Trade, the damage from alien species, and the effects of protectionism under alternate market structures

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ABSTRACT

We first construct three measures of the expected damage from the unintentional introduction of alien species into a country called Home. We then focus on four market structures. First, perfect competition prevails in both Home and Foreign, and Home is a small country. Second, the Home and the Foreign markets are both perfectly competitive, but Home is now a large country. Third, the exporter in Foreign is a monopolist and there are no import competing firms in Home. Finally, the Foreign exporter and the import competing firm in Home engage in Cournot competition. In all four scenarios, we analyze the impact of small and optimal Home tariffs on prices, exports, imports, the damage from alien species, and social welfare in Home. *Inter alia*, our analysis identifies conditions under which it makes sense to use trade policy (tariffs) to regulate invasive species and conditions under which it does not.

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1. Introduction

The fact that alien species (also known as invasive or non-native species) have been and continue to be introduced into one part of the world from another is not new. What is new is the realization that such introductions, particularly the unintentional ones, have often been very costly for the concerned nations. In this regard, consider the case of the United States. A report by the Office of Technology Assessment (OTA, 1993) declared that the annual monetary damage resulting from biological invasions is between $4.7 and $6.5 billion. More recent research by Pimentel et al. (2000) has concluded that the total annual monetary damage from invasive species is in fact over $100 billion.

Researchers now recognize that maritime trade in goods comprises a sizeable proportion of the world's total international trade in goods. Ships are the primary vehicle in maritime trade, and consequently they are routinely used to carry goods of all kinds (often in containers) from one country to another. Now, international trade theorists have demonstrated that there are benefits to the nations involved in such voluntary trade. This notwithstanding, in recent times, natural resource and environmental economists have contended that these gains are likely to be smaller than what most researchers have believed thus far. Why? As Perrings et al. (2000), Costello and McAusland (2003), Batabyal (2004), Batabyal et al. (2005), and Margolis et al. (2005) have noted, this is because in addition to carrying goods between nations, ships have

also managed to carry an assortment of deleterious non-native plant and animal species from one part of the world to another.

As far as unintentional introductions, the primary focus of this paper, are concerned, there are two main ways in which alien species have been carried from one part of the world to another. First, many invasive species have been introduced into a country, often inadvertently, by ships discarding their ballast water. Cargo ships usually carry ballast water in order to increase vessel stability when they are not carrying full loads. When these ships come into a seaport, this ballast water must be jettisoned before cargo can be loaded. This manner of species introductions is important, and the problem of managing alien species that have been introduced into a particular nation by means of the discharge of ballast water has now received some attention in the economics literature (see Nunes and Van den Bergh, 2004; Yang and Perakis, 2004; Batabyal and Beladi, 2006).

The second way in which alien species have been introduced into a particular country is by means of contaminated goods (agricultural goods readily come to mind) that may or may not be carried in containers. In this regard, the reader should note that invasive species can remain concealed in containers for long periods of time. In addition, material such as wood, which is often used to pack the cargo in the containers, may itself contain alien species. In fact, as pointed out by Costello and McAusland, a joint report from the United States Department of Agriculture (USDA), the Animal and Plant Health Inspection Service (APHIS), and the United States Forest Service (USFS) has noted that nearly 51.8 percent of maritime shipments contain solid wood packing materials and that infection rates for solid wood packing materials are substantial (USDA, APHIS, and USFS, 2000, p. 25). For example, inspections of wooden spools from China revealed infection rates between 22 percent and 24 percent, and inspections of braces for granite blocks imported into Canada were found to hold live insects 32 percent of the time (USDA, APHIS, and USFS, pp. 27–28).

Economists and ecologists are both very interested in managing invasive species. This is because (see the first paragraph of this section) biological invasions can and often have proven to be very costly from an economic standpoint. In addition to these economic costs, the work of Vitousek et al. (1996), Simberloff et al. (1997), Costello and McAusland (2003), and others reminds us that alien species can alter ecosystem processes, act as vectors of diseases, and diminish biological diversity. In this regard, Cox (1993) has observed that out of 256 vertebrate extinctions with a known cause, 109 are the outcome of biological invasions. This discussion tells us that non-native species have been and continue to be a great menace to society.

It is only very recently that economists have begun to analyze questions pertaining to invasive species management. For instance, Eiswerth and Johnson (2002) have studied an intertemporal model of alien species stock management. They note that the optimal level of management effort is responsive to ecological factors that are not only species and site specific but also stochastic in nature. Second, Olson and Roy (2002) have used a stochastic framework to examine the circumstances under which it is optimal to wipe out an invasive species and the circumstances under which it is not optimal to do so. Third, Horan et al. (2002) have analyzed the properties of management approaches under full information and under uncertainty. Fourth, Batabyal et al. (2005) have observed that there is a tension between economic cost minimization and inspection stringency in invasive species management. Finally, Batabyal and Beladi have analyzed maximization problems stemming from the steady state analysis of two multi-person inspection regimes.

Despite the known connection between goods trade between countries and the damage from alien species, with the exception of Jenkins (1996), ecologists in general have paid *scant attention* to the role of trade policy in mitigating the damage from alien species introductions. Jenkins has contended that it may be necessary to use trade policy (bans and restrictions) to protect biological diversity. Very recently, a small number of papers have begun to analyze issues at the interface of international trade and invasive species management. Barbier and Shogren (2004) have analyzed a growth model in which a biological invasion occurs as a spillover effect from the importation of capital goods. They show that when a biological invasion diminishes the productivity of all firms in the economy, the government ought to impose an output tax to equate the private and the social desires for consumption growth and capital accumulation. Costello and McAusland (2003) and McAusland and Costello (2004) have studied the impact that tariffs have on the damage from invasive species introductions. Costello and McAusland show that a tariff can either decrease or increase the damage from invasive species. McAusland and Costello show that although it is always optimal to use tariffs to control the damage from alien species, the same cannot be said about inspections. In particular, in their model, there are several circumstances in which it is optimal not to inspect imported goods at all. Prestemon et al. (2006) study international trade in forest products and show that trade liberalization will have a negligible effect on US imports of Siberian logs and on the risk of a biological invasion. Finally, using an integrated model with an international trade component, Zhao et al. (2006) demonstrate the consumer and the producer responses to livestock disease outbreaks and the welfare effects of alternate invasive species management policies.

Although the papers cited in the previous paragraph have certainly advanced our understanding of the impacts of trade policy on the damage from invasive species, three outstanding questions concerning the desirability of using trade policy to manage invasive species remain. Therefore, the purpose of this paper is to analyze these three questions in detail. First, unlike the extant literature, we use a two country model to study the efficacy of tariffs as an invasive species management tool under four *different market structures*.[1] Second, we focus not just on small tariffs but on *small and on optimal* tariffs. Finally,

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[1] For analyses of tariffs in other contexts, see Parai (1999), Biswas and Marjit (2007), and Vishwasrao et al. (2007).