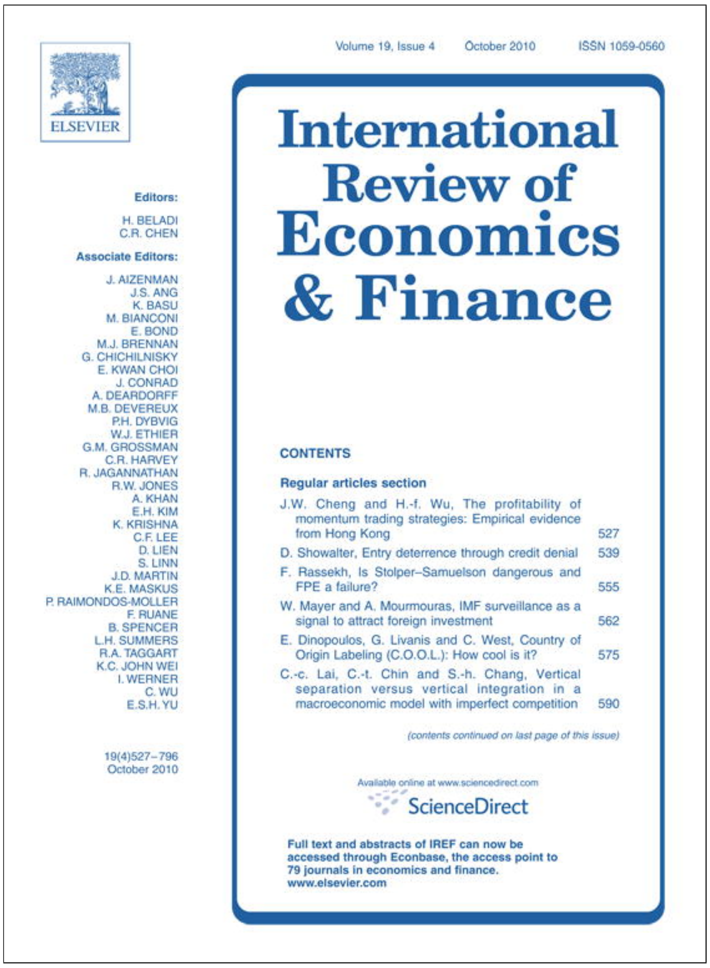

Volume 19, Issue 4 October 2010 ISSN 1059-0560

ELSEVIER

International Review of Economics & Finance

19(4)527–796
October 2010

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International Review of Economics and Finance 19 (2010) 575–589

Contents lists available at ScienceDirect

International Review of Economics and Finance

journal homepage: www.elsevier.com/locate/iref

Country of Origin Labeling (C.O.O.L.): How cool is it?

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ARTICLE INFO

Article history:
Received 1 March 2009
Received in revised form 2 November 2009
Accepted 1 December 2009
Available online 24 December 2009

JEL classification:
F10
F13
L15

Keywords:
Country-of-origin labeling
Protection
Product safety
Welfare
Insurance markets

ABSTRACT

This paper develops a partial-equilibrium model of a small open-economy trading an unsafe product. The model is used to analyze the welfare effects of trade with and without a *country-of-origin labeling* (COOL) program. The welfare gains from trade in the absence of COOL are ambiguous, may justify the imposition of a trade ban. Even if a full ban does not improve welfare and some restriction of trade is always welfare-enhancing. Under a tariff regime, more COOL trade is better than less trade. Independently of domestic market power, free trade coupled with a COOL program maximizes national welfare.

1. Introduction

The incidence of food-borne diseases has dramatically increased in the past fifteen years in the United States and in other industrialized countries. According to the Centers for Disease Control and Prevention (CDC, 2009), food-borne infections in the United States annually cause approximately 76 million illnesses, costing $23 billion per year. Widely publicized outbreaks such as "Mad Cow" disease (Bovine Spongiform Encephalopathy or BSE), avian influenza ("bird flu") and the contamination of animal feed with cancer-causing dioxin and polychlorinated biphenyls (PCBs) have led to greater consumer awareness of potential food hazards and increased consumer demand for safer products. Concomitantly, these outbreaks have triggered national revisions in trade policies. The efficacy of these policy responses is the focus of this research.

The imposition of temporary import bans has been one response. BSE outbreaks resulted in a spate of such bans in 2003. A virtually worldwide ban on Canadian beef exports followed the May 20, 2003 announcement that a single breeder cow in Alberta had tested positive for BSE. By August, Canada's beef export market had dwindled from $4.1 billion annually to near zero. In less than ten days following the December 23, 2003 diagnosis of a BSE case in the United States, over 30 countries had banned US imports, including Japan, traditionally the largest buyer of American beef. More recently, outbreaks of bird flu in Delaware and Texas prompted the European Union to ban imports of poultry from the United States. Country-of-origin labeling (COOL) is another policy measure addressing the problem of potentially unsafe food imports. COOL allows consumers to differentiate products that may embody different health risks as a consequence of the uneven geographical origins of food-borne diseases.

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1059-0560/$ – see front matter
doi:10.1016/j.iref.2009.12.001

Japan has mandated a COOL for all meat imports since 1997. In the U.S., the 2002 Farm Security and Rural Investment Act (2002 Farm Bill) called for voluntary COOL on September 30, 2002 and mandatory COOL by September 30, 2004 for a number of food products such as beef, pork, fresh fruit and vegetables (Federal Register, 2009).[1]

Juxtaposed against the emotional intensity that often surrounds health-related issues and the sometimes extreme measures that have been implemented to deal with food-borne diseases in particular, is a relatively scant literature analyzing the economics of trade policy in risky products. Many questions remain unanswered. From an economic welfare perspective, are trade embargoes rational when there is a food safety concern? Perhaps under some circumstances but not others? What are the welfare effects of policies such as COOL? Should a COOL be augmented by traditional protectionist trade policy instruments (e.g., tariffs and/or quotas)?

Product safety, and in particular food safety, issues have been analyzed theoretically and empirically, but primarily in the context of *closed*-economy, partial-equilibrium models.[2] In the international context, there are three related literatures. First, considerable attention has been given to product quality and government intervention to help exporters overcome informational barriers that impede foreign market entry (in particular, adverse country-of-origin reputations), or to improve the distribution of income.[3] While this set of studies and the current one each embodies a type of endogenous quality determination, the nature and consequences of product quality differences, key decision-making units, international trade context, and pertinent policy analyses differ substantially.[4]

Second, consumer inability to distinguish safe and unsafe products in the marketplace resembles consumer inability to distinguish goods by production process (eco-friendly, sweatshop, etc.) which, if known, would affect willingness to pay.[5] Since welfare analyses of trade policy in the latter context lack explicit representation of how production process affects consumer utility, it is difficult to directly compare these studies with the present model. In addition, "labeling" in this literature is standard-conforming certification, a process that allows the consumer to definitively separate products of different "quality" in the marketplace. In contrast, in the current model, risk of purchasing and consuming an unsafe product cannot be completely eliminated. If the only labeling possibility is country of origin, and if the consumer knows the proportion of imports that are standard-conforming versus non-standard conforming, then straightforward representation of how production process affects utility renders the situation a special case of this study's more general model.

A third strand of literature analyzes *rules of origin* (ROO) that prevent transshipment in a Free Trade Area (FTA). The effects of ROO on trade, welfare and distribution of rents in the supply chain under various market structures have been extensively examined in the literature.[6] While both ROO and COOL involve "country labeling," there are critical distinctions for policy analysis modeling. ROO impacts the consumer directly via price (higher or lower depending upon eligibility for tariff-free shipment). COOL, in contrast, directly influences consumer behavior by expanding information on product attributes he/she associates with expected product safety. Price consequences are only indirect, as the change in consumer information alters demand conditions. More basically, the unobservable product-quality differences inherent in a COOL analysis give rise to the possibility of different prices for domestic and foreign production that do not characterize homogeneous ROO markets.

The agricultural economics literature has focused on estimating the consumers' willingness to pay for labeled products,[7] associated costs with COOL implementation,[8] and effects of COOL implementation on the meat industry and specialty crop products.[9] While the potential demand effects are explicitly considered by the latter strand of literature, they focus on the potential market effects of COOL either on the U.S. meat industry or in the U.S. specialty crops sector and quantification of welfare effects is achieved through numerical simulation or through the use of specific values for elasticities of demand and supply.

This paper develops a partial equilibrium model to analyze the welfare effects of a COOL program in the presence of risky foods supplied by local and/or foreign producers in a small open economy under perfect competition or a domestic monopolist. The theoretical model uses building blocks from the seminal study by Oi (1973), who established that in the presence of

[1] However, implementation of COOL was delayed by Public Law 109–97 for all covered commodities except wild and farm-raised shellfish until September 30, 2008. The 2008 Food, Conservation and Energy Act (2008 Farm Bill) amended the 2002 Farm Bill by adding chicken, goat, macadamia nuts, pecans, and ginseng as covered commodities and provisions for labeling products of multiple origins, among other changes. On January 15, 2009 the Agricultural Marketing Service of the USDA published the final regulation for the mandatory COOL for all covered commodities (74 FR 2658) and became effective on March 16, 2009 (Federal Register, 2009).

[2] See, for instance, Oi (1973), Epple and Raviv (1978), Spence (1977), Shapiro (1983), Daughety and Reinganum (1995), and Boom (1998) for theoretical analyses on product safety, among many others. For the impact of food safety on meat demand and for a partial review of empirical studies on food safety, see Piggott and Marsh (2004). For extensive theoretical analysis in a domestic context, see Fulton and Giannakas (2004) and references therein.

[3] See Donnenfeld, Weber, and Ben-Zion (1985), Bagwell and Staiger (1989), Bagwell (1991), Raff and Kim (1999), and Acharyya and Jones (2001) among many others.

[4] An interesting extension of the present research would link to these previous analyses by incorporating the possibility of consumer misperceptions of the safety of a specific country's exports as a consequence of the publicized outbreak of a food-borne disease in that country. Depending upon the nature of the disease, and the feasibility of its plausible incorporation into the potential exporter's explicit choice between 'high quality' and 'low quality' production, the situation could have similarities to examples that motivate the analyses of country-of-origin reputations.

[5] Haener and Luckert (1998) and Blend and van Ravenswaay (1999) provide empirical evidence of consumer willingness to pay a "green premium." Theoretical foundations of the literature date from the classic Akerlof (1970) study of the "hidden quality" problem associated with lemons in the used car market. Recent work by Gaisford and Lau (2000) and Beaulieu and Gaisford (2002) address welfare implications of indistinguishable standard-conforming and non-conforming goods, including effects of certification labeling.

[6] Lloyd (1993), Lopez-de-Silanes, Markusen, and Ruthenford (1996), Falvey and Reed (2002).

[7] Schupp and Gillespie (2001), Loureiro and Umberger (2003, 2005), Umberger, Feuz, Calkins, and Stiz (2003).

[8] Food Marketing Institute (2001), Sparks Companies Inc. (2003).

[9] Brester, Marsh, and Atwood (2004), Lusk and Anderson (2004), Plastina, Giannakas, and Pick (2008).

insurance markets, the uncertainty associated with the risk of consuming an unsafe product is reflected in the risk-adjusted price (RAP).[10] Higher than the market price, the RAP includes the proportion of unsafe units in the parent product and expected damage costs of consuming those hazardous units. In this paper, we consider a product with an inherent health risk. The consumer knows with some exogenous probability (equal to the proportion of unsafe units) that the product is risky, but cannot determine whether the consumption of any particular unit will lead to adverse health outcomes. The primary focus of the research is the welfare effects of *international trade* in such a product and *international trade policies* with regard to such a product, when safety varies by country of origin.

Un-COOL trade (i.e., free trade in the absence of a COOL program) involves an informational distortion associated with the inability of consumers to assign the correct risk level to a particular domestic and foreign good that leads to a pooling equilibrium and ambiguous gains from trade, when the proportion of safe units differs between the domestic and imported goods.[11] This result allows for the possibility of welfare-enhancing import restrictions and import bans (Propositions 2 and 3).

We then analyze the effects of introducing a COOL program that permits the consumer to differentiate safer domestically produced goods and less safe imports. Equilibrium requires equalization of the RAPs between the domestic and foreign goods resulting in an increase in the price and quantity of the healthier domestic product and an increase in the producer surplus (Proposition 4). Simultaneously, the implementation of COOL leads to a decrease in aggregate safe quantities of the product consumed and a decline in the expected consumer surplus. COOL removes the informational distortion associated with differential risk levels and reestablishes the traditional gains from trade (Proposition 5). In the presence of a COOL program, more trade (caused by a reduction in a tariff) increases the welfare of a small country even if it imports riskier goods. More COOL trade is better than less COOL trade and welfare under COOL trade exceeds that of autarky or un-COOL trade.

Finally, we analyze the welfare effects of trade restrictions in the presence of a COOL program and domestic monopoly power. Under a tariff, more COOL trade is better than less COOL trade, whereas under a binding import quota more COOL trade might be worse than less COOL trade (Proposition 6). The presence of an import quota preserves the market power of the domestic firm and restricts the domestic quantity produced more than that produced under perfect competition. More trade in this case may generate a decline in the level of national welfare by reducing the quantity of the domestic good.

While no model can thoroughly address the multiplicity of issues regarding food safety and global commerce, the current theoretical model sheds some light on the efficacy of trade policies commonly proposed to deal with those issues. It is a first step in developing a rational approach to the economic cost–benefit analysis of COOL programs that several industrial countries, including the US, are considering implementing or have recently implemented.

Section 2 introduces the economics of un-COOL free-trade, and derives its welfare implications, for a small country importing a riskier product than it produces domestically. Section 3 analyses the welfare effects of trade restrictions in the absence of a COOL program and in the presence of perfectly competitive markets. Section 4 analyzes the economic effects of COOL trade. Section 5 examines the welfare implications of trade restrictions under a COOL program and domestic monopoly power. Conclusions are provided in the last section and some proofs are relegated to appendices.

2. Free-trade equilibrium

Consider an economy producing an unsafe (risky) good denoted by X and an outside composite safe good Y, which will be used as the numeraire. Assume that labor is the only factor of production, and that each unit of good Y requires one unit of labor, implying that wages are equal to unity. To focus on the analysis of product safety we assume that perfect competition prevails in all markets and consumers have identical preferences. The assumption of perfect competition in the domestic market will be relaxed in Section 5. To facilitate the economic intuition, we will analyze the benchmark free-trade equilibrium in the absence of country-of-origin labeling (COOL), and focus on the case of a country that imports an unsafe good at a fixed international market price P^* (the small country case).

Denote with X_T the market quantity of the domestic risky product and with X_T^* the corresponding quantity of a risky imported product coming from the rest of the world, where subscript T will be use to indicate functions and variables associated with the (free) trade equilibrium. The risk associated with a purchase X_T of the unsafe domestic good is captured by the assumption that it embodies a certain proportion, λ, of safe units, $Z_T = \lambda X_T$, and a remaining unsafe portion, $(1-\lambda)$ with $0 \leq \lambda \leq 1$. Similarly, assume that $Z_T^* = \lambda^* X_T^*$ is the corresponding quantity of the foreign (imported) safe good so the aggregate consumption of safe units is given by $Z_T + Z_T^*$. We assume for simplicity that parameters $\lambda, \lambda^* \in [0,1]$ are exogenous and may differ from each other. Without loss of generality, assume that $\lambda^* < \lambda$, which implies that home produces a safer product than the rest of the world. We also assume that in the absence of COOL the consumer cannot distinguish domestic goods and imports in the market place although he/she knows all the parameters of the model and the market equilibrium values of the relevant endogenous variables.

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[10] In this paper we use the terminology of risk-adjusted price instead of full price, because it is more self-explanatory. The full price concept was developed by Becker (1965) to analyze the ultimate consumption flow.

[11] The terms "pooling" and "separating" equilibrium have been used in various strands of literature including signaling games, principal-agent problems and labor economics. In the present context, we will follow Spence (1973) and use the term pooling to denote the market equilibrium that, in the absence of COOL signaling, generates the same price between imports and domestically produced products despite safety differences. The term separating equilibrium will denote the situation where the presence of COOL signaling results in different market prices between imports and domestic goods.

Consumption of safe units yields positive utility, but consumption of unsafe units not only results in no addition to utility, but simultaneously incurs a cost L per unit of unsafe good consumed. Arguably an individual might derive positive utility from consuming the unsafe good before becoming sick. A dynamic framework could capture such initial positive utility followed by negative utility of illness. The static framework assumption of obtaining no utility from consuming contaminated food corresponds to a net zero discounted utility in the dynamic framework. Loss L is given exogenously and captures the direct (i.e., medical treatment) costs and the indirect (i.e., lost wages) costs of illness per-unit of unsafe X consumed. Parameter L can be as large as the economic cost of life (as in the case of the "Mad Cow" disease) and in principle depends on the quality of the health system.[12]

Assuming the representative consumer derives utility only from the safe units $Z_T+Z_T^*$ of the risky (unsafe) products $X_T+X_T^*$ and from the outside (safe) good Y; and, following the standard approach to partial-equilibrium analysis, suppose that the utility function is separable in X and Y

$$U(Z_T + Z_T^*, Y) = u(Z_T + Z_T^*) + Y, \tag{1}$$

where $u(Z_T+Z_T^*)$ is an increasing and concave function of the safe quantity available in the market and indicates that the consumer does not receive any utility from the unsafe units X_T-Z_T and $X_T^*-Z_T^*$. The price of product Y is equal to unity (numeraire), and free trade results in equalization of domestic and world prices, i.e., $P_T=P^*$. This property is based on the assumption that consumers cannot distinguish between the two risky goods. Since Y enters the consumer's utility linearly, Eq. (1) allows us to focus on partial-equilibrium analysis.

There are two equivalent representations of the consumer maximization problem in terms of aggregate market demand and utility achieved: (a) for an amount X_T purchased, exactly λX_T units are safe and $(1-\lambda)X_T$ are unsafe, entailing a monetary loss of $(1-\lambda)LX_T$; (b) For a given amount of X_T purchased, the proportion of safe units, k, is unknown, but has the known probability density function $f(k)$ where $\int_0^1 kf(k)\mathrm{d}k=\lambda$ and the consumer can insure against unsafe units by payment of an actuarially fair premium. Approach (a) is developed here; the equivalent insurable risk situation is shown in Appendix A.[13]

Because the imported and the domestic products are indistinguishable in the market place and their costs of illness per unsafe unit are identical, the consumer demand will depend on the average probability of remaining healthy

$$\lambda_T = \frac{Z_T + Z_T^*}{X_T + X_T^*} = \frac{Z_T + Z_T^*}{\frac{Z_T}{\lambda} + \frac{Z_T^*}{\lambda^*}}, \tag{2}$$

which is taken as a given parameter by the representative consumer. The consumer maximizes her/his utility Eq. (1) subject to the budget constraint $M \geq Y + P^*(X_T+X_T^*) + (1-\lambda_T)L(X_T+X_T^*)$, where M is consumer income, P^* is the free-trade common price of X_T and X_T^*, and $(1-\lambda_T)L(X_T+X_T^*)$ is the expected cost of illness. Since the budget constraint is binding at equilibrium, one can use it to eliminate quantity of the outside good Y from the right hand side of Eq. (1) and express the consumer's maximization problem as follows:

$$\underset{X_T + X_T^*}{Max}\,[u[\lambda_T(X_T + X_T^*)] + M - P^*(X_T + X_T^*) - (1-\lambda_T)L(X_T + X_T^*)], \tag{3}$$

where the argument in the utility function $\lambda_T(X_T+X_T^*)$ equals the amount of "safe" units consumed $Z_T+Z_T^*$ according to Eq. (2). The first-order condition for Eq. (3) can be written as

$$u'(Z_T + Z_T^*) = \frac{P^*}{\lambda_T} + \frac{(1-\lambda_T)}{\lambda_T}L, \tag{4}$$

where a prime superscript denotes a partial derivative. Concavity of $u(.)$ guarantees that the second-order condition for Eq. (3) is satisfied.

Recalling that the consumer derives utility only from good Y and the safe units $Z_T+Z_T^*$ of products X_T and X_T^*, it is obvious from Eq. (4) that the solution to the utility maximization problem Eq. (3) is identical to maximizing Eq. (1) with respect to $Z_T+Z_T^*$ subject to the budget constraint $M=\hat{P}_T(Z_T+Z_T^*)+Y$, where

$$\hat{P}_T = \frac{P^*}{\lambda_T} + \frac{(1-\lambda_T)}{\lambda_T}L \tag{5}$$

is the risk-adjusted price (RAP) of an unsafe good. In the presence of actuarially fair insurance and one unsafe product, the economic interpretation of Eq. (5) is described elegantly by Oi (1973)[14]: $\hat{P}_T$ is the risk-adjusted price (expected cost) of obtaining a

[12] For instance, according to the FSIS (Food Safety and Inspection Service) of the USDA, a consumer faces a $(1-\lambda)=3.5\times10^{-6}$ probability of becoming ill from salmonella, if he/she eats one egg. This probability is obtained by dividing 174,356, the estimated number of annual illnesses attributed to salmonella for 2000, by the U.S. population to obtain the per-capita chance of becoming ill and then dividing the resulting expression by 178, the annual per-capita consumption of eggs. One can measure the expected damage cost to the consumer using the cost of illness (COI) data available on the ERS website Foodborne Illness Cost Calculator (FCOI, 2008). The COI method includes both direct and indirect costs of an illness; and for salmonella, the ERS website estimates that the average cost of illness is $2126.

[13] Similar considerations apply to product X_T^*. The absence of actuarially fair and full insurance complicates the analysis under interpretation (b). See, for example, Epple and Raviv (1978).

[14] See also Becker (1965) who developed the technique of decomposing the full price of an ultimate consumption flow. Notice that the full price concept in these studies is termed as risk-adjusted price in our paper.

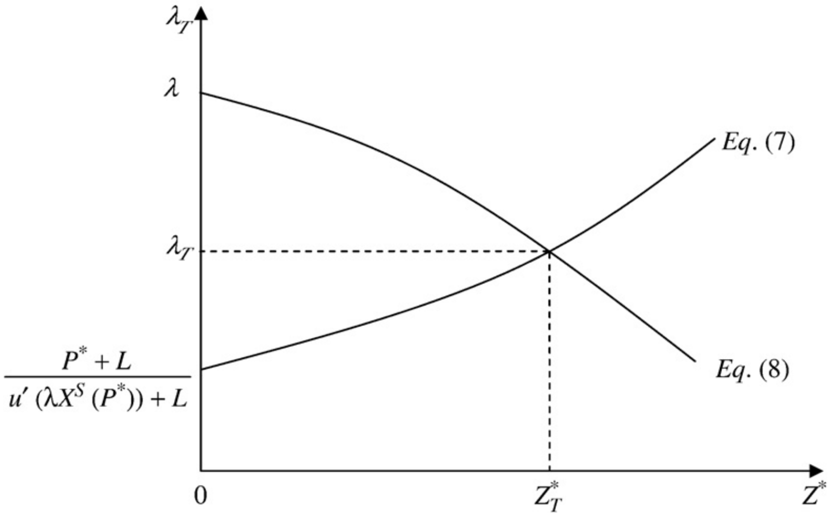

Fig. 1. Free-trade equilibrium of imports and product safety.

safe unit of a risky product, P^*/λ_T is the warranty price, and the term $(1-\lambda_T)L/\lambda_T$ is the actuarially fair insurance premium rate per "safe" unit.[15]

Eq. (4) defines the demand function for the safe quantity consumed $Z_T + Z_T^*$ as a function of its RAP $\hat{P}_T$, and is denoted by $Z_T^D(\hat{P}_T)$. This relationship will be used in calculating the expected consumer surplus in the welfare analysis. For instance, any parameter change that increases the RAP generates a reduction in the aggregate safe quantity consumed and a decline in consumer surplus.

The supply side of the economy is modeled as follows: assuming diminishing returns in the production of X_T, denote with $C(X_T)$ the total cost of producing X_T units of the risky product, where $C'(X_T)>0$ and $C''(X_T)>0$. Producer-profit maximization and perfect competition generate an upward-sloped inverse supply function of the risky product

$$P_T = C'(X_T) = C'(Z_T/\lambda), \tag{6}$$

where $P_T(0)=\underline{P}>0$. In other words, without loss of generality we assume that the supply curve intersects the vertical axis at a strictly positive price. Implicit in Eq. (6) is the assumption that the inverse supply of a risky good does not depend on the proportion of "safe" units produced domestically, but simply on the aggregate quantity X_T. The latter is obtained by simply inverting Eq. (6) to generate $X_T = X^S(P_T)$ and the domestic supply of safe units is given by $Z_T = \lambda X^S(P_T)$.

Substituting Eq. (2) and $Z_T = \lambda X^S(P^*)$ into Eq. (4) determines the free-trade equilibrium of safe imports Z_T^*, which can readily be transformed into the market-equilibrium quantity of imports $X_T^* = Z_T^*/\lambda$. Specifically, Eq. (4) can be written as

$$\lambda_T = \frac{P^* + L}{u'(\lambda X^S(P^*) + Z_T^*) + L} \tag{7}$$

and, for clarity of exposition, we replicate Eq. (2) below

$$\lambda_T = \frac{\lambda X^S(P^*) + Z_T^*}{X^S(P^*) + \frac{Z_T^*}{\lambda^*}}, \tag{8}$$

where $Z_T = \lambda X^S(P^*)$. Eqs. (7) and (8) constitute a system of two simultaneous equations in two unknowns λ_T and Z_T^*. This system has a unique equilibrium under the assumption that the domestically produced good is as safe as the imported good $(\lambda^* \leq \lambda < 1)$.[16] The solution is illustrated in Fig. 1.

The upward-sloped curve is the graph of Eq. (7). It has a positive vertical intercept and a positive slope: as the quantity of safe imports increases the marginal utility declines, and the denominator of Eq. (7) decreases. Eq. (8) defines a downward-sloped curve in the (λ_T, Z_T^*) space under the assumption that the domestically produced good is strictly safer than the imported one $(\lambda^* < \lambda < 1)$. The vertical intercept of the downward-sloped curve equals λ: for any level of safe domestic units Z_T, as the amount of imports increases, the level of product safety declines. The intersection of these two curves determines the free-trade equilibrium quantity of safe imports Z_T^* and the average probability of becoming ill $(1-\lambda_T)$. The total quantity of imports is given by $X_T^* = Z_T^*/\lambda^*$. If the imported good is as

[15] We illustrate the relative magnitude of the RAP for the case of eggs embodying the risk of contracting salmonella described in a previous footnote. Substituting the risk of becoming sick $(1-\lambda_T = 3.5\times10^{-6})$, the cost of illness ($L$=$2126), the market price of one grade A shell egg (P^*=$0.081), the RAP of eggs becomes $\hat{P}_T = \frac{0.081}{0.999997} + 2126{*}3.5\times10^{-6} = 0.088$. In other words, the consumer behaves as if the risk of salmonella generates an 8.6% increase in the market price for safe eggs with a corresponding decrease in the quantity of eggs consumed.

[16] We abstract from analyzing the case of a safer imported good, where multiple equilibria can arise, because the welfare analysis is straightforward: more imports generate the usual gains from trade and also increase the average safety of available goods and benefit the small country.

safe as the domestically produced good ($\lambda^*=\lambda<1$), Eq. (8) implies that the downward-sloped curve in Fig. 1 becomes horizontal at $\lambda_T=\lambda=\lambda^*$. In this case, the average probability of becoming ill is independent of the level of imports.

Let P_A denote the closed-economy (autarkic) price. In order to abstract from the uninteresting free-trade equilibria of no imports or no domestic production, we assume that

$$P^* < P_A \text{ and } X^S(P^*) > 0. \quad (9)$$

The next analytical step is to derive a welfare expression for the free-trade equilibrium which will be used in the subsequent analysis of trade restrictions and COOL. Assuming a total budget of M and given Eq. (2), the social planner derives utility from the amount of safe units consumed $Z_T+Z_T^*=\lambda_T(X_T+X_T^*)$ and incurs three types of costs: health costs $(1-\lambda_T)L(X_T+X_T^*)$; domestic production costs $C(X_T)$; and costs for imports $P^*X_T^*$. Hence, the free-trade welfare level is given by

$$W_T = u[\lambda_T(X_T + X_T^*)] + M-(1-\lambda_T)L(X_T + X_T^*)-C(X_T)-P^*X_T^*. \quad (10)$$

Consider now the special case where the level of import safety is the same as the level of domestic safety i.e., $\lambda_T=\lambda=\lambda^*$. In this special case, free-trade maximizes the level of national welfare. To see this result, differentiate Eq. (10) with respect to X_T and X_T^* to obtain

$$u'(Z_T + Z_T^*) = \frac{C'(X_T)}{\lambda_T} + \frac{(1-\lambda_T)}{\lambda_T}L, \quad (11)$$

$$u'(Z_T + Z_T^*) = \frac{P^*}{\lambda_T} + \frac{(1-\lambda_T)}{\lambda_T}L. \quad (12)$$

Under free trade, the domestic production of X_T is given by $P^*=C'(X_T)$, which means that Eqs. (11) and (12) become identical. Comparing then Eqs. (12) to (4) yields the desired result which is summarized by the following proposition:

Proposition 1. *If the proportion of safe imported units is the same as the proportion of domestic safe units ($\lambda=\lambda^*$) and markets are perfectly competitive, then a small open economy maximizes its national welfare by following a free-trade policy.*

The inability of consumers to differentiate between imported and domestically produced unsafe products does not play any role when the safety level of all products is the same and therefore free trade constitutes the first best policy for a small open economy. However, in the more realistic case where the safety level of imports differs from that of domestic goods, national welfare may not be maximized under free trade even if markets are perfectly competitive and the economy is small. The social planner has an incentive to alter the mix of imports and domestic products to choose the optimal level of λ_T. Thus unrestricted free trade opens the door for welfare enhancing trade restrictions and trade bans. These issues are addressed in the next section of the paper.

3. Welfare effects of trade restrictions

If the safety level of the imported good is less than that of the domestic good (i.e., $\lambda^*<\lambda<1$), there always exist trade restrictions that improve welfare. This section establishes the existence of welfare-improving import tariffs and import bans.

Consider now the imposition of a specific tariff t and assume that the tariff revenue is refunded to the consumer in a lump-sum fashion. The tariff-ridden welfare is given by

$$W_t \equiv u(Z_t + Z_t^*) + M-[(1-\lambda)X_t + (1-\lambda^*)X_t^*]L-C(X_t)-P^*X_t^*, \quad (13)$$

where subscript t denotes variables and functions associated with the tariff equilibrium. According to Eq. (13), the consumer receives utility from consumption of all domestic and imported safe units $Z_t+Z_t^*$, but incurs the costs of illness captured by the term in square brackets, the costs of producing the domestic good $C(X_t)$ and the costs of imports $P^*X_t^*$. Appendix B derives the following expression for the tariff–tariff ridden welfare function which corresponds to the indirect utility function associated with Eq. (13)

$$W_t = u(Z_t + Z_t^*)-\hat{P}_t[Z_t + Z_t^*] + M + P_tX_t-C(X_t) + tX_t^*, \quad (14)$$

where $P_t=P^*+t$ is the domestic market price and $\hat{P}_t=[P_t+(1-\lambda_t)L]/\lambda_t$ is the tariff-ridden RAP price. Variable $\lambda_t=(Z_t+Z_t^*)/(X_t+X_t^*)$ is the proportion of safe units consumed under a tariff regime and can be interpreted as the probability of remaining healthy for each unit of risky product consumed. Expression $u(Z_t+Z_t^*)-\hat{P}_t[Z_t+Z_t^*]$, is the expected consumer surplus, which depends on the RAP; and the last four terms capture consumer income measured by M, profits (producer surplus) $P_tX_t-C(X_t)$, and the tariff revenue tX_t^*.

Differentiating Eq. (14) with respect to the specific tariff, using the envelope theorem, and evaluating all derivatives at the free-trade equilibrium yields

$$\frac{\partial W_t}{\partial t}\Big|_{t=0} = -\frac{\partial \hat{P}_t}{\partial t}[Z_t + Z_t^*] + (X_t + X_t^*), \quad (15)$$

where $\partial\hat{P}_t/\partial t = [1/\lambda_t] - [(P_t + L)/\lambda_t^2][\partial\lambda_t/\partial t]$ is the ambiguous effect of a tariff change on RAP. The first term of Eq. (15) captures the tariff effect on consumer surplus which is in general ambiguous. The second term captures the tariff effect on producer surplus and tariff revenue which is positive because the imposition of a tariff raises the domestic market price and increases producer surplus and tariff revenue. One can obtain further insights on the source of welfare ambiguity by substituting the expression for $\partial\hat{P}_t/\partial t$ and the definition of λ_t in Eq. (15) to obtain

$$\frac{\partial W_t}{\partial t}\Big|_{t=0} = \frac{\partial\lambda_t}{\partial t}\left[\frac{(P_t + L)(Z_t + Z_t^*)}{\lambda_t^2}\right]. \tag{16}$$

The term in square brackets is positive and therefore the imposition of a tariff in the neighborhood of free trade affects the level of welfare via its impact on the average product safety captured by the term $\partial\lambda_t/\partial t$. In the case of less safe imports (i.e., $\lambda^* < \lambda$), the imposition of a tariff raises the probability of not becoming ill by shifting the composition of consumption towards safer domestic units and results in $\partial\lambda_t/\partial t > 0$.[17] In the case of equally safe imports (i.e., $\lambda^* = \lambda$), Eq. (8) implies that $\partial\lambda_t/\partial t = 0$ and therefore a tariff cannot affect the composition of consumption and welfare: free-trade is the best policy for a small open economy in accordance to Proposition 1.[18]

The following proposition states this novel result:

Proposition 2. *If the imported good is less safe than the domestically produced good, then at any unrestricted free-trade equilibrium, there always exists a welfare-enhancing tariff.*

The next step is to analyze the welfare effects of an import ban (i.e., a prohibitive tariff or import quota) which takes the economy to its autarkic equilibrium. Under an import ban, the consumer's problem can be stated as

$$\underset{X_A}{Max}[u(\lambda X_A) + M - P_A X_A - (1-\lambda)LX_A], \tag{17}$$

where subscript A is used to denote variables and functions associated with autarky. The consumer maximization problem under autarky is a special case of Eq. (3), where $\lambda_T = \lambda$ and $X_T^* = 0$, and yields the following first-order condition:

$$u'(Z_A) = \hat{P}_A = \frac{P_A}{\lambda} + \frac{(1-\lambda)}{\lambda}L. \tag{18}$$

Eq. (18) and the inverse supply function $P_A = C'(X_A) = C'(\lambda Z_A)$ determine the equilibrium quantity of safe units Z_A and the market price P_A. As in the free-trade equilibrium, the presence of an insurable risk creates a wedge between the producer and the consumer prices that depends positively on the per-unit costs of becoming ill and the fixed proportion of unsafe units embodied in the risky product.

The welfare level under an import ban is obtained by setting $\lambda_T = \lambda$ and $X_T^* = 0$ in Eq. (10)

$$W_A = u(\lambda X_A) + M - (1-\lambda)LX_A - C(X_A). \tag{19}$$

Maximizing Eq. (19) with respect to the market quantity of unsafe product X_A yields the following first-order condition:

$$u'(Z_A) = \frac{C'(X_A)}{\lambda} + \frac{(1-\lambda)}{\lambda}L, \tag{20}$$

which is identical to Eq. (18) because $P_A = C'(X_A)$. In other words, the closed-economy competitive equilibrium maximizes social welfare.

The welfare ranking between free-trade and autarky is ambiguous: in the case of less safe imports ($\lambda_T < \lambda$) the welfare effect of a trade ban is unclear because it raises the market price but also reduces the risk of illness by eliminating less safe imports. Of course, in the special case when $\lambda_T = \lambda = \lambda^*$ free trade maximizes social welfare and dominates the autarky equilibrium. In this case, an import ban reduces welfare because it eliminates the traditional gains from trade without affecting the probability of becoming ill. The same is true for the case of a small open economy that imports a safer good ($\lambda < \lambda_T$) where an import ban is welfare reducing because it increases the probability of becoming ill by unambiguously raising the RAP and by reducing the consumer surplus. These results are summarized by the following proposition:

Proposition 3. *Starting at the free-trade equilibrium and assuming that the domestically produced good is safer than the imported product ($\lambda^* < \lambda$), the introduction of an import ban by a small country results in an ambiguous effect on national welfare. If the domestically produced good is as safe or less safe than the imported product ($\lambda \leq \lambda^*$), then the introduction of an import ban by a small country reduces national welfare.*

The welfare ranking between the first-best autarkic equilibrium and the second best free-trade equilibrium represents an exception to the insights of the theory of distortions and welfare, according to which a first-best equilibrium must be superior to a second-best

[17] One can readily establish this result by noting that Eqs. (7) and (8) evaluated at $P_t = P^* + t$ determine the tariff-ridden market equilibrium values of λ_t and Z_t^*. If $\lambda^* < \lambda$, then an increase in the tariff shifts both curves in Fig. 1 upward establishing that $\partial\lambda_t/\partial t > 0$.

[18] The case of safer imports generates multiple equilibria and the possibility of import subsidies which might improve welfare for a small open economy beyond the free trade level. Space considerations prevents us from analyzing formally this case.

one.[19] In the present set up, a trade ban eliminates the traditional gains from trade and the informational distortion and leads to an unambiguous decline in national welfare when the imported good is safer than the domestically produced good. In other words, in the presence of an informational distortion, a move from autarky to free trade could reduce the welfare of a small open economy!

Proposition 3 is consistent with the evidence of import bans following outbreaks of food-borne disease abroad. These bans can be modeled as a move from free trade (with safe domestic and risky imported goods, $\lambda=1, \lambda^*<1$) to the autarky equilibrium. The welfare consequences of this move are in general ambiguous, and depend on the magnitudes of demand and supply elasticities, the severity in the reduction of food safety captured by the risk parameter λ^* and the damage costs L. For example, the larger the differential of safety risk between domestic and imported goods measured by $\lambda-\lambda^*$, the more likely it is that a trade ban will be welfare improving.

4. COOL trade

We are now in a position to analyze the economic effects of introducing country-of-origin labeling (COOL). In order to keep the analysis as simple as possible, we will not formally analyze the effects of costs associated with implementation of a COOL program. If the costs of instituting and maintaining a national COOL system are fixed or sunk costs, they constitute an additional welfare cost that can readily be incorporated in the cost–benefit calculations without altering the qualitative conclusions of the analysis. We will also treat COOL as a government policy introduced after the country has engaged in free trade and will maintain the small-country assumption for comparison purposes. In the presence of a COOL policy, the consumer can distinguish whether a good is imported or domestic, allowing the two types of X to have different prices. Denoting COOL values by subscript C, maximizing the consumer's utility function $u(Z_C+Z_C^*)+Y$ subject to a deterministic budget constraint $M=\hat{P}_C Z_C+\hat{P}^* Z_C^*+Y$ yields the following first-order conditions for an interior solution:

$$u'(Z_C+Z_C^*)=\hat{P}_C=\frac{P_C}{\lambda}+\frac{(1-\lambda)}{\lambda}L, \tag{21}$$

$$u'(Z_C+Z_C^*)=\hat{P}^*=\frac{P^*}{\lambda^*}+\frac{(1-\lambda^*)}{\lambda^*}L, \tag{22}$$

where P_C denotes the producer price of domestically produced good X_C, and P^* the market price of imports. Under COOL trade, the consumer buys the product with the lower risk-adjusted price, since a safe unit gives the consumer the same utility, whether it is produced domestically or imported. The different country-specific health risks generate perceived quality differences that are reflected in different market prices. Coexistence of both goods in the market requires that consumers derive the same marginal utility from the two risky products (that is, at the margin the consumer must be indifferent between consuming a safe unit of the domestic good and a safe unit of the imported good). This implies that the introduction of COOL results in equalization of RAP between the domestic and imported product. Formally, Eqs. (21) and (22) imply that

$$\hat{P}_C=[P_C+(1-\lambda)L]/\lambda=[P^*+(1-\lambda^*)L]/\lambda^*, \tag{23}$$

which determines P_C and equilibrium RAPs, $\hat{P}_C=\hat{P}^*$.

Unlike the equilibrium analyzed in the previous section, COOL trade introduces a market price differential in favor of the safer product. Solving Eq. (23) for the producer price of the domestically produced good yields

$$P_C=\lambda\left[\frac{P^*}{\lambda^*}+\left(\frac{\lambda-\lambda^*}{\lambda^*\lambda}\right)L\right]. \tag{24}$$

According to Eq. (24), the good with the lower safety risk (in this case the domestic product since $\lambda>\lambda^*$ by assumption) commands a higher market price at equilibrium because the consumer perceives it as a higher quality (healthier) good. Substituting Eq. (24) into the domestic supply of the risky good yields the equilibrium safe domestic quantity produced

$$Z_C=Z^S(\lambda,P_C)=\lambda X^S(P_C). \tag{25}$$

Since the introduction of COOL raises the market price of the domestic product relative to the domestic price of imports ($P_C>P^*$), the introduction of COOL generates a higher producer surplus compared to the free-trade equilibrium without COOL. Therefore, abstracting from implementation costs, the introduction of COOL will be supported by producers of domestic goods that are safer than imported ones.

[19] Bhagwati (1971) analyzed the second-best implications of price distortions, Krishna and Panagariya (2000) focused on the difference between quantity and price restrictions, and Krishna and Thursby (1991) analyzed the optimal targeting of policies in the presence of strategic (i.e., market power) distortions.

COOL effects on expected consumer surplus depend on COOL effects on the RAP. From Eq. (2) it is obvious that $\lambda_T = (1-s^*)\lambda + s^*\lambda^* > \lambda^*$, where $s^* = X_T^*/(X_T + X_T^*)$ is the consumption share of imports. It follows from Eqs. (12) and (22) that

$$\begin{aligned} u'(Z_C + Z_C^*) &= \hat{P}_C \\ &= \left(\frac{P^*}{\lambda^*} + \frac{(1-\lambda^*)}{\lambda^*}L\right) > \left(\frac{P^*}{\lambda_T} + \frac{(1-\lambda_T)}{\lambda_T}L\right) \\ &= \hat{P}_T = u'(Z_T + Z_T^*). \end{aligned} \tag{26}$$

The total amount of safe quantity consumed under COOL is strictly less than the corresponding quantity under free trade, i.e. $Z_C + Z_C^* < Z_T + Z_T^*$. This inequality follows from the concavity of the consumer's utility function. The result implies that, starting at the free-trade equilibrium, the introduction of COOL reduces the expected consumer surplus, which is an increasing function of the aggregate safe quantity consumed. Since the production of the safer domestic good increases with the introduction of COOL, (i.e., $Z_C > Z_T$), the safe (and market) quantity of imports declines (i.e., $Z_C^* < Z_T^*$). Thus, the introduction of COOL increases the domestic market price of the safer (domestic) product, reduces the quantity of the less safe (imported) product by more than the increase in domestic production, and results in a reduction of expected consumer surplus. These results lead to the following proposition that summarizes the economic effects of introducing a COOL program.

Proposition 4. Starting at the free-trade equilibrium and assuming that the domestically produced good is safer than the imported product ($\lambda > \lambda^*$), the introduction of COOL by a small country results in:

(a) An increase in the market price and market quantity of the safer domestic product.
(b) A decline in the market quantity and safe quantity of the less safe imported product.
(c) A decline in the total safe quantity consumed and a decline in the expected consumer surplus.
(d) An increase in the safe quantity of the domestic good and an increase in the producer surplus.

We are now in a position to establish the welfare effects of COOL. Denote with P^* the price for imports, with X_C^*, the quantity of imports under COOL, with P_C the price for domestically produced X_C, and with $C(X_C)$ the costs of producing X_C. Following the same reasoning as in the case of a tariff, the level of national welfare is given by

$$W_C = u(\lambda X_C + \lambda^* X_C^*) + M - [(1-\lambda)LX_C + (1-\lambda^*)LX_C^*] - C(X_C) - P^* X_C^*. \tag{27}$$

Differentiating Eq. (27) with respect to X_C and X_C^* yields the first-order conditions for an interior maximum for W_C ($X_C > 0$, $X_C^* > 0$)

$$\lambda u'(\lambda X_C + \lambda^* X_C^*) - (1-\lambda)L - C'(X_C) = 0 \tag{28}$$

and

$$\lambda^* u'(\lambda X_C + \lambda^* X_C^*) - (1-\lambda^*)L - P^* = 0. \tag{29}$$

The concavity of u and $C'' > 0$ assure second order conditions are satisfied. Given that both C' and u' are monotonic, if an interior maximum exists, it is unique. Since $C'(X_C) = P_C$, Eqs. (21) and (22) imply an interior COOL equilibrium is this unique maximum. Note that free trade can never maximize welfare since joint satisfaction of Eqs. (28) and (29) at ($X_C > 0, X_C^* > 0$) requires $C'(X_C) > P^*$ (assuming $\lambda \neq \lambda^*$) and in the free-trade equilibrium $C'(X_T) = P^*$. Appendix C establishes that if an interior maximum exists, it dominates corner solutions of $X_C = 0$ and $X_C^* = 0$. Hence, if an interior COOL equilibrium exists, it welfare dominates both autarky and the free-trade equilibrium.

A corner COOL equilibrium at all imports is precluded by Eq. (9).[20] A corner COOL equilibrium at the autarky solution can be consistent with Eq. (9). In that case,

$$\frac{P_A + (1-\lambda)L}{\lambda} = u'(\lambda X_A) < \frac{P^* + (1-\lambda^*)L}{\lambda^*}$$

i.e., at the autarky solution, the marginal utility of an additional unit of Z is less than the RAP of buying it as an import and hence, there is no market for imports. In this situation, clearly the equivalent autarky and corner COOL equilibria dominate the un-COOL trade equilibrium because no interior maximum exists. Hence, welfare under a COOL regime always exceeds that of un-COOL trade and it exceeds that of autarky except in cases the two are equivalent.

Furthermore, it is straightforward to establish that under COOL, any trade restriction reduces welfare.[21] If a non-prohibitive specific tariff, t, is imposed on imports, the COOL equilibrium can be determined as above by replacing P^* by $P^* + t$. Eqs. (22), (24),

[20] A corner COOL equilibrium at all imports can exist only if $(P^* + (1-\lambda^*)L)/\lambda^* < (C'(0) + (1-\lambda)L)/\lambda$ which is precluded by Eq. (15) and $C''(.) > 0$ which imply $C'(0) < P^*$, and $\lambda > \lambda^*$.

[21] For this derivation we assume an interior COOL solution since imposing tariffs in the corner COOL solution of autarky is uninteresting.

and (25) then determine the market-equilibrium values of P_C, Z_C, and Z_C^*. Substituting $Z_C = \lambda X_C$ and $Z_C^* = \lambda^* X_C^*$ in Eq. (22) and differentiating totally the system of these equations yields

$$\left.\frac{dX_C}{dt}\right|_{t\geq 0} = \frac{\lambda}{\lambda^*}\frac{\partial X_C}{\partial P_C} > 0, \tag{30}$$

$$\left.\frac{dX_C^*}{dt}\right|_{t\geq 0} = \frac{1}{(\lambda^*)^2}\left[\frac{1}{u''(.)} - \lambda^2\frac{\partial X_C}{\partial P_C}\right] < 0. \tag{31}$$

Because the safe quantities of domestic and imported products are proportional to X_C and X_C^*, an increase in protection increases Z_C and reduces Z_C^*. As a result, protection has the standard effects of increasing the domestic production and reducing the level of imports.

For any given budget M, the social planner derives utility from the safe units consumed $u(\lambda X_C + \lambda^* X_C^*)$ and faces insurance costs $(1-\lambda)LX_C + (1-\lambda^*)LX_C^*$ to cover the costs of illness from domestic and imported risky products. In addition, the social planner faces domestic production costs $C(X_C)$ and import costs $(P^* + t)X_C^*$. Since the government collects the tariff revenue $t \cdot X_C^*$, which is distributed back to consumers, under the standard assumption, the net social costs of imports are simply $P^* X_C^*$. Consequently, the level of national welfare as a function of the tariff is

$$\begin{aligned} W_C(t) = {} & u(\lambda X_C(t) + \lambda^* X_C^*(t)) + M - [(1-\lambda)LX_C(t) + (1-\lambda^*)LX_C^*(t)] \\ & - C(X_C(t)) - P^* X_C^*(t). \end{aligned}$$

Differentiating the above expression with respect to the specific tariff yields

$$\frac{\partial W_C}{\partial t} = \{\lambda u' - (1-\lambda)L - C'(.)\}\frac{\partial X_C}{\partial t} + [\lambda^* u' - (1-\lambda^*)L - P^*]\frac{\partial X_C^*}{\partial t}. \tag{32}$$

Eq. (21) and the property $P_C = C'(X_C)$ imply that, under COOL, the term in the curly bracket of Eq. (32) is zero. From Eq. (22), the expression in the square bracket is equal to the value of the specific tariff. Therefore, taking into account the above analysis and using Eq. (31) one can derive two standard expressions for the effects of a specific tariff on national welfare in the presence of COOL[22]

$$\left.\frac{\partial W_C}{\partial t}\right|_{t>0} = t\frac{\partial X_C^*}{\partial t} < 0, \tag{33}$$

$$\left.\frac{\partial W_C}{\partial t}\right|_{t=0} = t\frac{\partial X_C^*}{\partial t} = 0. \tag{34}$$

Inequality Eq. (33) states that national welfare is a decreasing function of the specific tariff for strictly positive values of t and Eq. (34) implies that welfare is maximized under COOL trade. In other words, there is no need for COOL trade import bans! We have established formally two key welfare results which are summarized in the following proposition.[23]

Proposition 5. *In the presence of country-of-origin labeling (COOL) and perfectly competitive markets, when the domestically produced good is safer than the imported product ($\lambda^* < \lambda$), if an interior COOL equilibrium exists, it welfare dominates both autarky and the free-trade un-COOL equilibrium. In addition, a reduction in protection increases a small country's level of national welfare: more COOL trade is better than less COOL trade, and COOL (free) trade is the best policy for a small country.*

The introduction of a COOL policy (as opposed to traditional policy instruments such as tariffs or quotas) reestablishes the traditional optimality of trade which asserts that more trade is better than less trade for a country that cannot change the terms-of-trade. This proposition also implies that if the costs of maintaining a COOL policy are unaffected by changes in the level of protection, more COOL trade is better even if a small country imports riskier goods. In the absence of market power, COOL seems to be the best policy instrument to offer protection from unsafe imports, assuming of course that the consumer is as informed as the policy makers about the potential risk of imports.

[22] See Feenstra (2004, Chapter 7) for a derivation of an identical expression in the case of a small country imposing a specific tariff in the absence of unsafe food trade.

[23] If the COOL equilibrium with no tariff is a corner solution, the argument doesn't technically hold. However, if it is a corner at the autarky solution, the issue of tariffs is superfluous. If it is a corner with imports only, then a tariff which does not change the nature of that equilibrium leaves welfare unchanged—the consumer pays more for imports, but is returned the tariff revenues.

5. Domestic market power

In this section, we analyze the welfare effects of trade restrictions in the presence of domestic market power and a COOL policy. For comparison purposes, we maintain the small-country assumption, and based on space limitations we abstract from strategic market interactions.[24] Instead, we introduce imperfect competition by assuming that there is a single firm producing the domestic safer good.

When the trade restriction takes the form of a tariff, the results of the previous section hold even in the presence of domestic market power: more COOL trade is better than less COOL trade, and COOL (free) trade is the best policy for a small country. The reason is that, under a tariff, the domestic monopolist faces a horizontal demand curve and maximizes profits by setting the tariff inclusive price equal to marginal costs of production. Formally, the first-order conditions of the consumer-maximization problem Eqs. (21) and (22), which hold in this case, imply that the inverse demand for the domestic monopolist is horizontal and given by evaluating Eq. (24) at P^*+t to obtain $P_C=\frac{\lambda}{\lambda^*}\left(P^*+t+\frac{(\lambda-\lambda^*)}{\lambda}L\right)$. The domestic monopolist maximizes profits $\pi_C=P_CX_C-C(X_C)$ by setting $P_C=C'(X_C)$, and acts as a perfectly competitive firm. This means that Eqs. (32)−(34) apply even in the presence of domestic market power.

When the trade restriction takes the form of a binding import quota, the domestic monopoly power is preserved, and more COOL trade is not necessarily better than less COOL trade. Consider now an import quota Q that restricts the imported quantity of X_C^* below its free-trade COOL level. Denote with subscript Q functions and variables associated with the quota equilibrium. It is assumed that the quota amount of Q is purchased at the fixed world price P^* and sold to domestic consumers at price $P_Q^*>P^*$ since the quota is binding by assumption. Then, the representative consumer maximizes her utility $u(Z_Q+Z_Q^*)+Y$, where $Z_Q^*=\lambda^*Q<Z_C^*$ is the quota-ridden amount of safe imported units, subject to the deterministic budget constraint $M=\hat{P}_QZ_Q+\hat{P}_Q^*Z_Q^*+Y$. The first-order conditions can be expressed as

$$u'(Z_Q+Z_Q^*)=\hat{P}_Q=\frac{P_Q}{\lambda}+\frac{(1-\lambda)}{\lambda}L \tag{35}$$

$$u'(Z_Q+Z_Q^*)=\hat{P}_Q^*=\frac{P_Q^*}{\lambda^*}+\frac{(1-\lambda^*)}{\lambda^*}L, \tag{36}$$

and imply that the introduction of COOL results in equalization of RAP between the domestic and imported goods (i.e., $\hat{P}_Q=\hat{P}_Q^*$). This in turn means that the safer domestic good is sold at a higher price than the imported quota-constrained good (i.e., $P_Q>P_Q^*$).

Substituting $Z_Q=\lambda X_Q$ and $Z_Q^*=\lambda^*Q$ into Eq. (35) yields the downward-sloped inverse demand function for the domestic monopolist

$$P_Q=\lambda u'(\lambda X_Q+\lambda^*Q)-(1-\lambda)L, \tag{37}$$

which is well defined for sufficiently large values of λ. In addition, the inverse demand function declines in X_Q and Q, and generates the following marginal revenue (MR) function

$$MR=\lambda u'(\cdot)+\lambda^2X_Qu''(\cdot)-(1-\lambda)L. \tag{38}$$

Following the industrial-organization literature, we assume that the MR function is well behaved: the right-hand-side of Eq. (38) is strictly positive and decreases in the domestic quantity produced X_Q; the imported and domestic goods are strategic substitutes, that is an increase in the import quota shifts the MR curve to the left and reduces the equilibrium quantity produced (i.e., $\partial X_Q/\partial Q<0$).[25] In addition, we assume that the domestic monopolist faces positive and increasing marginal costs (i.e., $C'(\cdot)>0, C'(\cdot)>0$). Consequently the domestic monopolist maximizes profits $\pi_Q=P_QX_Q-C(X_Q)$ by choosing the quantity where marginal revenue equals marginal cost

$$MR=C'(X_Q), \tag{39}$$

where MR is given by Eq. (38). Because the left-hand-side of Eq. (39) is less than P_Q, the domestic monopolist exercises its market power by restricting the quantity sold and charging a higher price, thanks to the binding import quota. In addition, differentiating totally Eq. (39) yields the standard result that an increase in imports caused by a less restrictive quota reduces the domestic quantity produced (i.e., $dX_Q/dQ=[C''(\cdot)-(\partial MR/\partial X_Q)]/(\partial MR/\partial Q)<0$).

We are now in a position to analyze the welfare effects of an import quota in the presence of a COOL program and domestic monopoly power. Assume that the quota rents $(P_Q^*-P^*)Q$ are distributed back to consumers in a lump-sum fashion. Following the same reasoning as in the case of a specific tariff, one can express the quota-ridden welfare for the small open economy as $W_Q(t)=u(\lambda X_Q(Q)+\lambda^*Q)+M-[(1-\lambda)LX_Q(Q)+(1-\lambda^*)LQ]-C(X_Q(Q))-P^*Q$.

[24] See for instance, Beard and Thompson (2003) who analyze a strategic market interaction model with linear demand and cost functions and Choi (2010) who considers genetically modified products.

[25] A sufficient but hardly necessary condition for the domestic and imported goods to be strategic substitutes is that the slope of the inverse demand curve does not increase in its argument, that is, $u''(\cdot)\leq 0$.

Differentiating this expression with respect to the import quota yields the change in welfare caused by a marginal increase in the import quota.

$$\frac{\partial W_Q}{\partial Q} = \{\lambda u' - (1-\lambda)L - C'(.)\}\frac{\partial X_Q}{\partial Q} + [\lambda^* u' - (1-\lambda^*)L - P^*].$$

Substituting Eqs. (35) and (36) in the above expression yields

$$\frac{\partial W_Q}{\partial Q} = [P_Q - C'(\cdot)]\frac{\partial X_Q}{\partial Q} + (P_Q^* - P^*). \tag{40}$$

The first term of the right-hand-side of Eq. (40) is negative: an increase in the import quota restricts further the quantity of the domestic good which is sold in a price that exceeds its social marginal costs due to the monopoly distortion.[26] In other words, an increase in the import quota moves the domestic quantity produced away from its socially optimum value X_Q^S which satisfies $P_Q = C'(X_Q^S)$. The second term is positive and corresponds to the quota-rent rate: in the presence of a binding quota, the RAP of imports is higher compared to the free COOL trade equilibrium (see Eq. (36)), and therefore more imports increase welfare. Therefore, a marginal change in a binding import quota has an ambiguous effect on national welfare of a small open economy under a COOL program. In the case of a non-binding import quota, the right-hand-side of Eq. (40) becomes zero and implies that free trade coupled with a COOL program maximizes national welfare of a small open economy even in the presence of domestic market power. The following proposition summarizes the results of our analysis.

Proposition 6. *In the presence of country-of-origin labeling (COOL) and domestic monopoly power, when the domestically produced good is safer than the imported product ($\lambda^* < \lambda$), a free-trade policy maximizes national welfare. If trade is restricted by a non-prohibitive specific tariff, then a reduction in protection increases a small country's level of national welfare. However, if trade is restricted by a binding import quota a reduction in protection has an ambiguous effect on a small country's level of national welfare.*

6. Concluding remarks

The present study developed an open-economy model in which the small country produces an unsafe product and imports another riskier product under conditions of perfect competition or domestic monopoly power. Product risk was modeled as the exogenous proportion of units of the parent good that lead to adverse health outcomes. Consumers were assumed to know this proportion, but they could not distinguish whether a particular unit of the good was safe or unsafe. The model was used to analyze two cases. The first was a free-trade regime without country-of-origin labeling (COOL), and the second was a free-trade regime coupled with a COOL program.

We established that, in the absence of a COOL program, free trade is suboptimal and leaves open the possibility of welfare-improving tariffs and trade bans. Even if free un-COOL trade dominates an import ban, welfare can always be increased by some restriction of un-COOL trade: un-COOL trade introduces an informational distortion to the open economy which generates a suboptimal mix between more safe domestically produced and less safe imported goods.

The introduction of COOL allows each consumer to distinguish and incorporate into his/her behavior the differential health risk between imports and domestic goods and reestablishes the traditional insight that more (COOL) trade is better than less (COOL) trade for a small country even if imports are riskier. As a policy, COOL free trade maximizes the welfare level of a small open economy and therefore dominates trade bans and un-COOL trade. COOL free trade is the best policy for a small open economy in the presence or absence of domestic market power. However, under a binding tariff more COOL trade is better than less COOL trade independently of domestic market power; whereas under a binding import quota more COOL trade is not necessarily better than less COOL trade in the presence of domestic monopoly power.

We suspect that these properties would hold in a general equilibrium framework and in the case of two large countries. The present paper focused on the case where imports carry a higher safety risk that domestically produced goods to highlight the finding that even in this case, implementation of a COOL program reestablishes the desirability and optimality of free trade. More generally, the analysis can be readily applied to the case of safer imports: the introduction of a COOL program reduces the market price of the domestically produced good below that of the imported one and the COOL trade equilibrium results in higher consumption of safe units.

Of course the model's properties and results depend on numerous assumptions. We have assumed that consumers are fully informed about the safety risks of the two products and that risks are exogenously given at the same values for all consumers. However, consumers could form a subjective estimate of the risk of the product, which may be higher or lower than the objective risk assumed in this paper, or consumer-specific self-protection actions could modify λ. Simultaneously, we have assumed λ is exogenously given to producers and does not impact their supply decisions. Relaxing that assumption would allow analysis of policies that provide direct incentives to producers to increase the safety of their products.

A more general model would also specify multiple import suppliers and multiple levels of country-specific risky products. This framework could allow the analysis of COOL applied to a subset of (as opposed to all) suppliers. We conjecture that even in this

[26] Eqs. (39) and (35) imply that $P_Q - C'(\cdot) = -\lambda^2 X_Q u''(\cdot) > 0$.

case the basic conclusions of our analysis regarding the welfare effects of COOL would remain valid. We have also avoided incorporating the effects of costs associated with implementation and maintenance of national COOL programs and the introduction of costly testing and disposal of unsafe units. Further, we have assumed that a competitive insurance market exists that offers an actuarially fair insurance premium to the consumers in order to cover the damages from consumption of unsafe goods. Finally we have analyzed the case of full consumer liability and abstracted from principal-agent and moral hazard issues associated with producer incentives and imperfectly-competitive markets. Space limitations conditioned our decision to focus on the analysis of domestic monopoly power and to abstract from oligopolistic interactions. Introducing alternative market-structure considerations would allow one to analyze the interaction between strategic and informational distortions building on Krishna and Thursby's (1991) seminal work. All these topics represent very fruitful avenues for future research some of which constitute work in progress by the authors. We complete the paper by addressing the title question for the demanding reader:

How cool is COOL trade? We believe that the informational properties of COOL are pretty cool indeed!

Appendix A. An alternative insurable risk representation of market demand and consumer utility

Assume that for any amount of good X, the realized proportion of safe units is a random variable k $(0\leq k\leq 1)$ with probability density function $f(k)$ where $\int_0^1 f(k)\mathrm{d}k=1$ and $\int_0^1 kf(k)\mathrm{d}k=\lambda$. An insurance market exists that insures a purchase X in the following way: the consumer pays a premium b per unit of X simultaneously with the purchase of X. If a proportion $(1-k_0)$, $(0\leq k_0<1)$ turns out to be unsafe, the insurance company replaces the proportion $(1-k_0)X$ (purchased at market price P per unit of X) and also pays the costs associated with consuming the defective units, $(1-k_0)XL$. Of the replaced units, if a proportion $(1-k_1)$ $(0\leq k_1<1)$ turns out to be unsafe, the insurance company replaces the $(1-k_0)(1-k_1)X$ units and reimburses the consumer for the costs associated with consuming the defective units, $(1-k_0)(1-k_1)XL$. This process continues indefinitely unless terminated by a totally safe set of replacement units. The expected number of replacement units the insurance company must purchase is

$$X\cdot E[(1-k_0)+(1-k_0)(1-k_1)+(1-k_0)(1-k_1)(1-k_2)+\ldots],$$

which assuming independence of realized k in sequential rounds of replacement is $((1-\lambda)X)/\lambda$. For each replacement unit, the insurance company pays P to purchase the replacement and pays L to reimburse the consumer for the loss associated with the unsafe unit that generated the replacement. Hence, an actuarially fair premium to insure X units is

$$bX=\frac{(1-\lambda)(P+L)X}{\lambda}\ \text{ or }\ b=\frac{(1-\lambda)(P+L)}{\lambda}. \tag{A1}$$

The existence of insurance allows the consumer to effectively purchase safe units of X, i.e., Z, at a price of $P+b=(P/\lambda)+((1-\lambda)L/\lambda)$ and the fully insured consumer maximizes $u(Z)+M-[(P/\lambda)+((1-\lambda)L/\lambda)]Z$ which yields the same first-order condition as Eq. (4) in the text. The total amount of X demanded at a given price P^* is $Z^*=Z_T+Z_T^*$ by the consumer where (P^*,Z^*) satisfy text Eq. (4). In addition, the expected demand of the insurance company to fulfill its replacement obligations is $(1-\lambda)Z^*/\lambda$. Combining the demand of the consumer and the insurance company, total quantity of X demanded at price P^* is $Z^*+[(1-\lambda)Z^*/\lambda]=Z^*/\lambda$, exactly the same amount of X the consumer purchases given the maximization problem as developed in the text—no insurance market, but certain realization of a safe proportion λ in any amount of X purchased.

It is straightforward to establish the consumer would always fully insure purchases given premium b in Eq. (A1). Suppose the consumer was at a partial insurance point, Z^* units of X purchased insured and X^* units of X uninsured. His expected utility is

$$\begin{aligned}&\int_0^1 u(Z^*+kX^*)f(k)dk+M-PX^*-(1-\lambda)LX^*-(b+P)Z^*\\&\quad<u(Z^*+\lambda X^*)+M-PX^*-(1-\lambda)LX^*-(b+P)Z^*\\&\quad=u(Z^*+\lambda X^*)+M-(b+P)\lambda X^*-(b+P)Z^*,\end{aligned} \tag{A2}$$

where the strict inequality in Eq. (A2) follows from concavity of $u(.)$. Also, Eq. (A2) implies that the consumer is able to obtain higher utility by trading his X^* units of uninsured X for λX^* units of insured X. Hence, the consumer will always fully insure.

Appendix B. Derivation of Eq. (14)

Welfare as a function of the specific tariff t, W_t, is given for the free-trade case by

$$W_t\equiv u(Z_t+Z_t^*)+M-[(1-\lambda)X_t+(1-\lambda^*)X_t^*]L-C(X_t)-P^*X_t^*. \tag{B1}$$

The definition $\lambda_t=(Z_t+Z_t^*)/(X_t+X_t^*)$ implies that $[(1-\lambda)X_t+(1-\lambda^*)X_t^*]=(X_t+X_t^*)(1-\lambda_t)$. Substituting this expression into Eq. (B1) yields

$$W_t\equiv u(Z_t+Z_t^*)+M-(X_t+X_t^*)(1-\lambda_t)L-C(X_t)-P^*X_t^*. \tag{B2}$$

The definition of RAP $\hat{P}_t = [P^* + t + (1-\lambda_t)L]/\lambda_t$ implies that $(1-\lambda_t)L = \hat{P}_t\lambda_t - (P^* + t)$. Substitute this expression into Eq. (B2) to obtain

$$W_t \equiv u(Z_t + Z_t^*) + M - \hat{P}_t \frac{(X_t + X_t^*)}{\lambda_t} + (P^* + t)(X_t + X_t^*) - C(X_t) - P^* X_t^*. \tag{B3}$$

Substitute into Eq. (B3) $\lambda_t = (Z_t + Z_t^*)/(X_t + X_t^*)$ and perform the algebra to obtain Eq. (14)

$$W_t \equiv u(Z_t + Z_t^*) + M - \hat{P}_t(Z_t + Z_t^*) + P_t X_t - C(X_t) + t^* X_t^* \tag{B4}$$

where $P_t = P^* + t$.

Appendix C. If an interior maximum of W_C in Eq. (27) exists, then it is a global maximum

Since u' and C' are monotonic, Eqs. (21) and (22) imply that if an interior maximum exists, it is unique. Assuming the autarky equilibrium is not a corner, a corner solution to Eq. (27) defined by $X_C^* = 0$ cannot be a maximum if $(\partial W_C / \partial X_C^*)|_{X_C^*=0} > 0$. Similarly, assuming a market of only imports would yield a non-corner solution, a corner solution defined by $X_C = 0$ cannot be a maximum if $(\partial W / \partial X_C)|_{X_C=0} > 0$.

Suppose a critical point $(X_C > 0, X_C^* > 0)$ exists satisfying Eqs. (28) and (29). Then, from the autarky solution compared with Eq. (28)

$$\begin{aligned} &\lambda u'(\lambda X_A) - (1-\lambda)L - C'(X_A) = 0 \text{ and} \\ &\lambda u'(\lambda X_C + \lambda^* X_C^*) - (1-\lambda)L - C'(X_C) = 0. \end{aligned} \tag{C1}$$

Since $C'' > 0$ and $X^* > 0$ and $u' < 0$, $X_C < X_A$ and $u'(\lambda X_C + \lambda^* X_C^*) < u'(\lambda X_A)$. It then follows from Eq. (29)

$$\lambda^* u'(\lambda X_A) - (1-\lambda^*)L - P^* > 0 \Rightarrow \left.\frac{\partial W_C}{\partial X_C^*}\right|_{X_C^*=0} > 0.$$

Let $\overline{X}_C^*$ denote the level of imports that maximizes W_C given that $X_C = 0$. Again assume a critical point $(X_C > 0, X_C^* > 0)$ satisfying Eqs. (28) and (29). Then

$$\frac{C'(X_C) + (1-\lambda)L}{\lambda} = \frac{P^* + (1-\lambda^*)L}{\lambda^*} = u'(\lambda^* \, \overline{X}_C^*) \tag{C2}$$

or

$$\lambda u'(\lambda^* \, \overline{X}_C^*) - (1-\lambda)L - C'(X_C) = 0. \tag{C3}$$

Since $C'(X_C) > C'(0)$, Eq. (C3) implies $(\partial W / \partial X_C)|_{X_C=0} > 0$. Thus, if an interior maximum to W_C exists, it dominates corner solutions.

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