Becker (1968),¹⁰ where criminal activity represents a rational response to the risk of apprehension, the magnitude of punishment, and the returns to successful crime. Through this specification, the profile of a smuggler can be characterized with regard to his or her risk preference. Restrictions to free trade increase the incentives to smuggle. As the supply of the imported good becomes restricted—through either trade bans, regionalized trade zones, or tariffs—the difference between the origin price and the destination price increases. Smuggling shrinks this disparity and, by doing so, creates a feedback effect that makes further smuggling less profitable. This article shows that this disparity is smaller when either demand or supply for the good is more elastic among any of the foreign trade partners.

Regionalization also reduces this disparity by expanding the markets in which trade can proceed uninhibited by dividing countries into zones in which trade might occur legitimately because the relevant SPS or resource risk is limited (Paarlberg and Lee 1998). This article distinguishes between *origin* and *destination regionalization* and considers the effects under either scenario. *Origin regionalization* occurs, for example, when Brazil quarantines an area with hoof-and-mouth disease and prohibits exports of beef from that area, but allows exports from the remaining disease-free regions. *Destination regionalization* occurs when the United States allows Mexican avocado imports only into northern states where pests cannot survive cold winters. Encouragement for regionalization comes from Article Six of the SPS Agreement of the World Trade Organization (WTO)¹¹ and the Appendix II provisions of CITES.

Agricultural Trade and Smuggling

Consider an economy where three nations trade and the following conditions hold:

¹⁰ See Eide (1999), who presents a survey that includes a contrast of economic models of crime with sociological models. Two distinctions of economic models are the emphasis on criminals responding to incentives and the emphasis on criminals being less risk averse than non-criminals.

¹¹ Article six states that “Members shall ensure that their SPS measures are adapted to the SPS characteristics of the area—whether all of a country, part of a country, or all or parts of several countries—from which the product originated and to which the product is destined.”

- goods are homogenous and trade in competitive markets at a single price,
- the transportation costs from country i to country j are constant per unit and equal to $\sigma_{i \rightarrow j}$, and
- prices and transportation costs are such that country 1 (C_1) imports from countries 2 (C_2) and 3 (C_3).

For country i , Q_i^D and Q_i^S are the quantities demanded and supplied, NX_i is the difference between the domestic quantities demanded and supplied, and P_i^F is the free trade price. Equilibrium can be described as

$$(1) \quad \sum_i (Q_i^S - Q_i^D) = \underbrace{Q_1^S(P_1^{FT}) - Q_1^D(P_1^{FT})}_{NX_1 = -(NX_2 + NX_3)} + \underbrace{Q_2^S(P_2^{FT}) - Q_2^D(P_2^{FT})}_{NX_2} + \underbrace{Q_3^S(P_3^{FT}) - Q_3^D(P_3^{FT})}_{NX_3} = 0.$$

Constant per unit transportation costs imply that P_1 is equal to $P_2 + \sigma_{2 \rightarrow 1}$ and that P_1 is equal to $P_3 + \sigma_{3 \rightarrow 1}$.

Suppose that a trade ban is enacted that restricts all imports from C_2 , and P_i^{TB} are the prices following a trade ban. This effect on each market is depicted in Figure 1. Following the trade ban, NX_2 will be zero if the ban is perfectly implemented. In this case, P_1 and P_3 increase to P_1^{TB} and P_3^{TB} , while P_2 falls to P_2^{TB} , the autarky price in C_2 .

To model smuggling, assume that smuggling the good from C_2 and C_1 creates a fixed per-unit cost¹² of $\varpi_{2 \rightarrow 1}$. This specification is relaxed in the following section once risk is incorporated into the model. In this case, however, firms will smuggle goods as long as

$$(2) \quad P_1^{TB} - P_2^{TB} \geq \sigma_{2 \rightarrow 1} + \varpi_{2 \rightarrow 1}.$$

From Figure 1, it is clear that $P_1^{TB} > P_1^F$ and $P_2^{TB} < P_2^F$. Denoting $\Delta P_1 = P_1^{TB} - P_1^F \geq 0$ and $\Delta P_2 = P_2^{TB} - P_2^F \leq 0$, the smuggling condition in equation (2) becomes

$$(3) \quad \Delta P_1 - \Delta P_2 \geq \varpi_{2 \rightarrow 1}.$$

¹² Norton (1988) and Martin and Panagariya (1984) alternatively treat the cost of smuggling to be a proportion of the shipment's value.

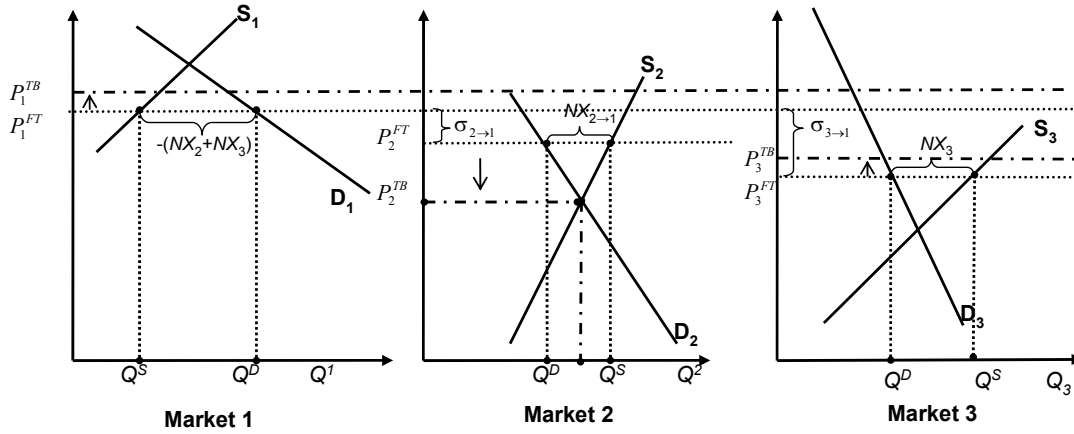


Figure 1. The Free Trade and Trade Ban Equilibrium

Equations (2) and (3) simply imply that buyers will purchase smuggled goods if the total difference in price exceeds the cost of smuggling.

The Demand for Smuggled Goods

Point values for supply and demand elasticities at the equilibrium free trade values are used to describe the trade ban's effect on prices.¹³ Though useful for analytical purposes, this methodology become less reliable for prediction as hypothesized changes move further from the quantity levels at which estimates are made, an important concern if the reduction in trade from a ban is large.

When a trade ban is enacted, NX_2 falls to zero. Noting that when trade costs are constant then $\partial P_3 / \partial P_1 = 1$, the total derivative of excess demand equals

$$(4) \quad \frac{\partial Q_1^S}{\partial P_1} \Delta P_1 - \frac{\partial Q_1^D}{\partial P_1} \Delta P_1 \\ = \frac{\partial Q_3^D}{\partial P_3} \Delta P - \frac{\partial Q_3^S}{\partial P_3} \Delta P_1 + \Delta NX_2.$$

For each country, let Q_i^D equal $\gamma_i Q_i^S$, where $Q_i^S(1 - \gamma_i)$ is country i 's net exports (for net exporters, γ_i is less than one; for net importers, γ_i is greater than one). To obtain a point estimate of the total effect on a price from a trade ban, convert the derivatives to elasticities as follows:

$$(5) \quad \varepsilon_1^S \frac{Q_1^S}{P_1} \Delta P_1 - \varepsilon_1^D \frac{\gamma_1 Q_1^S}{P_1} \Delta P_1 \\ = \varepsilon_3^D \frac{\gamma_3 Q_3^S}{P_3} \Delta P_1 - \varepsilon_3^S \frac{Q_3^S}{P_3} \Delta P_1 - \Delta NX_2$$

$$(6) \quad \Delta P_1 = \frac{-\Delta NX_2}{\left[\frac{Q_1}{P_1} (\varepsilon_1^S - \gamma_1 \varepsilon_1^D) + \frac{Q_3}{P_3} (\varepsilon_3^S - \gamma_3 \varepsilon_3^D) \right]} \\ = \frac{(1 - \gamma_2) Q_2^S}{\left[\frac{Q_1}{P_1} (\varepsilon_1^S - \gamma_1 \varepsilon_1^D) + \frac{Q_3}{P_3} (\varepsilon_3^S - \gamma_3 \varepsilon_3^D) \right]}.$$

When a complete trade ban is enacted, NX_2 decreases from $(1 - \gamma_2) Q_2^S$ to zero so that ΔNX_2 equals $-(1 - \gamma_2) Q_2^S$. Because ε_i^D is always negative, ΔP_1 is positive. This model is easily generalized to an N -country market as follows:

$$(7) \quad \Delta P_1 = \frac{(1 - \gamma_2) Q_2^S}{\sum_{i \neq 2} \frac{Q_i}{P_i} (\varepsilon_i^S - \gamma_i \varepsilon_i^D)} \geq 0.$$

¹³ Equilibrium free trade levels of prices and quantities may be observed in the period before a new trade ban is enacted. Alternatively, for longstanding trade barriers, a similar analysis model can be developed for observed prices and quantities with a trade ban in place, although this may be more difficult to interpret.

As either supply or demand becomes more inelastic in any potential trading country, the price effect from a trade ban and the incentive for exporters to smuggle is larger.

The effect of the trade ban on ΔP_2 is solved in a similar fashion:

$$(8) \quad Q_2^S(P_2) - Q_2^D(P_2) = NX_2.$$

And the total derivative of the above is

$$(9) \quad \varepsilon_2^S \left(\frac{Q_2^S}{P_2} \Delta P_2 \right) - \varepsilon_2^D \left(\frac{Q_2^D}{P_2} \Delta P_2 \right) = \Delta NX_2$$

$$(10) \quad \Delta P_2 = \frac{-(1-\gamma_2)Q_2^S}{\frac{Q_2^S}{P_2}(\varepsilon_2^S - \gamma_2\varepsilon_2^D)} \leq 0.$$

Combining expressions (3), (7), and (10) and substituting ΔNX_2 back in for $(1-\gamma_2)Q_2^S$, the condition for smuggling is

$$(11) \quad \Delta P_1 - \Delta P_2 = \left[\frac{1}{\sum_{i \neq 2} \frac{Q_i^S}{P_i} (\varepsilon_i^S - \gamma_i \varepsilon_i^D)} + \frac{1}{\frac{Q_2^S}{P_2} (\varepsilon_2^S - \gamma_2 \varepsilon_2^D)} \right] \geq \varpi_{2 \rightarrow 1}.$$

The intuition behind equation (11) lies in the price responsiveness of supply and demand of all countries. Essentially, smuggling increases the shipping cost from C_2 . Equation (11) shows a disequilibrium analysis by artificially fixing net exports at zero for C_2 regardless of whether the new prices that result from that trade ban are sufficient for exports to undertake that added cost. If the resulting total difference in price ($\Delta P_1 - \Delta P_2$) is greater than the smuggling cost, then firms will choose to smuggle. Prices among trade partner countries rise dramatically as buyers in those countries are unresponsive to the price increase associated with a trade ban and local suppliers cannot easily expand production to close the trade gap created by the ban.

Furthermore, equation (11) can be used to construct a demand curve for smuggled goods

where $(\Delta P_1 - \Delta P_2)$ is dependent on the amount of smuggling that occurs. A demand curve for smuggled goods can be derived by replacing the ΔNX_2 term with $\Delta NX_2 - SMG$, where SMG is the amount of smuggling, and then solving for SMG . The solution takes the form

$$(12) \quad SMG^D = D(\Delta P_1 - \Delta P_2 | Q_i, P_i, \gamma_i, \varpi_{2 \rightarrow 1}, \varepsilon_i^D, \varepsilon_i^S).$$

In general, the demand for smuggled goods increases when the number of countries banned from trade is larger, the demand and supply of the smuggled goods are more inelastic, and the cost of smuggling is smaller.

The Supply of Smuggled Goods

In the previous section, the cost of smuggling was assumed fixed for any level of output. This specification is now relaxed to include the additional cost of a random probability of detection and penalty. Heterogeneity in the preferences for risk by smugglers makes the supply of smuggled goods upwards-sloping.

Assume that there are M possible firms that offer trading services of the prohibited good for possible export. For simplicity, assume that each firm sells only one unit of the good at a time and that firms selling multiple goods can be represented as multiple identical firms selling a single unit. After a trade ban, firms have the option of either selling the good on the domestic market or smuggling the goods abroad. If a firm sells the good on the domestic market, it receives P_2^{TB} with certainty. If the firm smuggles, it pays the fixed smuggling cost of $\varpi_{2 \rightarrow 1}$ and, additionally, faces a chance of incurring a per-unit fine (f) and receiving a zero payment for its goods with probability π .¹⁴ Because smuggling is risky, the decision to smuggle depends in large part on the indi-

¹⁴ The Plant Health Protection Act (PHPA) of 2000 and the Animal Health Protection Act (AHPA) of 2002 significantly raised the penalties for violations of agricultural quarantines. In general, illegal commercial shipments are felonies punishable with a maximum of 5 years in prison and fines of up to \$500,000. APHIS (2006) indicates that a base penalty of \$5,000 per animal or shipment is established for violations of the AHPA, and that a flat base of \$10,000 is established for PHPA violations. In each case, mitigating factors, including whether the shipments are commercial, can increase these fines.

vidual producer's coefficient of risk aversion, φ_i . Let $U(P_2^{TB})$ be the certain utility payment of the smuggler selling her good domestically at P_2^{TB} . Let the expected utility from smuggling one unit of a good equal

$$(13) \quad U^e(P_1^{TB}, \varphi_i | \pi, f, \varpi_{2 \rightarrow 1}, \sigma_{2 \rightarrow 1}) \\ = \pi U(f, \varpi_{2 \rightarrow 1}, \sigma_{2 \rightarrow 1}, \varphi_i) \\ + (1 - \pi) U(P_1^{TB}, \varpi_{2 \rightarrow 1}, \sigma_{2 \rightarrow 1}, \varphi_i).$$

Trader i will smuggle if her φ_i is sufficiently low that equation (14) holds:

$$(14) \quad U(P_2^{TB}) \leq U^e(P_1^{TB}, \varphi_i | \pi, f, \varpi_{2 \rightarrow 1}, \sigma_{2 \rightarrow 1}).$$

In equation (14), the right-hand side, U^e , represents a lottery with random payments determined by the probability of detection, while the left-hand side, U^{CE} , is the certainty equivalent utility a potential smuggler must receive domestically for her to be dissuaded from smuggling abroad. Intuitively, where the subscript represents partial derivatives, the following identities hold:

$$(15) \quad U_{\pi}^e, U_f^e, U_{\varpi}^e, U_{\sigma}^e, U_{\varphi}^e < 0, U_{P_1^{TB}}^e > 0, U_{P_2^{TB}}^e > 0.$$

The coefficient of risk aversion, φ , varies over traders; those with higher φ values are more risk averse and less willing to sacrifice the certain payment of selling domestically for the random payoff of smuggling.

If P_1^{TB} and P_2^{TB} are known, then the level of φ_i that solves equation (14) with equality can be solved as

$$(16) \quad \tilde{\varphi} = U_e^{-1}(\tilde{U}_2^{CE}, P_1^{TB}, P_2^{TB} | \pi, f, \varpi_{2 \rightarrow 1}, \sigma_{2 \rightarrow 1}).$$

Traders who have φ_i below $\tilde{\varphi}$ (are less risk averse and) will smuggle goods, while producers with φ_i greater than $\tilde{\varphi}$ (are more risk averse and) will sell domestically. Assume that $F(\varphi)$ represents the distribution of risk preferences across M potential traders of a good.¹⁵ For simplicity, assume that

risk preferences are distributed independently of any other variables in the expected utility function¹⁶ and that firms shipping multiple goods can be represented as exporters of a single good with multiple points on the risk distribution. As a practical matter, a variable change that raises the expected utility from a risk event will increase $\tilde{\varphi}$. As $\tilde{\varphi}$ increases, more potential exporters will smuggle goods, because $F(\varphi)$ is strictly increasing in φ .

In this case, the supply of smuggled goods is

$$(17) \quad SMG(\Delta P_1 - \Delta P_2 | \dots) \\ = M \times F(\tilde{\varphi}, P_1^{TB}, P_2^{TB}, \pi, f, \varpi_{2 \rightarrow 1}, \sigma_{2 \rightarrow 1}).$$

The provision of smuggled goods is increasing in $\Delta P_1 - \Delta P_2$ and is driven primarily by the distribution of risk preferences across traders rather than by differences in other variables such as smuggling costs, differential probabilities of detection,¹⁷ and economies of scale. This specification coincides with the literature's emphasis (Becker 1968, Eide 1999) on offenders being less risk averse and generally more deterred by the probability of conviction than by the magnitude of the punishment. It also fits the stylized fact that agricultural cargo smuggling into the United States is a calculated risk that trans-shipment or falsified cargo manifests will go undetected, a risk that is difficult for the importer to influence and inexpensive in terms of direct costs.

The Market for Smuggled Goods

The equilibrium level of smuggling is determined by the intersection of the smuggling supply and demand curves depicted in Figure 2. As the level of smuggling ($SMG_{2 \rightarrow 1}$) approaches that which entirely replaces the free trade level ($NX_{2 \rightarrow 1}^{FT}$), the post-ban price difference ($\Delta P_1 - \Delta P_2$) approaches zero. However, the supply curve does not intersect the vertical axis at zero but instead at $(\Delta P_1 - \Delta P_2)^L$. This occurs because even risk-neutral firms that might not demand a risk premium will still require

¹⁵ As a practical matter, it is important to recognize that smuggling is likely to occur through intermediaries as well as actual producers. In this case, M would be the total number of potential exporters and $F(\varphi)$ would represent their distribution.

¹⁶ In particular, I assume that φ is uncorrelated with $\varpi_{2 \rightarrow 1}$ and π . If smugglers can invest in ways to avoid detection or bribe inspectors, then this specification may break down.

¹⁷ Martin and Panagariya (1984) argue that the probability of detection increases with the percentage of illegal trade that a firm conducts.

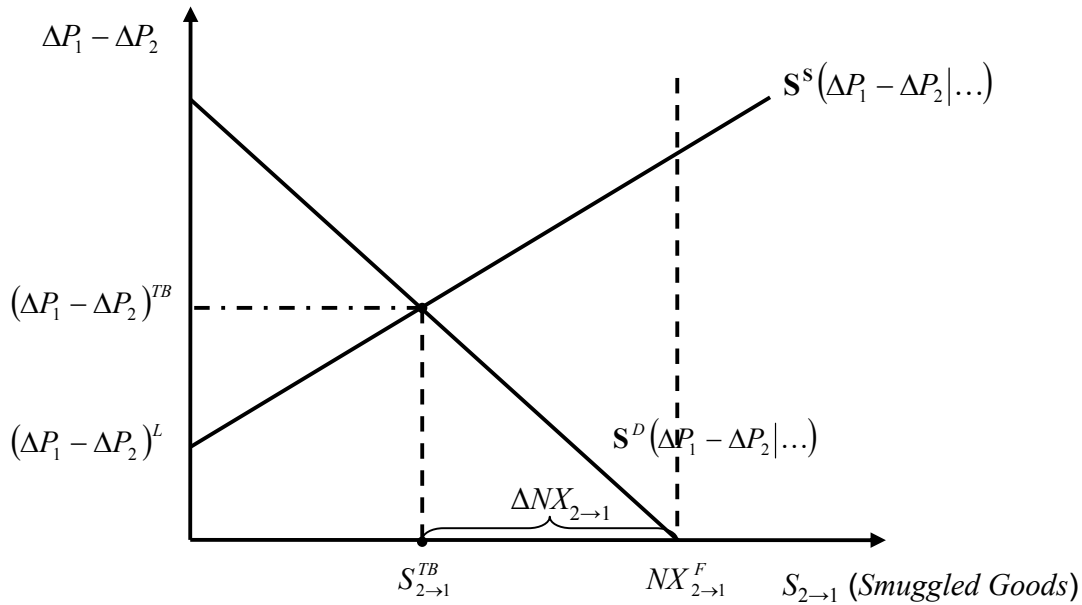


Figure 2. The Market for Smuggled Goods

a price spread to compensate them for the cost of fines associated with being caught.

As Figure 2 makes clear, smuggling increases with rightward shifts (expansions) of either the demand or supply curves. In this section, three propositions can be set forth about smuggling.

PROPOSITION 1. Smuggling of a good is larger when either supply or demand is inelastic, both domestically or among trade partners.

When supply or demand among trading partners is inelastic, sellers and buyers are unresponsive to small changes in price. Consumers, domestic and abroad, do not curtail consumption as the price of the good rises. Similarly, sellers do not expand production as the price rises. For this reason, a trade ban causing relatively small reductions in imports results in large price spreads (net of transportation costs) between the destination country and origin. In terms of Figure 2, the values of ε_i^D or ε_i^S are low in absolute value, and as these values are lower, the demand for smuggled goods is further to the right. In equilibrium, the equilibrium level of smuggled goods is higher.

PROPOSITION 2. More smuggling occurs as there are fewer trade partners for a good.

Other things equal, additional trading partners expand the available alternative producers from which banned imports may be replaced. Although the price reduction in the banned country is unaffected by this change, a larger number of alternative supply sources reduces the upward price pressure in the importing country. In terms of Figure 2, relative to situations with a larger number of trade partners, having fewer trade partners shifts the demand curve to the right. Similarly, a larger number of trade partners decreases the denominator in equation (11), which increases the price disparity and equilibrium level of smuggling for any given trade ban.

PROPOSITION 3. Less smuggling occurs when traders are more risk averse.

Increased risk aversion among traders causes fewer smuggled goods to be offered for any given price spread and causes the supply of smuggled goods to shift leftward in Figure 2. In terms of equation (16), fewer traders will have φ_i less than

$\tilde{\phi}$ if traders are more risk averse, and a lower level of smuggling will result in equilibrium.

Additionally, smuggling falls when either the penalties for smuggling are increased or the probability of detecting smuggling increases. As the result of criminal activity, the supply of smuggled goods decreases when the cost of smuggling increases or when sellers become more averse to risk (Becker 1968). A lively debate persists on the extent to which criminal penalties and sanctions are a practical deterrent to criminal activity, efficient compared with other measures, and compatible with normative views of justice and social constraints faced by the polity (Bar-Gill and Harel 2001). We do not hope to resolve those issues in this article but merely take the criminal sanctions and inspection variables as explanatory factors in explaining smuggling.

Applications

Production Restrictions

Often, smuggled goods have a limited supply in the destination country because trade or production of the good itself is not feasible or represents an unacceptable SPS or resource risk. For example, Japan purchases substantial amounts of ivory despite having no domestic sources other than pre-existing stocks; also, goods designated as federal noxious weeds, such as turkey berry (*solanum torvum*), are prohibited entirely in the United States even though they function as consumer goods. Production prohibitions make supply more inelastic and exacerbate the price disparity caused by a trade ban, thereby increasing smuggling.

Regionalization

Regionalization occurs when countries are divided into geographic regions where trade restrictions can be imposed differentially. For instance, the United States imports avocados from only some portions of Mexico and citrus from only some portions of Argentina. Similarly, following a 2004 outbreak of Exotic Newcastle Disease, exports of poultry were restricted from Cali-

fornia but not from other portions of the United States. *Origin regionalization* refers to when goods can be exported only from limited parts of the origin country, whereas *destination regionalization* refers to when goods can be imported only into parts of the destination country. This section addresses origin regionalization, while a similar analysis of destination regionalization is in the Appendix. Origin regionalization has the immediate benefit of dampening the domestic price increase when a good is banned because, first, the restriction on existing trade is smaller, and, second, the unrestricted region can expand output in response to a price increase. However, regionalization may encourage smuggling if the fall in price of the banned good is especially precipitous.

PROPOSITION 4. Under origin regionalization, smuggling is more likely when the restricted region primarily supplies but does not consume in the domestic market.

Suppose that country 2 is divided into trading regions *A* and *B*—where region *A* is banned from trading. Region *A* produces αQ_2^S and consumes $\beta\gamma_2 Q_2^S$, while region *B* produces $(1-\alpha)Q_2^S$ and consumes $(1-\beta)\gamma_2 Q_2^S$. In this case, ΔNX_2^{OR} is $[-(\alpha-\beta\gamma_2)Q_2^S - S]$. If producer and consumer types are distributed randomly across regions *A* and *B*, the elasticities of supply and demand in both regions remain the same, while only the quantities change. In this case, the new effect of a trade ban is

$$(18) \quad (\Delta P_1 - \Delta P_2)^{OR} = \frac{[(\alpha - \beta\gamma_2)Q_2^S]}{\sum_{i \neq 2} \frac{Q_i^S}{P_i} (\epsilon_i^S - \gamma_i \epsilon_i^D) + \frac{Q_2^S}{P_2} [(1-\alpha)\epsilon_2^S - (1-\beta)\gamma_2 \epsilon_2^D]} + \frac{[(\alpha - \beta\gamma_2)Q_2^S]}{\frac{Q_2^S}{P_2} (\alpha \epsilon_2^S - \beta\gamma_2 \epsilon_2^D)}.$$

Whether origin regionalization encourages smuggling depends on whether it creates a larger price spread. It is easier to analyze the total effect on the price spread by considering its separate effect on $(\Delta P_1)^{OR}$ and $(-\Delta P_2)^{OR}$.

Once common terms are removed, $-(\Delta P_2)^{OR}$ is greater than $-\Delta P_2$ whenever β is less than α .

Similarly, the price change $(\Delta P_1)^{OR}$ is greater than ΔP_1 when

$$(19) \quad \beta \leq \frac{\alpha [E + (1 - \gamma_2)q\epsilon_2^S] - (1 - \gamma_2)E}{\gamma_2 [E + (1 - \gamma_2)q\epsilon_2^D]},$$

where E is

$$\sum_{i \neq 2} (Q_i^S / P_i) (\epsilon_i^S - \gamma_i \epsilon_i^D)$$

and q is Q_2/P_2 . The right-hand side of equation (19) is positive when

$$(20) \quad \sum_{i \neq 2} (Q_i^S / P_i) (\gamma_i \epsilon_i^S - \epsilon_i^D) \geq (1 - \gamma_2) \frac{Q_2^S}{P_2} |\epsilon_2^D|,$$

a condition that is likely to hold as long as C_2 is not an extremely large exporter or very elastic demander. Under this condition, origin regionalization is more likely to cause a larger price difference if α is larger or β is smaller, or, in other words, if region A produces a very large share or produces a small share of domestic output.

The effect on the supply curve is more complicated as it depends on both the distribution of risk preferences across regions and the ability to shift risk among agents. Firms may be able to shift risk to intermediaries in the actual smuggling of goods. These intermediaries may be either at the origin or destination. Therefore, the distribution of risk preferences may not be simply that of producers. If risk shifting is very difficult, then it is reasonable to assume that risk preferences are affected in approximately the same manner as producers in general. In this case, M should be multiplied by α , the portion of producers in the restricted region. This will reduce the supply of smuggled goods as producers are now more risk averse and therefore must be compensated with a larger price spread in order to smuggle. If risk shifting is very easy across regions, then M will remain roughly constant and the supply curve will remain unchanged.

Destination regionalization follows the same logic and, for that reason, the formal derivations are relegated to the Appendix. In general, destination regionalization can also exacerbate price

swings when the region permitted to import goods is not the primary consumption region. Destination regionalization also suffers from the fact that the cost of smuggling goods (ω) is also likely to be significantly lower once goods enter a country.

Destruction in Government Eradication Programs and Price Support

Trade bans arising from SPS concerns are typically associated with government efforts to contain the spread of the harmful organisms by destroying products at the point of production. For instance, in 2003, approximately 2 million chickens in California were destroyed to contain Exotic Newcastle Disease; since 1995, approximately 870,000 Florida citrus trees were destroyed in the (ultimately unsuccessful) attempt to control citrus canker; and between 2003 and 2005, 47 million chickens were culled in Vietnam in order to contain the spread of avian influenza. Compensation for the destruction of agricultural crops can vary dramatically and is often less than complete. For example, Abbas (2006) reported that inadequate compensation to Egyptian farmers has undermined the government's effort to have farmers report avian influenza occurrences.

Similarly, destruction by governments may be associated with support payments. If government compensates farmers in the origin country at P_2^G where $P_2^{TB} \leq P_2^G \leq P_2^{FT}$, they can reduce ΔP_2 , which reduces the incentive to smuggle goods abroad. Compensation to farmers at pre-crisis levels, however, may be inadequate if the destination price P_1^{FT} rises dramatically. Also, while the costs of eradication are likely to be borne by the origin country, the benefits of reduced smuggling (in terms of less risk) will accrue at the destination. At the same time, regionalization can reduce the magnitude of government payments. Origin regionalization may then be used to encourage trade partners to engage in more comprehensive SPS control measures, including destruction and compensation.

Stockpiling and Storage

By stockpiling goods, governments might intervene to prevent the destination price (P_1) from

reaching a price level that triggers smuggling. In this case, the external incentive to smuggle goods becomes smaller as ΔP_1 shrinks. For instance, Kremer and Morcom (2000) advocate stockpiling storable products generated from open access resources subject to biological growth processes. They show that the anticipated price increases from future scarcity will cause over-harvesting in the near term. They suggest that their analysis applies to 84 storable plant and animal goods, including, in particular, the famous 1988 decision by the Kenyan Wildlife Service to destroy confiscated and legally harvested elephant ivory rather than to store the ivory and sell it if elephant populations fall dangerously low. In their model, rational, forward-thinking poachers anticipate the future depletion of a resource (or, analogously, the increased cost of future increases in enforcement of laws restricting trade) and accelerate their poaching now. By threatening to sell stocks if the population should fall, the government credibly commits to a policy that eliminates poaching at precisely the time when poachers fear that the elephant population is threatened and accelerate their poaching.¹⁸

Substitutes

The development of substitutes for the banned goods will reduce smuggling in two ways. First, it will lower the demand for the good subject to the trade ban. Second, it will lower the elasticity of demand in all countries and thus dampen the price increase caused by a trade ban. Von Hippel and von Hippel (2002) find evidence that the introduction of the impotency drug Viagra reduced the trade in endangered-animal parts associated with traditional Chinese medicine (TCM) and banned under CITES. They find that the introduction of Viagra in 1998 caused a simultaneous reduction in the price and quantity harvested of threatened but legally traded TCM parts including harp seal penises, hooded seal penises, and antler velvet, despite the subsequent recovery of Asian economies and the previous inelasticity of their demand

curves. More commonly, the substitutes may be encouraged by facilitating captive breeding programs (which allows Appendix I CITES species to be moved to Appendix II species) and expediting clearance of less risky, treated products.

Conclusions

As Naim (2005, p. 239) states, "Illicit trade is driven by high profits and not low morals." Smuggling is a crime that is intimately interwoven with the normal operations of markets, and smugglers are likely to respond rationally to profit incentives as well as penalties and risks. Regionalization may help to mitigate the opportunity for profit and reduce the costs of law enforcement, but this depends significantly on the specific geographic distribution of production and consumption and the ability of government to enforce potential trade bans.

Regulation is an outgrowth of law, and laws are often broken. In addition to other worthy concerns, policymakers should be cautious of the market incentives for the violation of regulations. As awareness of the potential costs of invasive species and trade disruptions caused by SPS factors has grown, the need for understanding the factors that influence pathways for these threats has also grown. As globalization and trade interdependence increase, so do the threats of illicit trade. This article indicates where those threats may lie and how they might be mitigated.

References

- Abbas, M. 2006. "Poor Egyptians Refuse to Sign Up to Bird Flu Cull." *Daily Star* (Nawa, Egypt). Available at <http://www.dailystaregypt.com> (March 30).
- Ameden, H.A., S. Cash, and D. Zilberman. 2007. "Invasive Species Management: Importers, Border Enforcement and Risk." Selected paper prepared for the annual meetings of the American Agricultural Economics Association, Portland, Oregon (July 29–August 1).
- Animal Plant Health Inspection Service (APHIS). 2006. Personal communication with USDA's Inspection Enforcement Service, APHIS, U.S. Department of Agriculture, Washington, D.C. (November 27). Available upon request. APHIS [see Animal Plant Health Inspection Service].
- Bar-Gill, O., and A. Harel. 2001. "Crime Rates and Expected Sanctions: The Economics of Deterrence Revisited." *Journal of Legal Studies* 30(2): 485–501.
- Becker, G. 1968. "Crime and Punishment: An Economic Approach." *Journal of Political Economy* 76(2): 169–217.

¹⁸ Fischer (2003), Fischer (2004), and Heltberg (2001) argue that legal sales may reduce the stigma effect on demand. Van Kooten (2006) finds that the stigma effect is likely to be too small to maintain stable elephant populations in the presence of a trade ban and argues for more liberal trade in ivory and monetary payments for herd maintenance.

- Bhagwati, J., and B. Hensen. 1973. "A Theoretical Analysis of Smuggling." *Quarterly Journal of Economics* 87(2): 172–187.
- Costello, C., and C. McAusland. 2003. "Protectionism, Trade, and Measures of Damage from Exotic Species Introductions." *American Journal of Agricultural Economics* 85(4): 964–975.
- Costello, C., M. Springborn, C. McAusland, and A. Solow. 2007. "Unintended Biological Invasions: Does Risk Vary by Trading Partner?" *Journal of Environmental Economics and Management* 54(3): 262–276.
- Deflem, M., and K. Henry-Turner. 2001. "Smuggling." In D. Luckenbill and D.L. Peck, eds., *Encyclopedia of Criminology and Deviant Behavior: Crime and Juvenile Delinquency* (Vol. 2). Philadelphia, PA: Brunner-Routledge.
- Eide, E. 1999. "Economics of Criminal Behavior." In B. Bouckaert and G. de Geest, eds., *Encyclopedia of Law and Economics* (Vol. 5). Cheltenham, UK: Edgar Elgar Publishing Ltd.
- Fischer, C. 2003. "Trading in Endangered Species: Legal Sales Versus Total Bans." *Resources* 150(1): 12–14.
- _____. 2004. "The Complex Interactions of Markets for Endangered Species Products." *Journal of Environmental Economics and Management* 48(2): 926–953.
- Fisman, R., and S. Wei. 2004. "Tax Rates and Tax Evasion: Evidence from 'Missing Imports' in China." *Journal of Political Economy* 112(2): 471–496.
- Franklin, J. 1997. "Aviculture under Fire." Canadian Parrot Symposium, Victoria, BC, Canada (May 17–19). Available at <http://www.silvio-co.com/cps/articles/1997/index.htm>.
- Goel, R.K. 2004. "Cigarette Demand in Canada and the U.S.: Canadian Cigarette Smuggling." *Applied Economic Letters* 11(9): 537–540.
- Heltberg, R. 2001. "Impact of the Ivory Trade Ban on Poaching Incentives: A Numerical Example." *Ecological Economics* 36(2): 189–195.
- Henry, L.A. 2004. *A Tale of Two Cities: A Comparative Study of Traditional Chinese Medicine Markets in San Francisco and New York City*. TRAFFIC North America. Washington, D.C.: World Wildlife Fund.
- Interpol. 2006. Personal communication with a specialist officer for wildlife crime (September 21). Available upon request.
- Kattoulas, V. 2002. "Crime: The Death of Sushi?" *Far Eastern Economic Review* 165(32): 48–51.
- Kremer, M., and C. Morcom. 2000. "Elephants." *American Economic Review* 90(1): 212–234.
- Kurlansky, M. 1997. *Cod: A Biography of a Fish That Changed the World*. New York: Penguin Books.
- Lawrence, M., and A. Panagariya. 1984. "Smuggling, Trade, and Price Disparity: A Crime-Theoretic Approach." *Journal of International Economics* 17(3): 201–218.
- Lynch, L., and E. Lichtenberg. 2006. "Foreword: Special Issue on Invasive Species." *Agricultural and Resource Economics Review* 35(1): iii–v.
- Martin, L., and A. Panagariya. 1984. "Smuggling, Trade and Price Disparity." *Journal of International Economics* 17(3): 201–217.
- Meichtry, S. 2006. "Swell or Swill: Top Vineyards Fend Off Bogus Bottle." *Wall Street Journal*, Section B1, August 10.
- Naim, M. 2005. *Illicit*. New York: Doubleday.
- Norton, D.A.G. 1988. "On the Economic Theory of Smuggling." *Economica* 55(217): 107–118.
- Office of Technology Assessment (OTA). 1993. "Harmful Non-Indigenous Species in the United States." Report No. OTAF-F-565, OTA, Washington, D.C.
- OTA [see Office of Technology Assessment].
- Paarlberg, P.L., and J.G. Lee. 1998. "Import Restrictions in the Presence of a Health Risk: An Illustration Using FMD." *American Journal of Agricultural Economics* 80(1): 175–183.
- Peterson, E., and D. Orden. 2006. "Linking Risk and Economic Assessments in the Analysis of Plant Pest Regulations: The Case of U.S. Imports of Avocados from Mexico." Contractor and Cooperator Report No. 25, Economic Research Service, U.S. Department of Agriculture, Washington, D.C.
- Pimentel, D., L. Lach, R. Zuniga, and D. Morrison. 2000. "Environmental and Economic Costs of Nonindigenous Species in the United States." *BioScience* 50(1): 53–65.
- Pimentel, D., R. Zuniga, and D. Morrison. 2005. "Update on the Environmental and Economic Costs Associated with Alien Invasive Species in the United States." *Ecological Economics* 52(3): 273–288.
- Pitt, M. 1981. "Smuggling and Price Disparity." *Journal of International Economics* 11(5): 447–458.
- Reed, R.N. 2005. "An Ecological Assessment of Risk Analysis of Non-native Boas and Pythons as Potentially Invasive Species in the United States." *Risk Analysis* 25(3): 753–766.
- Rosenthal, E. 2008. "Europe's Appetite for Seafood Propels Illegal Trade." *The New York Times*, Section A, January 15.
- Saba, R.P., T.R. Beard, and R.B. Ekelund. 1995. "The Demand for Cigarette Smuggling." *Economic Inquiry* 33(2): 189–202.
- Sheikh, M.A. 1974. "Smuggling, Production and Welfare." *Journal of International Economics* 4(4): 355–364.
- Sipress, A. 2006. "In Vietnam, a Gateway for Bird Flu." *Washington Post*, Section A23, July 30.
- Smith, A. 1776. *An Inquiry into the Nature and Causes of the Wealth of Nations*. London: Strahan and Cadell.
- Thursby, M., R. Jensen, and J. Thursby. 1991. "Smuggling, Camouflaging, and Market Structure." *The Quarterly Journal of Economics* 106(3): 789–814.
- U.S. Customs and Border Patrol. 2005. "U.S. Customs and Border Patrol Interception of Illegal Citrus Cuttings Becomes First Felony Conviction in Violations of the Plant Protection Act of 2005." Press release dated September 9, available at <http://www.cbp.gov>.

- von Hippel, F.A., and W. von Hippel. 2002. "Sex Drugs and Animal Parts: Will Viagra Save Threatened Species?" *Environmental Conservation* 29(3): 277–281.
- van Kooten, G.C. 2006. "A Dynamic Bioeconomic Model of Ivory Trade: Details and Extended Results." Working Paper No. 2006-03, Department of Economics, University of Victoria, Victoria, BC, Canada.
- Williamson, M. 1999. "Invasions." *Ecography* 22(1): 5–12.
- Zansler, M.L., T.H. Spreen, and R.P. Muraro. 2005. "Florida's Citrus Canker Eradication Program (CCEP): Summary of Annual Costs and Benefits." Extension Digital Information Source (EDIS) No. FE532, Food and Resource Economics Department, University of Florida, Gainesville, FL. Available at <http://edis.ifas.ufl/FE532>.

Appendix: Destination Regionalization

Assume that the destination country is divided into region C, where imports are restricted, and region D, where they are unrestricted, and that external smuggling from the origin country to region C is zero so that goods produced domestically in region D are not shipped to region C. The terms α_1 and β_1 are the proportion of country 1's production that is produced and consumed in region C. Region C's net imports are equal to $(\alpha_1 - \beta_1\gamma_1)Q_1^S$, so regionalization has an impact on prices only if α_1 exceeds $\beta_1\gamma_1$. When a trade ban is implemented, absent any price changes, imports to region C fall from $(\alpha_1 - \beta_1\gamma_1)Q_1^S$ to zero, and exports to region D rise by the same amount. Prices rise in region C and fall in the remaining trade-linked region D and its trade partners.

Let $\Delta P_{1C} (= P_{1C}^{TB} - P_{1C}^F)$ and $\Delta P_{1D} (= P_{1D}^{TD} - P_{1D}^F)$ represent the new price changes. Producers will smuggle goods if

$$(A1) \quad \Delta P_{1C} - \Delta P_{1D} \geq \varpi_{D \rightarrow C}.$$

While this condition is similar to equation (3), it is very likely that $\omega_{D \rightarrow C}$ is less than $\omega_{2 \rightarrow 1}$ for several reasons. First, there are far more access points to domestic travel than to foreign travel. Second, domestic traders are likely to have far more protections from periodic, random inspections than are foreign traders. Third, the volume of domestic movement of goods is likely to exceed foreign movement of goods.

Again, decomposing the price effect into two parts and assuming that producers and consumers are randomly allocated across regions, ΔP_{1C} is solved by first noting that $(\Delta NX_{2 \rightarrow 1C})^{DR} = -(\alpha_1 - \beta_1\gamma_1)Q_1^S$. The change in price is found by first noting that

$$\beta Q_1^D(P_{1C}) - \alpha Q_1^S(P_{1C}) = NX_{2 \rightarrow 1C} = (\alpha_1 - \beta_1\gamma_1)\bar{Q}_1^S.$$

Taking the total derivative, the change in the region C price is

$$(A2) \quad \Delta P_{1C} = \frac{(\alpha_1 - \beta_1\gamma_1)Q_1^S}{\frac{Q_1^S}{P_1}(\alpha_1\varepsilon_1^S - \beta_1\gamma_1\varepsilon_1^D)} \geq 0.$$

Similarly, ΔP_{1D} is solved noting that

$$(A3) \quad \Delta P_{1D} = [-(\alpha_1 - \beta_1\gamma_1)Q_1^S] \times \left[\left(\frac{Q_1^S}{P_1} \right) ((1 - \alpha_1)\varepsilon_1^S - (1 - \beta_1)\gamma_1\varepsilon_1^D) + \sum_{i \neq 1} \left(\frac{Q_i^S}{P_i} \right) (\varepsilon_i^S - \gamma_i\varepsilon_i^D) \right]^{-1}.$$

The total price difference is then

$$(A4) \quad (\Delta P_{1C} - \Delta P_{1D})^{DR} = \left[\frac{((\alpha_1 - \beta_1\gamma_1)Q_1^S)}{\frac{Q_1^S}{P_1}(\alpha_1\varepsilon_1^S - \beta_1\gamma_1\varepsilon_1^D)} \right] + \left[\frac{((\alpha_1 - \beta_1\gamma_1)Q_1^S)}{\left(\left(\frac{Q_1^S}{P_1} \right) ((1 - \alpha_1)\varepsilon_1^S - (1 - \beta_1)\gamma_1\varepsilon_1^D) + \sum_{i \neq 1} \left(\frac{Q_i^S}{P_i} \right) (\varepsilon_i^S - \gamma_i\varepsilon_i^D) \right)} \right].$$

Under most conditions, the demand for smuggled goods decreases as either α_1 increases or β_1 decreases for the same intuition as with origin regionalization. If region C produces more and consumes less, there will be a smaller price swing from the resulting trade ban. Region C is more autonomous and can replace its lost trade with

more of its own capacity rather than by smuggling.

If trade occurs only between country 1 and country 2, then $(1-\gamma_1)Q_1^S$ is equal to $(1-\gamma_2)Q_2^S$, as country 1's imports must equal country 2's exports. In this case, under the assumption that $\varpi_{D \rightarrow C}$ and $\varpi_{2 \rightarrow 1}$ are equal, then equation (A4) and equation (18) are identical. Under this very specialized condition, the demand for smuggled goods would remain the same, while the supply of smuggling would rise due to the lower probability of detection once goods are within the borders. This concern may have been applicable to

the ban on importation of avocados from Mexico to all lower 48 states until 1997, even though the SPS threat of Mexican avocados is limited to the main avocado growing regions of southern California. Peterson and Orden (2006) note that this area historically has both consumed and produced a large portion of avocados in the United States. A concern regarding the liberalization of the avocado trade is that it would make it easier for potentially risky avocados to enter this region once they had entered the United States if $\varpi_{D \rightarrow C}$ is less than $\varpi_{2 \rightarrow 1}$.