How Cool is C.O.O.L.?

Elias Dinopoulos Grigorios Livanis Carol West*
University of Florida

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Abstract: This paper develops a partial equilibrium model of a small open-economy producing and trading an unsafe product that is supplied by perfectly competitive producers. The presence of product safety considerations, in this case risks to health, introduces a wedge between the market prices producers receive and the higher risk-adjusted prices consumers respond to. The size of the wedge depends positively on the per-unit cost of illness and the proportion of unsafe units embodied in the parent risky product. The model is used to analyze the welfare effects of trade with and without a *country-of-origin labeling* (COOL) program. Assuming imports are less safe than domestic production, the welfare gains from trade in the absence of COOL are ambiguous and may justify the imposition of a trade ban. Even if a full ban does not improve welfare, some restriction of trade is always welfare-enhancing. These outcomes derive from an informational distortion that prevents consumers from distinguishing the different country-specific risks embodied in the foreign and domestic products resulting in a pooling equilibrium. The presence of a COOL program removes the informational distortion and generates a welfare maximizing separating equilibrium in which the safer (domestic) product commands a higher market price. In the presence of a COOL program, more trade– caused by a reduction in protection– is better than less trade.

Key Words: Country-of-origin labeling, protection, product safety, welfare.

JEL Classification:

Address for Correspondence: Elias Dinopoulos, Department of Economics, University of Florida, Gainesville, Fl 32611. *E-mail*: elias.dinopoulos@cba.ufl.edu. An electronic version of the paper is available at http://bear.cba.ufl.edu/dinopoulos/research.html.

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* Elias Dinopoulos and Carol West are Professors of Economics at the University of Florida. Grigorios Livanis is postdoctoral research associate at the International Agricultural Trade and Policy Center, Department of Food and Resource Economics, at the University of Florida.

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1. Introduction

The incidence of foodborne 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 2004), foodborne 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 potentially embody different health risks as a consequence of the uneven geographical origins of foodborne diseases. Japan has mandated a COOL for all meat imports since 1997. In the U.S., the 2002 Food Security and Rural Investment Act 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 2003). Recently, Congress approved a two-year delay for COOL implementation.

Juxtaposed against the emotional intensity that often surrounds health-related issues and the sometimes extreme measures that have been implemented to deal with foodborne diseases in particular, is a relatively scant literature analyzing the economics of trade policy in risky food-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)?

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.[1] 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).[2] 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.[3]

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.[4] 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

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[1] 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.

[2] See Grossman and Horn (1988), Bagwell and Staiger (1989), Falvey (1989), Bagwell (1991), Raff and Kim (1999), and Chisik (2003) among many others.

[3] 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 foodborne 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.

[4] Haener and Luckert (1998) and Blend and Ravensway (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.

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.[5] 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.

This paper develops a partial equilibrium model to analyze the welfare effects of a COOL program in the presence of risky foods supplied by domestic and/or foreign producers under perfect competition. The theoretical model uses building blocks from the seminal study by Oi (1973), who established that in the presence of insurance markets, the uncertainty associated with the risk of consuming an unsafe product is reflected in the risk-adjusted price (RAP)[6]. 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 that is measured by the proportion of its unsafe units supplied in the market. 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.

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[5] Krueger (1993, 1997), Lloyd (1993), Lopez-de-Silanes, Markusen and Rutherford (1996), Rodriguez (2001), Falvey and Reed (2002). For a recent literature review see Krishna (2005).

[6] 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.

We first analyze the effects of product risk and severity of the disease (as measured by the per-unit opportunity cost plus monetary cost of illness) on social welfare for the autarky (closed-economy) equilibrium. Because the presence of safety risk creates a difference between the consumer (RAP) and the producer (market) price, the market for a risky product might not exist (Proposition 1). As intuitively expected, an increase in the riskiness of the product, or in the cost of illness, leads to a decrease in social welfare (Proposition 2).

For a small country that imports a riskier product than it produces, movement from the autarky equilibrium to free-trade in the absence of a COOL program (i.e., un-COOL trade) leads to a decrease in the production of safer domestic units and to a decrease in producer surplus. The effect of un-COOL free trade on expected consumer surplus is ambiguous and the welfare ranking between un-COOL trade and autarky is also ambiguous (Proposition 3). This result is consistent with the theory of distortions (Bhagwati 1971): Un-COOL trade involves an informational distortion associated with the inability of consumers to assign the correct risk level to domestic and foreign goods that leads to a pooling equilibrium and ambiguous gains from trade. This result allows for the possibility of welfare-enhancing import bans. Even in the case where an import ban does not dominate un-COOL free trade, *some* restriction of un-COOL trade is always welfare-enhancing.

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 COOL, 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.

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 of the paper develops the model and studies the properties of the closed-economy equilibrium. Section 3 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 4 analyzes the economic effects of COOL trade. Conclusions are provided in the last section and some proofs are relegated to appendixes.

2. Closed-Economy 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 risk associated with a purchase X of the unsafe good is captured by the assumption that it embodies a certain proportion, λ, of safe units, $Z = \lambda X$, and a remaining unsafe portion, $(1-\lambda)$ with $0 \leq \lambda \leq 1$. 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. While the consumer knows the risk of becoming ill, captured by parameter λ [7], he/she cannot differentiate between a safe and an unsafe unit. For instance, according to the Food Safety and Inspection Service (FSIS 2004) of the USDA, a consumer faces a $(1-\lambda) = 3.5 \times 10^{-6}$ 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 .

An alternative interpretation of the risk embodied in X is as follows: Rather than an expected proportion, λ, of safe units in any purchase X and a resultant $(1-\lambda)$ expected

[7] In our formulation the probability of the adverse health outcome is treated as "objective" information. Thus, any consumer who faces the same problem will assign the same probability. One could introduce the case where λ depends on self-protection actions and on a set of information (i.e. past experience) that each consumer uses in forming risk perceptions. This is an interesting generalization that is left for future research. Notice, though that any valuation of a public policy change should be based on objective risks.

proportion of unsafe units, the consumer making a purchase of X faces an exogenous probability $(1-\lambda)$ the purchase will make him/her ill. Concomitantly, with probability λ, the purchase can be expected to be consumed without adverse health consequences. If a particular expenditure on X turns out to be a "bad lot," then the associated cost of illness is proportional to the volume of X purchased and consumed. Both interpretations yield the same key relationships that are used in the subsequent model analysis, but formal presentation is restricted to the first interpretation.

We postulate the existence of a competitive health (medical) insurance market that provides insurance to all consumers in the market against the loss L caused by the consumption of the unsafe product. 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. Following the insurance literature, we further assume that the insurance offered to the consumers is full and actuarially fair in the sense that the insurance premium equals the expected value of the insurance claims.[8] In the case 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 2004). The COI method includes both direct and indirect costs of an illness. In the case of Salmonella in eggs, the ERS website data imply that the average cost of illness is $2,126.

Assuming the representative consumer derives utility only from the safe units Z of product X 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

$$U(Z,Y) = u(Z) + Y \tag{1}$$

where $u(Z)$ is an increasing and concave function of the safe quantity of the risky good X and indicates that the consumer does not receive any utility from the unsafe units $X-Z$[9]. In this formulation, the price of product Y is equal to unity (numeraire), while the market price of

[8] The absence of an actuarially fair and full insurance complicates the analysis. See Oi (1973) and especially Epple and Raviv (1978) among others for more details on this issue. Oi (1973) adopts the assumption of full and actuarially fair insurance, while Epple and Raviv (1978) provide also results for the case of partial insurance.

[9] The analysis can be generalized to the case of severe risky products that result in a negative utility level if one risky unit is consumed. This novel extension is beyond the scope of the present paper.

product X is denoted by P. Since Y enters the consumer's utility linearly, equation (1) allows us to focus on partial-equilibrium analysis, while the assumption of a single unsafe product will be relaxed in section 4 that analyzes the economic effects of COOL.

The above notation and assumptions imply the following maximization problem for the representative consumer. For a given amount of X purchased, only λX will yield positive utility. Insuring against the expected cost of illness (or setting aside the funds to pay for it) requires expenditure of $(1-\lambda)LX$. Assuming a total budget M, and a price P of X, the consumer's maximization problem is as follows:

$$\underset{X}{Max}\left[u\left(\lambda X\right)+M-PX-(1-\lambda)LX\right] \tag{2}$$

The first-order condition for (2) can be written as

$$u'\left(Z\right)=\frac{P}{\lambda}+\frac{(1-\lambda)}{\lambda}L \tag{3}$$

where a prime superscript denotes a partial derivate and the argument in the left-hand side of (3) is equal to the amount of "safe" food consumed ($Z=\lambda X$). Concavity of $u\left(.\right)$ guarantees that the second-order condition for (2) is satisfied.

Recalling that the consumer derives utility only from good Y and the safe units Z of product X, it is obvious from (3) that the solution to the utility maximization problem (2) is identical to maximizing $U\left(Z,Y\right)=u\left(Z\right)+Y$ subject to the budget constraint $M=\hat{P}Z+Y$, where

$$\hat{P}=\frac{P}{\lambda}+\frac{(1-\lambda)}{\lambda}L \tag{4}$$

is the risk-adjusted price (RAP) of an unsafe good. In the presence of actuarially fair insurance, the economic interpretation of (4) is described elegantly by Oi (1973)[10]: $\hat{P}$ is the risk-adjusted price (expected cost) of obtaining a safe unit of a risky product, P/λ is the warranty price, and the term $(1-\lambda)L/\lambda$ is the actuarially fair insurance premium rate per "safe" unit.

We illustrate the relative magnitude of the RAP for the case of eggs embodying the risk of contracting Salmonella. Substituting the risk of becoming sick ($1-\lambda=3.5\times10^{-6}$), the cost of illness ($L=\$2{,}126$), the market price of one grade A shell egg ($P=\$0.081$), the RAP of eggs

[10] 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.

becomes $\hat{P} = \frac{0.081}{0.999997} + 2{,}126 * 3.5 \times 10^{-6} = \$0.088$. 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.

Equation (3) defines the demand function for the safe quantity of a risky product X as a function of its RAP $\hat{P}$, and is denoted by $Z^D\left(\hat{P}\right)$. This relationship will be used in calculating the expected consumer surplus in the welfare analysis. Recalling the relationship between the safe and unsafe quantities of a risky product, $Z = \lambda X$, the demand for the risky product X can be obtained then by $X^D\left(\hat{P}\right) = Z^D\left(\hat{P}\right)/\lambda$. Substituting $\lambda X = Z$ into the left-hand side of (3) yields the inverse market demand function of the risky good X, where the dependent variable is the market price (as opposed to the RAP):

$$P = \lambda u'\left(\lambda X\right) - (1-\lambda)L \tag{5}$$

Equation (5) yields the first result of our model which is stated in the following proposition:

Proposition 1: *A market for an unsafe product does not exist if the following condition holds:* $\overline{P} = \lambda u'\left(0\right) - (1-\lambda)L \le 0$*, i.e., the vertical intercept of its market demand curve is non-positive.*

The condition in proposition 1 defines a lower bound of product safety $\lambda_0 = L/(L + u'\left(0\right)) < 1$ which varies positively with L and negatively with the marginal utility of consuming the first safe unit of the good.

The supply side of the economy is modeled as follows: We assume that producers maximize profits with respect to a given market price P of the risky product X and that the output of good X supplied is given by

$$X^S\left(P\right) \tag{6}$$

where $\partial X^S\left(P\right)/\partial P > 0$, and $X^S\left(\underline{P}\right) = 0$ for a non-negative price $\underline{P} \ge 0$: The supply curve is upward sloping and has a non-negative vertical intercept. The assumption of a non-negative vertical intercept is not critical for the analysis. Implicit in (6) is the assumption that the supply of a risky good does not depend on the proportion of "safe" units, but simply on per unit market price of X.[11] For welfare analysis purposes, it is useful to invert (6) and define the inverse supply of a risky good X

$$P = P(X) = P(Z/\lambda) \tag{7}$$

where $\partial P(X)/\partial X > 0$ and $P(0) = \underline{P} > 0$. The supply of safe units $Z^S(\lambda, P)$ is straightforwardly obtained by multiplying (6) by the proportion of safe units λ, i.e., $Z^S(\lambda, P) = \lambda X^S(P)$.

The autarky (closed-economy) equilibrium condition requires equality between the quantity supplied and the quantity demanded for the tradeable good X:

$$X^S(P) = X^D(P, \lambda, L) \tag{8}$$

Condition (8) determines the market equilibrium price P_A (where subscript A denotes the autarky equilibrium) and the equilibrium quantity of X, X_A. In addition, multiplying both sides of equation (8) by λ, evaluated at P_A, yields

$$Z^S(\lambda, P_A) = \lambda X^D(P_A, \lambda, L) \equiv Z^D\left(\hat{P}(P_A, \lambda, L)\right) \quad . \tag{9}$$

which implies equality between the equilibrium level of safe units of good X produced and consumed. Having determined the producer price P_A, one can calculate the consumer RAP, $\hat{P}_A$, directly by setting $P = P_A$ in (4).

Figure 1 illustrates the closed-economy equilibrium. The horizontal axis measures the amount of safe and total units, Z and X respectively, and the vertical axis denotes prices (both market and risk adjusted). The upward-slopped curve $X^S(P)$ illustrates the supply (and inverse supply) curve of the risky good, and the downward-slopped curve $X^D(P, \lambda, L)$ is the market demand curve for the risky good X, which is implicitly defined by equation (5).[12] The intersection of these two curves illustrates geometrically the solution of (8), which yields the closed-economy market-equilibrium price P_A and quantity produced X_A. Having determined the equilibrium quantity of the risky good produced X_A, one can readily determine the equilibrium

[11] One could introduce the assumption that the supply of a risky good is a decreasing function of λ and analyze the effects of policies that provide direct incentives to producers to increase the safety of their products. This generalization is beyond the scope of the present paper and constitutes an interesting topic for further research.

[12] These curves are not straight lines in general, but the use of linear curves in all figures of the paper is based on expositional considerations.

amount of safe units $Z_A = \lambda X_A$ by subtracting horizontally the amount of unsafe units $(1-\lambda)X_A$ from X_A (i.e., the intersection of P_A and $Z^S(\lambda, P)$).

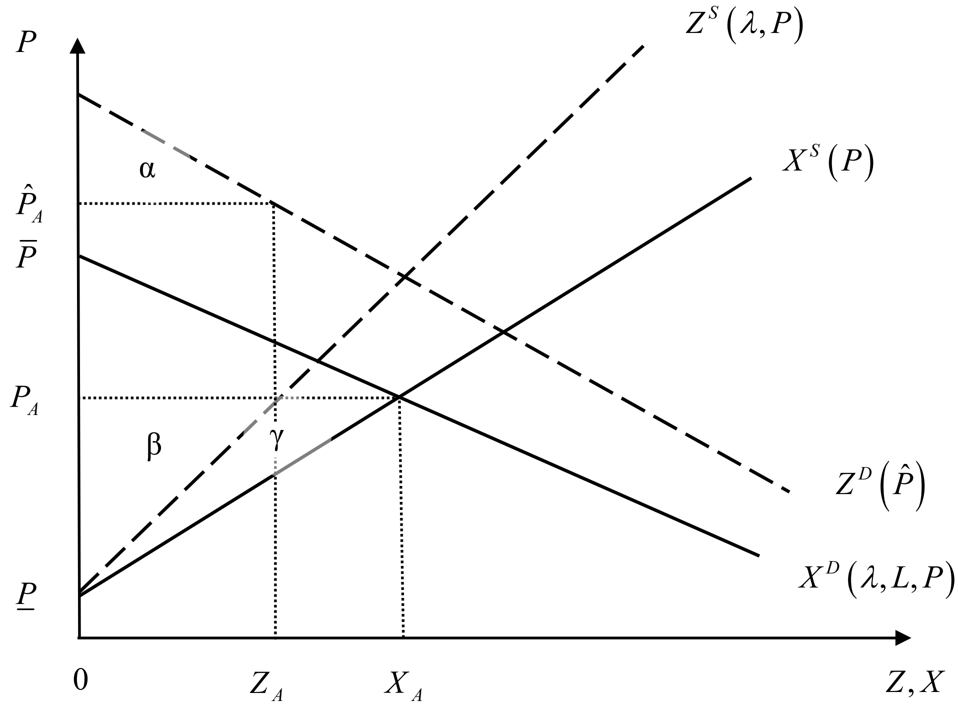

Figure 1: Closed-Economy Equilibrium

The downward-slopped curve $Z^D(\hat{P})$ illustrates the demand curve for safe units Z as a function of the risk-adjusted price $\hat{P}$ (defined in equation (3)). Evaluating this inverse demand curve at the equilibrium level of safe units Z_A yields the equilibrium RAP, $\hat{P}_A$, which exceeds the market price. Area (α) that is located below curve $Z^D(\hat{P})$ and above the equilibrium RAP, $\hat{P}_A$, is equal to the expected consumer surplus.

Area (β+γ), which is located below the market equilibrium price P_A and above the supply curve $X^S(P)$, measures producer surplus. In our analysis producer surplus captures the rents to specific factors (or industry profits) associated with the supply of X_A risky units, given our assumption that consumers bear all the risks and so producers are not concerned with the distinction between safe and unsafe units. Consequently, the closed-economy equilibrium level of social welfare is measured by area (α+β+γ). This geometric property will be utilized later in the welfare analysis of various public policies. We need to emphasize that the use of this standard measure of producer surplus implies that producers are not liable for the production of unsafe units and our analysis abstracts from moral hazard and principal-agent considerations associated with the production of unsafe products. These issues have been analyzed in closed economy models and constitute an important direction for future research.[13]

It is apparent from Fig. 1 that, in the presence of foodborne risk, the closed-economy equilibrium involves two distinct types of welfare distortions. First, consumer behavior depends on the RAP, which exceeds the market price. This discrepancy between the two prices is similar to the welfare effects of a specific tax incidence that reduces total welfare. Second, unlike a tax incidence, in the present model the "tax revenue" is proportional to the value of the unsafe units which does not yield any utility to the consumer. In other words, the corresponding "tax revenue" is not a transfer but a pure welfare loss associated with the production and consumption of unsafe units. This welfare loss is measured by the area $(\hat{P}_A - P_A)Z_A$ in Fig. 1 and depends on the market quantity of *Z*, the proportion of unsafe units, and the per-unit cost of illness.

In addition, for any given parameters of the model and in the presence of perfect competition, the market solution maximizes social welfare (defined as the sum of expected consumer plus producer surplus). In other words, unless the social planner can alter the risk parameter λ (perhaps though testing) or the per-unit cost of illness L (through health care reforms or development of better treatments), the market solution coincides with the maximization of social welfare. To establish this property, denote with $C(X)$ the aggregate social (and private) costs of producing X units of the risky good. Assuming a total budget of M, the social planner derives utility from the amount of safe units consumed $Z = \lambda X$ and incurs two types of costs, health insurance costs $(1-\lambda)LX$ and production costs $C(X)$. Hence, the social planner's problem is

$$\underset{X}{Max} \left[u(\lambda X) + M - (1-\lambda)LX - C(X) \right]$$

which yields the first-order condition

$$u'(Z) = \frac{C'(X)}{\lambda} + \frac{(1-\lambda)}{\lambda} L \qquad (10)$$

[13] Spence (1977), Epple and Raviv (1978), and Boom (1998) among others have developed closed-economy models that explicitly analyze producer liability issues.

In the competitive market equilibrium, $P = C'(X)$. Comparing (10) with (3) yields the desired result, namely that, under consumer liability and full insurance, the market equilibrium maximizes the level of national welfare.

Differentiating the equilibrium conditions (8) and/or (9) totally, one can derive the comparative statics properties of the closed-economy equilibrium.

Proposition 2: *The closed-economy equilibrium is characterized by the following properties:*

(a) An increase in per-unit damage cost $L\uparrow$ *shifts the market demand curve in Fig. 1,* $X^D(\lambda, L, P)$*, downward and generates: a decline in the market-equilibrium price* P_A*; a fall in the equilibrium quantities* X_A *and* Z_A*; an increase in the risk-adjusted price* $\hat{P}_A$*; and a reduction the social welfare, measured by expected consumer plus producer surplus.*

(b) A decline in product safety, measured by a reduction in parameter $\lambda\downarrow$*, reduces social welfare.*

(c) If the market price elasticity for product X *is not numerically small, i.e.,* $-\varepsilon_P = -(\partial X^D/\partial P)(P/X^D) > P/(P+L)$*, then a decline in product safety, measured by a reduction in parameter* $\lambda\downarrow$*, shifts the market demand curve in Fig. 1,* $X^D(\lambda, L, P)$*, downward generating declines in the market-equilibrium price* P_A*, the market-equilibrium quantity* X_A *and the amount of safe quantity* Z_A *and a rise in the equilibrium risk-adjusted price* $\hat{P}_A$*.*

Part (a) follows straightforwardly from (5) and Figure 1. For part (b), differentiate welfare ($W = u(\lambda X) + M - (1-\lambda)LX - C(X)$) with respect to λ and simplify using (10) to verify $dW/d\lambda > 0$. For (c), substitute λX for Z in (10) and then differentiate totally to determine $dX/d\lambda$ whose sign depends upon the sign of $u''(.)\lambda X + u'(.) + L$. Use (5) differentiated with respect to X (λ fixed) to establish (c). For the rest of the analysis we assume 2.c holds.

These results are consistent with the empirical evidence that consumer demand is susceptible to any new information concerning the way consumers perceive objective (or subjective) threats to food safety as measured by the parameters λ and L. For instance, according to Piggott and Marsh (2004) the public will generally respond to a foodborne outbreak by decreasing its consumption, at least in the short run. Moreover, if the food-safety problem is recurring, it can result in an inward shift of consumer demand for a specific good. In the case of the 1996 outbreak of BSE ("Mad Cow" disease) in the United Kingdom, both the product risk (1-λ) and loss L (equal to the statistical value of life) were large and caused a substantial decline in the demand for beef. However, if the product risk (1-λ) is very small then even for large L the difference between the RAP and the market price will be small and the demand for a risky product will be determined by its market price. This is consistent with the findings of a report by the Foreign Agricultural Service of the USDA (FAS 1998), which indicated that while E.U. consumers are concerned with food safety, price of beef is also important in deciding whether or not to purchase beef. That is, if the price of beef is low enough, consumers may buy it despite any remaining concerns over BSE.

3. Un-COOL Free Trade

Having established the welfare properties and comparative statics of the closed economy equilibrium, we now analyze the benchmark free-trade equilibrium in the absence of country-of-origin labeling (COOL). We assume that the consumer cannot distinguish imports and domestic goods in the marketplace although he/she knows all the parameters of the model and the market equilibrium values of the relevant endogenous variables. Consequently, this section analyzes the pooling equilibrium associated with an informational distortion: The inability of the domestic consumer to differentiate between imports and domestic products. To facilitate the economic intuition and the clarity of the geometric analysis, we will illustrate the free-trade equilibrium for the case of a country that imports an unsafe good at a fixed international market price P^* (the small-country case). This implies that the home country faces a horizontal supply curve of imports at the international market price P^* and each unit of imports carries a risk of becoming ill equal to $1-\lambda^*$.[14]

Denote with X_T the market quantity of the domestic risky product and with X_T^* the corresponding quantity of risky imports coming from the rest of the world, where subscript T will be used to indicate function and variables associated with the (free) trade equilibrium. Let $Z_T = \lambda X_T$ be the domestic "safe" quantity consumed that does not result in any adverse health outcomes. Similarly, assume that $Z_T^* = \lambda^* X_T^*$ is the corresponding quantity of the foreign

[14] Here we abstract from analyzing the case in which a country's imports originate from a variety of countries with different safety parameters λ^*. This case can be analyzed, but it is beyond the scope of the present paper.

(imported) safe food so the aggregate consumption of safe units is given by $Z_T + Z_T*$. Assume, for simplicity that parameters $\lambda, \lambda^* \in [0,1]$ are exogenous and may differ from each other. Without loss of generality, assume $\max\left(\lambda_0^*, \lambda_0\right) < \lambda^* < \lambda < 1$, which implies markets exist for each of the two products and home produces a safer product than the rest of the world. Assume finally that damage costs L associated with consumption of unsafe domestic and imported goods are equal—i.e., the illness imports carry is the same as that of domestic production.

Since consumers cannot distinguish between the two risky goods, free-trade will result in equalization of the domestic and world prices, i.e., $P = P*$. The market quantity supplied will be $X_T + X_T*$, where the domestic quantity supplied X_T is given by $X^S\left(P*\right)$ —the domestic supply curve evaluated at the world market price. The domestic supply of safe units is consequently given by $Z_T = \lambda X_T$. To determine the market-equilibrium quantity of imports X_T* note that imported and domestic goods are indistinguishable in the marketplace and their costs of illness per unsafe unit consumed are identical. This implies consumer demand will depend on the average probability of becoming ill $\lambda_T = (Z_T + Z_T*)/(X_T + X_T*)$. In this case, the solution to the consumer problem can be obtained by assuming that he/she maximizes utility $u\left(Z_T + Z_T*\right)$ by choosing the aggregate quantity consumed $Z_T + Z_T*$ subject to the non-stochastic budget constraint $M = Y + \hat{P}_T(Z_T + Z_T*)$. The first-order condition of the consumer's maximization problem is then given by

$$u'\left(Z_T + Z_T*\right) = \hat{P}_T = [P* + (1-\lambda_T)L]/\lambda_T \tag{11}$$

where $P*$ is the common market price, $\hat{P}_T$ is the free-trade risk-adjusted price,

$$\lambda_T = \frac{Z_T + Z_T*}{\mathrm{X}_T + X_T*} = \frac{Z_T + Z_T*}{\frac{Z_T}{\lambda} + \frac{Z_T*}{\lambda*}} = (1-s*)\lambda + s*\lambda* \tag{12}$$

is the free-trade consumption safety level, and $s* = X_T*/(X_T + X_T*)$ is the consumption share of imports. Un-COOL free-trade yields a common market price $P*$ and a common RAP given by (11). Substituting (12) and $Z_T = \lambda X^S\left(P*\right)$ into (11) determines the un-COOL free-trade equilibrium value of safe imports Z_T*, which can readily be transformed into the market-equilibrium quantity of imports $X_T* = Z_T*/\lambda*$.

Fig. 2 illustrates the determination of the un-COOL free-trade equilibrium values of safe imports and λ_T in the $(\lambda_T, Z_T{*})$ space. Specifically, equation (11) can be written as

$$\lambda_T(Z_T{*}) = \frac{P{*}+L}{u'\left(Z_T(P{*})+Z_T{*}\right)+L} \tag{13}$$

and, for clarity of exposition, we replicate equation (12) below

$$\lambda_T = \frac{Z_T + Z_T{*}}{\frac{Z_T}{\lambda} + \frac{Z_T{*}}{\lambda{*}}}. \tag{14}$$

Because the domestic quantity of safe units $Z_T(P{*}) = \lambda X^S(P{*})$ is a function only of the world price and λ, (13) and (14) constitute a system of two simultaneous equations in two unknowns λ_T and $Z_T{*}$. The solution is illustrated in Fig. 2. The upward-slopped curve is the graph of equation (13). It has a positive vertical intercept defined by setting $Z_T{*} = 0$ in equation (13), and a positive slope:

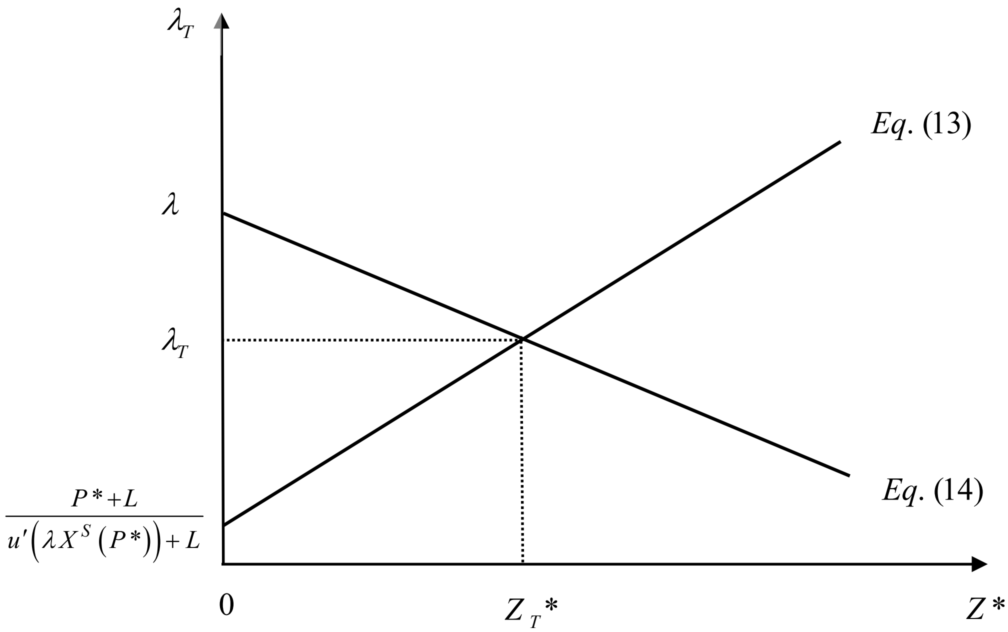

Figure 2. Determination of Free-Trade Equilibrium of Imports and Food Safety

As the quantity of safe imports increases the marginal utility declines, and the denominator of (13) decreases. Equation (14) defines a downward-slopped curve in the $(\lambda_T, Z_T{*})$ space under the assumption that domestically produced goods are safer than imported ones ($\lambda^* < \lambda < 1$). The vertical intercept of the downward-slopped curve equals λ: For any level of safe domestic units $Z_T\left(P^*\right)$, 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 level of λ_T. The total quantity of imports is given by $X_T^* = Z_T^* / \lambda^*$.

Note that if $P^* \geq P_A$, the graph of equation (13) in Fig. 2 lies above that of equation (14) for non-zero Z_T^* and the free-trade equilibrium reduces to the autarky equilibrium. If $X^S\left(P^*\right) = 0$, (14) in Fig. 2 is undefined at Z^*=0 and otherwise horizontal at $\lambda_T = \lambda^*$. The free-trade equilibrium reduces to one of solely purchasing imports. We abstract from these uninteresting degenerative equilibria by assuming:

$$P^* < P_A \text{ and } X^S\left(P^*\right) > 0 \tag{15}$$

Fig. 3 illustrates the welfare effects of unsafe food imports and the autarky welfare level. It does this by superimposing on the closed-economy equilibrium in Fig. 1, the market supply of imports, which is a horizontal line intersecting the vertical axis at P^*.

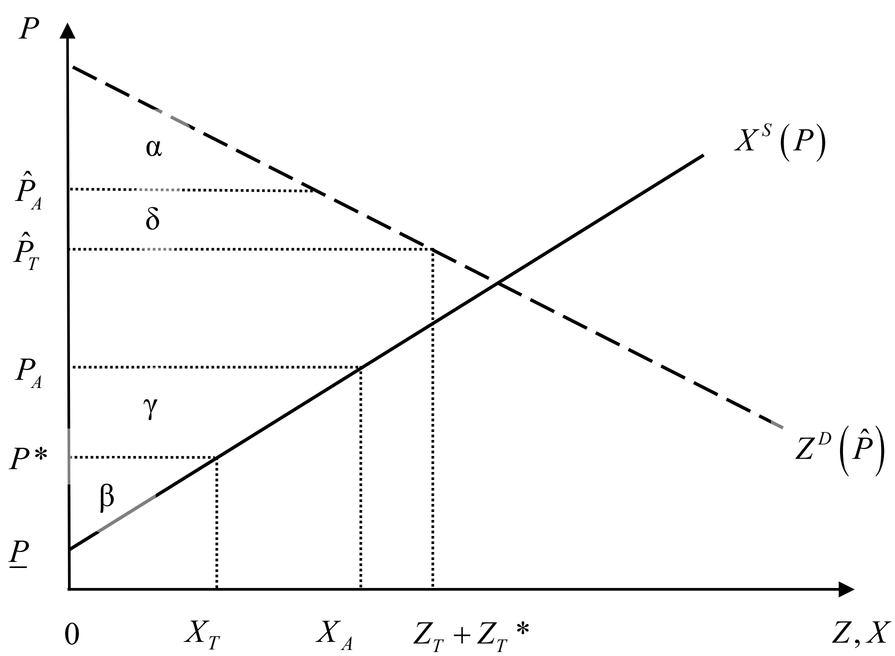

Figure 3. Un-COOL Free-Trade Equilibrium

The closed-economy equilibrium corresponds to the market price P_A, and the RAP $\hat{P}_A$ where $Z^D(\hat{P}_A) = \lambda X_A$. Price P_A determines the producer surplus (β+γ) and RAP $\hat{P}_A$ determines expected consumer surplus (α). The opening of trade establishes a lower producer price P^* and results in the importation of $Z_T^* = \lambda^* X_T^*$ units of safe imports and $(1-\lambda^*)X_T^*$ units of unsafe imports. Under un-COOL free trade, domestic producers face a lower price and reduce the quantity of unsafe and safe food produced, and therefore the producer surplus is equal to area (β). The move from autarky to free trade results in a decline in the producer surplus which equals area (γ) in Fig. 3.

The effects of un-COOL free trade on the expected consumer surplus (and the total welfare) are in general ambiguous. In order to calculate the RAP associated with the free-trade equilibrium, one has to add the safe quantity embodied in imports Z_T^*, which is determined in Fig. 2, to the domestic quantity of safe units Z_T. The RAP under free trade $\hat{P}_T$ corresponds to the total safe quantity consumed $Z_T + Z_T^*$. The area (α+δ), which is below curve $Z^D\left(\hat{P}\right)$ and above the RAP $\hat{P}_T$ corresponds to the expected consumer surplus under un-COOL free trade. In general, the consumer welfare ranking between autarky and free-trade is ambiguous and depends on the ranking of the RAPs under the two regimes. The ranking is unclear because the move from autarky to free trade lowers price, but increases risk of illness.

Fig. 3 illustrates a case in which the move from autarky to un-COOL free trade leaves the economy's welfare unchanged: Un-COOL free-trade reduces the market price from P_A to P^* and reduces the producer surplus by area (γ). This reduction in welfare is the same as the increase in expected consumer surplus measured by area (δ), caused by a reduction in the RAP from $\hat{P}_A$ to $\hat{P}_T$. Thus, even if imports are more risky than domestic products, the economy is indifferent between imposing an import ban and engaging in free trade. Of course, in this case consumers like free trade more than the import ban (free trade results in higher consumer surplus than autarky), while producers would advocate an import ban based on the effects of trade on producer surplus. It is straightforward to show the existence of cases for welfare improving import bans. For example, starting at an equilibrium of indifference between a ban and free trade, a decline in import safety λ^* does not affect the graph of equation (13) in Fig. 2, but rotates clockwise from its intercept the graph of equation (14) and results in a lesser safe quantity of imports Z_T*, for any given market price $P*$. This implies that the total safe quantity available to consumers $Z_T + Z_T*$ declines in Fig. 3, and the expected consumer surplus under free un-COOL trade falls. Since the expected producer surplus depends on the market price $P*$, a reduction in $\lambda*$ leaves this component of national welfare unaffected. Consequently, the expected gain from trade measured by area (δ-γ) is negative and an import ban improves welfare. One can readily construct other scenarios that justify the ban of unsafe imports based on other parameter changes.

Note finally that even if free trade is preferred to a ban, there always exists a restriction of trade that improves welfare—i.e., free un-COOL trade is never welfare maximizing for a small country. (Proof is given in the Appendix A). The effects of moving from autarky to free-trade are summarized in the following proposition:

Proposition 3*: Starting at the autarky equilibrium and assuming that the domestically produced good is safer than the imported product ($\lambda > \lambda*$), the introduction of free-trade by a small country results in:*

(a) A decline in the market price and market quantity of the safer domestic product.

(b) An increase in the market quantity and safe quantity of the less safe imported product.

(c) An ambiguous effect on the total safe quantity consumed and on the expected consumer surplus.

(d) A decrease in the safe quantity of the domestic good and a decrease in the producer surplus.

(e) An ambiguous effect on national welfare measured by producer plus expected consumer surplus, but if welfare improves as a result of free trade, it can always be raised further by some restriction of free un-COOL trade.

The reason for the ambiguous welfare ranking between the autarky and pooling equilibria can be traced to the theory of market distortions: While free trade introduces standard efficiency gains, it simultaneously introduces an informational distortion forcing consumers to act on a common (average) safety risk. The model is consistent with the evidence of import bans following outbreaks of foodborne disease abroad. These bans can be modeled as a move from un-COOL 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 $\lambda *$ 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.

The reason for the existence of a welfare enhancing trade restriction (even if free trade dominates an import ban) also derives from the informational distortion introduced by the imports. In particular, from the individual consumer perspective, the marginal unit of X carries a risk $(1-\lambda_T) < (1-\lambda^*)$. However, for society, the marginal unit of X is imported and carries the higher illness risk $(1-\lambda^*)$. Alternatively, the RAP associated with a marginal unit of Z for the consumer is less than the RAP associated with a marginal unit of Z for society. Consequently, consumers over-consume Z in the free-trade equilibrium, setting up the conditions for welfare-enhancing trade restrictions.

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. The introduction of COOL removes the informational distortion associated with the inability of consumers to incorporate the safety risk differential between imports and domestic goods. In the presence of COOL trade, 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 $u\left(Z_C + Z_C *\right) + Y$ 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 :

$$u'\left(Z_C + Z_C *\right) = \hat{P}_C = \frac{P_C}{\lambda} + \frac{(1-\lambda)}{\lambda} L \qquad (16)$$

$$u'\left(Z_C + Z_C *\right) = \hat{P}* = \frac{P *}{\lambda *} + \frac{(1-\lambda *)}{\lambda *} L \qquad (17)$$

where P_C denotes the producer price of domestically produced X, P^* the producer price of imports and "^" indicates associated RAP. 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, 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, equations (16) and (17) imply that

$$\hat{P}_C = [P_C + (1-\lambda)L]/\lambda = [P^* + (1-\lambda^*)L]/\lambda^* \tag{18}$$

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 equation (18) for the producer price of the domestically produced good yields

$$P_C = \lambda\left[\frac{P^*}{\lambda^*} + \left(\frac{\lambda - \lambda^*}{\lambda^*\lambda}\right)L\right] \tag{19}$$

According to equation (19), 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 (19) into the domestic supply of the risky good yields the equilibrium safe domestic quantity produced

$$Z_C = Z^S(\lambda, P_C) = \lambda X^S(P_C) \tag{20}$$

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.

COOL effects on expected consumer surplus depend on COOL effects on the RAP. From (12) it is obvious that $\lambda_T = (1-s^*)\lambda + s^*\lambda^* > \lambda^*$. It follows from (11) and (17) that

$$u'\left(Z_C + Z_C*\right) =$$

$$\hat{P}_C = \left(\frac{P*}{\lambda*} + \frac{(1-\lambda*)}{\lambda*}L\right) > \left(\frac{P*}{\lambda_T} + \frac{(1-\lambda_T)}{\lambda_T}L\right) = \hat{P}_T = \tag{21}$$

$$u'\left(Z_T + Z_T*\right)$$

The total amount of safe quantity consumed under COOL free trade is strictly less than the corresponding quantity under un-COOL 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 un-COOL 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 consumption 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, 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 un-COOL 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 optimality of COOL. With a price $P*$ for imports, $X*$, and P for domestically produced X, X_d, and a domestic cost of producing X_d, $C\left(X_d\right)$, the level of national welfare in general is given by:

$$W = u\left(\lambda X_d + \lambda * X*\right) + M - [(1-\lambda)LX_d + (1-\lambda*)LX*] - C\left(X_d\right) - P*X* \tag{22}$$

An interior maximum for W ($X_d > 0, X* > 0$), requires:

$$\lambda u'\left(\lambda X_d + \lambda * X*\right) - (1-\lambda)L - C'\left(X_d\right) = 0 \quad \text{and} \tag{23}$$

$$\lambda^* u'\left(\lambda X_d + \lambda^* X^*\right) - (1-\lambda^*)L - P^* = 0 \tag{24}$$

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 $C'(X_C) = P_C$, (16) and (17) imply an interior COOL equilibrium is this unique maximum. Note that un-COOL trade can never maximize welfare since joint satisfaction of (23) and (24) at ($X_d > 0, X^* > 0$) requires $C'(X_d) > P^*$ (assuming $\lambda > \lambda^*$) and in the un-COOL trade equilibrium $C'(X_T) = P^*$. Appendix B establishes that if an interior maximum exists, it dominates corner solutions of $X_d = 0$ and $X^* = 0$. Hence, if an interior COOL equilibrium exists, it dominates both autarky and the un-COOL trade equilibrium. A corner COOL equilibrium at all imports is precluded by (15).[15] A corner COOL equilibrium at the autarky solution can be consistent with (15). 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 equilbria dominate the un-COOL trade equibrium 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 any restriction of COOL trade reduces welfare[16]. If a non-prohibitive specific tariff, t, is imposed on imports, the COOL equilibrium can be determined as above by replacing P^* by $P^* + t$. Equations (17), (19) and (20) with P^* replaced by $P^* + t$ 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 (17) and differentiating totally the system of these equations yields

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

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

$$\left.\frac{dX_C}{dt}\right|_{t\geq 0} = \frac{\lambda}{\lambda^*}\frac{\partial X_C}{\partial P_C} > 0 \tag{25}$$

$$\left.\frac{dX_C^*}{dt}\right|_{t\geq 0} = \frac{1}{(\lambda^*)^2}\left[\frac{1}{u''(.)} - \lambda^2\frac{\partial X_C}{\partial P_C}\right] < 0\,. \tag{26}$$

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 $u\left(\lambda X_C + \lambda^* X_C^*\right)$ 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 $C\left(X_C\right)$ 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 $P^* X_C^*$. The level of national welfare as a function of the specific tariff is

$$W(t) = u\left(\lambda X_C\left(t\right) + \lambda^* X_C^*\left(t\right)\right) + M - \left[(1-\lambda)LX_C\left(t\right) + (1-\lambda^*)LX_C^*\left(t\right)\right] \\ - C\left(X_C\left(t\right)\right) - P^* X_C^*\left(t\right)$$

Differentiating the above expression with respect to the specific tariff yields:

$$\frac{dW}{dt} = \left\{\lambda u' - (1-\lambda)L - C'\left(.\right)\right\}\frac{dX_C}{dt} + \left[\lambda^* u' - (1-\lambda^*)L - P^*\right]\frac{dX_C^*}{dt} \tag{27}$$

Equation (16) and the property $P_C = C'\left(X_C\right)$ imply that, under COOL, the term in the curly bracket of (27) is zero. From (17), the expression in the square bracket is equal to the value of the specific tariff. Therefore, taking into account the above analysis and using (26) one can derive two standard expressions for the effects of a specific tariff on national welfare in the presence of COOL[17]

$$\left.\frac{dW}{dt}\right|_{t>0} = t\frac{dX_C^*}{dt} < 0 \tag{28}$$

[17] 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.

$$\left.\frac{dW}{dt}\right|_{t=0} = t\frac{dX_C*}{dt} = 0 \tag{29}$$

Inequality (28) states that national welfare is a decreasing function of the specific tariff for strictly positive values of t and equation (29) implies that welfare is maximized under COOL free trade. In 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.[18]

Proposition 5: *In the presence of country-of-origin labeling (COOL), even if the domestically produced good is safer than the imported product ($\lambda > \lambda*$), 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.*

Proposition 5 is consistent with the theory of trade distortions applied to this particular informational welfare distortion. The introduction of a COOL policy removes this distortion and 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. 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.

4. Concluding Remarks

The present study developed a small open-economy partial-equilibrium model in which the small country produces an unsafe product and imports another riskier product under conditions of perfect competition. 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 three cases. The first was the closed-economy equilibrium, the second a free-trade regime without country-of-origin labeling (COOL), and the third was a free-trade regime coupled with a COOL program.

[18] 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.

We established that the competitive equilibrium maximized social welfare for the closed economy situation where social welfare is measured by the sum of expected consumer and producer surplus. The presence of insurable risk creates a wedge between the producer and consumer price that depends positively on the per-unit cost of becoming ill and on the proportion of unsafe units embodied in the risky product. In the absence of a COOL program, the opening of trade with another country that produces a riskier good at a lower price results in a reduction in expected producer surplus and an ambiguous effect on expected consumer surplus. An ambiguous welfare outcome leaves open the possibility of welfare-improving trade bans. Even if free un-COOL trade dominates an import ban, welfare can always be increased by some restriction of un-COOL trade. The outcomes are consistent with the generalized theory of distortions: Un-COOL trade introduces an informational distortion to the open economy because the consumer cannot distinguish and incorporate into his/her behavior the differential risk between imports and domestic goods.

The introduction of COOL addresses the source of the distortion directly, maximizes welfare 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 dominates trade bans and un-COOL trade. We suspect that this property would hold in a general equilibrium framework and in the case of a large country.

Of course the model's properties and results depend on several assumptions. We have assumed that the consumers are fully informed about the safety risk of the two products. 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. We have also abstracted from analyzing the more realistic case of multiple import suppliers and multiple levels of country-specific risky products. 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. All these important 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? Pretty cool indeed!

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Appendix A

At any unrestricted un-COOL trade equilibrium, there always exists a trade restriction that improves welfare.

A1. Tariff

Welfare as a function of the specific tariff t, $W(t)$, is given for the un-COOL case by

$$W(t) = u\left(\lambda X_T(t) + \lambda^* X_T^*(t)\right) + M - \left[(1-\lambda)LX_T(t) + (1-\lambda^*)LX_T^*(t)\right]$$
$$- C\left(X_T(t)\right) - P^* X_T^*(t)$$

Totally differentiating this expression with respect to tariff yields

$$\frac{dW}{dt} = \{\lambda u' - (1-\lambda)L - C'(.)\}\frac{dX_T}{dt} + [\lambda^* u' - (1-\lambda^*)L - P^*]\frac{dX_T^*}{dt} \quad \text{(A1)}$$

With un-COOL trade and a specific tariff, t, on imports (13) is modified by replacing P^* by $P^* + t$ and (14) is unchanged except for recognition that Z_T is a function of ($P^* + t$). For given Z_T^*, the shifts in equations (13) and (14) in Figure 2 as a function of t are readily determined by differentiation to both be upward, establishing that

$$\frac{d\lambda_T}{dt} > 0 \quad \text{(A2)}$$

The sign of $\frac{dZ_T^*}{dt}$ cannot be definitively established. However, re-writing (14) in terms of X,

$$\lambda_T = \frac{\lambda X_T + \lambda^* X_T^*}{X_T + X_T^*} \quad \text{(A3)}$$

it is straightforward to show (A2), (A3) and $\lambda > \lambda^*$, imply the elasticity of X_T with respect to t exceeds the elasticity of X_T^* with respect to t or:

$$\frac{dX_T}{dt} > \frac{X_T}{X_T^*}\frac{dX_T^*}{dt} \quad \text{(A4)}$$

From (11), $\lambda^* < \lambda_T < \lambda$, and $C'(X_T) = P^*$ at $t = 0$, it follows at an un-COOL equilibrium with $t = 0$, the term in curly brackets in (A1) is strictly positive while the term in square brackets is strictly negative. Since $C'(X_T) = P^* + t$ and $C''(.) > 0$, $\frac{dX_T}{dt} > 0$. If $\frac{dX_T^*}{dt} < 0$, then it follows directly from the signs of the terms in brackets of (A1) that $\left.\frac{dW}{dt}\right|_{t=0} > 0$. If $\frac{dX_T *}{dt} > 0$, then use (A4) to derive at $t = 0$,

$$\left.\frac{dW}{dt}\right|_{t=0} > \left[(\lambda \frac{X_T}{X_T *} + \lambda *)(u' + L) - (\frac{X_T}{X_T *} + 1)(L + P*) \right] \frac{dX_T *}{dt} \quad \text{(A5)}$$

Under the assumption $\frac{dX_T *}{dt} > 0$, the sign of the right-hand side of (A5) is determined by the sign of the term the square brackets. The latter is the same as the sign of $[.]/(\frac{X_T}{X_T *} + 1) = \lambda_T u' + \lambda_T L - L - P* = 0$. Given the strict inequality of (A5) it follows that $\left.\frac{dW}{dt}\right|_{t=0} > 0$ and imposition of a tariff improves welfare.

Although there is at least a marginal tariff that unambiguously improves welfare, it is questionable whether or not the tariff constitutes a "trade restriction" in the case of $\frac{dX_T *}{dt} > 0$ — i.e., the tariff actually increases imports. This outcome can occur because the increase in safety of the pooled X, $\frac{d\lambda_T}{dt} > 0$, increases demand for all X (including imports which are indistinguishable from domestic production) and the positive safety effect of a tariff can offset the negative price effect of the tariff. Note that given an equilibrium with $t > 0$, it does not necessarily follow that $\frac{dW}{dt} > 0$. In this case, the term in curly brackets in (A1) remains unambiguously positive, but the term in square brackets is not unambiguously negative since it includes the positive value of the specific tariff.

A2. Quota

In contrast to a tariff that can actually raise imports, imposition of a quota on $X*$ at an un-restricted un-COOL trade equilibrium is an unambiguous trade restriction. Hence, we now show that at any unrestricted un-COOL trade equilibrium, there exists a quota on $X*$ that reduces imports and raises welfare. As noted in the text, total Z purchased in the COOL equilibrium is less than Z purchased in the un-COOL equilibrium.

Consider a quota in the latter that restricts $Z*$ to $\bar{Z}* = Z_C + Z_C * - Z_T < Z_T *$. It is assumed the quota amount of $X*$, $\bar{Z}*/\lambda*$ is purchased at world price $P*$, mixed with domestic production and then sold to consumers. Price (P_q) of both imported X and domestic X (X_q), is determined by supply equals demand given the quota and domestic production determined by $C'(X_q) = P_q$. Profit on the quota purchase and resale $(P_q - P*)\bar{X}*$ is returned to the consumer. The general expression for welfare given in (22) is unaffected. To distinguish pooled λ in general from its specific value of λ_T in the unrestricted un-COOL equilibrium, define:

$$\lambda_p = \frac{Z^d + Z*}{X^d + X*} = \frac{\lambda X^d + \lambda * X*}{X^d + X*} \tag{A6}$$

Where superscript d denotes supply of Z or X from domestic sources and superscript * denotes supply from imports. With the quota, P_q and λ_p, must simultaneously satisfy:

$$u'\left(\lambda X^S\left(P_q\right) + \bar{Z}*\right) = \frac{P_q + (1-\lambda_p)L}{\lambda_p} \tag{A7}$$

and

$$\lambda_p = \frac{\lambda X^S(P_q) + \bar{Z}*}{X^S(P_q) + (\bar{Z}*/\lambda*)} \tag{A8}$$

Equations (A7) and (A8) define two relationships between λ_p and P_q that must hold in equilibrium. Each individually defines a relationship $P_q\left(\lambda_p\right)$. It is straightforward to show by differentiation that for both (A7) and (A8), $P_q\left(\lambda_p\right)$ is upward sloping, raising the question of whether they intersect and the nature of that intersection. Note, however, that by choice of $\bar{Z}*$, $\left(\lambda*,\ P*\right)$ satisfies (A7): From the unrestricted, un-COOL trade equilibrium, $\lambda X^S\left(P*\right) = Z_T$, $Z_T + \bar{Z}* = Z_C + Z_C*$ and from the COOL trade equilibrium condition (17), it then follows $\left(\lambda*,\ P*\right)$ satisfies (A7). In contrast, at $P*$, since $\lambda X^S\left(P*\right) = Z_T$ but $\bar{Z}* < Z_T*$, it follows that λ_p in (A8) corresponding to $P*$ must exceed λ_T. Denote this value of λ_p by λ_{p*8}. Since both curves are strictly upward sloping $\left(\lambda_{p*8}, P*\right)$ satisfying (A8) lies below (A7) at λ_{p*8}.

At $\lambda_p = \lambda$, there is finite P_q that satisfies (A7): By selection of $\overline{Z}*$ and the fact $Z_T < Z_C$, it follows that $\overline{Z}*+Z_C > \overline{Z}*+Z_T = Z_C + Z_C*$. The COOL market equilibrium implies at the point $(\lambda,\ P_C)$, the left-hand side of (A7) (equal to $u'(Z_C + \overline{Z}*)$) is less than the right-hand side (equal to $u'(Z_C + Z_C*)$). At $(\lambda,\ P*)$, the left-hand side of (A7) (greater than $u'(Z_T + Z_T*)$) exceeds the right-hand side (less than $(P*+(1-\lambda_T)L)/\lambda_T$)). Hence, there exists $\tilde{P}$, $P* < \tilde{P} < P_C$ such that (λ, $\tilde{P}$) satisfies (A7). Given $\overline{Z}*$>0, there is no P_q that satisfies (A8) at $\lambda_p = \lambda$. For (A8), $P_q \to \infty$ as $\lambda_p \to \lambda$.

From: (a) $P_q(\lambda_p)$ strictly increasing for both (A7) and (A8); (b) $(\lambda_{p*8}, P*)$ satisfying (A8), but lying below (A7) at $\lambda_{p*8} > \lambda_T$; (c) $(\lambda, \tilde{P})$ satisfying (A7) for $P* < \tilde{P} < P_C$; and (d) for (A8), $P_q \to \infty$ as $\lambda_p \to \lambda$, it follows there exists $(\widehat{\lambda}_p, \widehat{P}_q)$, jointly satisfying (A7) and (A8) and characterized by $\lambda_T < \widehat{\lambda}_p < \lambda$ and $P* < \widehat{P}_q < P_C$.

Letting W_T and W_q denote welfare in the original un-restricted un-COOL equilibrium and the new quota-constrained equilibrium respectively, then, using (22) rewritten in terms of Z, letting Z_q denote domestic production of Z under the quota, and noting since $P* < \widehat{P}_q$, $Z_T < Z_q$ and by construction $\overline{Z}* < Z_T*$:

$$W_T = M + \int_0^{Z_T} u'(Z)dZ - \int_0^{Z_T} \frac{1}{\lambda} C'(\frac{Z}{\lambda})dZ - (1-\lambda)L\frac{Z_T}{\lambda} + \int_{Z_T}^{Z_T+\overline{Z}*} u'(Z)dZ - P*\frac{\overline{Z}*}{\lambda*} - (1-\lambda*)L\frac{\overline{Z}*}{\lambda*} +$$
$$\int_{Z_T+\overline{Z}*}^{Z_T+Z_T*} u'(Z)dZ - P*\frac{(Z_T*-\overline{Z}*)}{\lambda*} - (1-\lambda*)L\frac{(Z_T*-\overline{Z}*)}{\lambda*}$$

$$W_q = M + \int_0^{Z_T} u'(Z)dZ - \int_0^{Z_T} \frac{1}{\lambda} C'(\frac{Z}{\lambda})dZ - (1-\lambda)L\frac{Z_T}{\lambda} + \int_{Z_T}^{Z_T+\overline{Z}*} u'(Z)dZ - P*\frac{\overline{Z}*}{\lambda*} - (1-\lambda*)L\frac{\overline{Z}*}{\lambda*} +$$
$$\int_{Z_T+\overline{Z}*}^{Z_q+\overline{Z}*} u'(Z)dZ - \int_{Z_T}^{Z_q} \frac{1}{\lambda} C'(\frac{Z}{\lambda})dZ - (1-\lambda)L\frac{(Z_q - Z_T)}{\lambda}$$

The first seven terms in W_T and W_q are identical. Combined, the last three terms of W_T are strictly negative since by selection of $\overline{Z}*$, $u'(Z_T + \overline{Z}*) = \frac{P* + (1-\lambda*)L}{\lambda*}$ and $u'' < 0$. Combined, the last three terms of W_q are positive. From the quota equilibrium,

$$u'(Z_q + \overline{Z}*) = \frac{\widehat{P}_q + (1-\widehat{\lambda}_p)L}{\widehat{\lambda}_p} > \frac{\widehat{P}_q + (1-\lambda)L}{\lambda} \tag{A9}$$

and $C'(\frac{Z_q}{\lambda}) = \widehat{P}_q$, the combined positive sign of the final three terms in W_q follow from $u'' < 0$ and $c'' > 0$. Hence $W_q > W_T$.

Appendix B: If an interior maximum of W in (22) exists, then it is a global maximum.

Since u' and C' are monotonic, (23) and (24) imply that if an interior maximum exists, it is unique. Assuming the autarky equilibrium is not a corner, a corner solution to (22) defined by $X* = 0$ cannot be a maximum if $\left.\frac{dW}{dX*}\right|_{X*=0} > 0$. Similarly, assuming a market of only imports would yield a non-corner solution, a corner solution defined by $X_d = 0$ cannot be a maximum if $\left.\frac{dW}{dX_d}\right|_{X_d=0} > 0$.

Suppose a critical point ($X_d > 0, X* > 0$) exists satisfying (23) and (24). Then, from the autarky solution compared with (23):

$$\lambda u'(\lambda X_A) - (1-\lambda)L - C'(X_A) = 0 \quad \text{and} \tag{B1}$$

$$\lambda u'(\lambda X_d + \lambda * X*) - (1-\lambda)L - C'(X_d) = 0$$

Since $C'' > 0$ and $X* > 0$ and $u'' < 0$, $X_d < X_A$ and $u'(\lambda X_d + \lambda * X*) < u'(\lambda X_A)$. It then follows from (24):

$$\lambda * u'(\lambda X_A) - (1-\lambda*)L - P* > 0 \Rightarrow \left.\frac{dW}{dX*}\right|_{X*=0} > 0.$$

Let $\overline{X}*$ denote the level of imports that maximizes W given that $X_d = 0$. Again assume a critical point ($X_d > 0, X* > 0$) satisfying (23) and (24). Then

$$\frac{C'(X_d) + (1-\lambda)L}{\lambda} = \frac{P^* + (1-\lambda^*)L}{\lambda^*} = u'(\lambda^* \bar{X}^*) \quad \text{or} \tag{B2}$$

$$\lambda u'(\lambda^* \bar{X}^*) - (1-\lambda)L - C'(X_d) = 0 \tag{B3}$$

Since $C'(X_d) > C'(0)$, (B3) implies $\left.\frac{dW}{dX_d}\right|_{X_d=0} > 0$. Thus, if an interior maximum to W exists, it dominates corner solutions.