'North-South Trade and Food Standards:
What Can General Equilibrium Analysis Tell Us?'

Abstract:

The tension between standards being, on the one hand consumer-driven, but on the other providing protection to domestic producers, characterizes much of their economic analysis. What is somewhat surprising about the literature on food standards and international trade is the lack of any extensive theoretical underpinnings for what has essentially been either descriptive or empirical analysis. This paper explores in more detail the link between international trade and standards based on resolution of a public goods problem. Specifically, a general equilibrium setting is sketched out, drawing on existing analysis in the trade and environmental economics literature, and designed to capture some key stylized facts and basic hypotheses concerning North-South trade where standards are targeted at negative externalities in food production. The key conclusions to be drawn are that while a clear theoretical foundation exists for the hypothesis of "standards as barriers" to trade, this is not the case for the hypothesis of "barriers as a catalyst" for trade, pointing to the need for further research on the latter hypothesis.

Keywords: North-South trade, food standards

JEL Codes: F13, F18, and Q17

Introduction

In the post-war period, the distribution of goods within national markets and across borders has become increasingly affected by the proliferation of standards and technical regulations (Maskus and Wilson 2001; Essaji 2008), with increased regulatory intensity being particularly noticeable in the food and agricultural sector over the past two decades (Roberts 1999; Josling, Roberts and Orden 2004; Henson and Jaffee 2008; Maertens and Swinnen 2008). Based on data for the two-digit Harmonized System (HS), Essaji (2008) finds that six of the ten sectors with the highest intensity of technical regulations (TR) cover food and agricultural products.

The proliferation of standards and technical regulations in the food and agricultural sectors, as well as the wider manufacturing sector, is typically regarded as the response of policymakers to consumer demands for improved product safety, increased environmental protection, and greater product information (Roberts 1999; Maskus and Wilson 2001; Wilson 2008; Essaji 2009). Roberts (1999: 337) argues that standards and technical regulations 'have as their *prima facie* objective the correction of market inefficiencies stemming from externalities associated with the production, distribution, and consumption of these products. These externalities may be regional, national, transnational, or global'.

The key to this description is the role of technical regulations and standards in solving market failures. Josling *et al*. (2004), suggest that standards in the food and agricultural sector can be classified under two broad categories: (i) provision of public goods such as control of pesticide use in agricultural production; and (ii) reduction of transactions costs associated with information asymmetries between producers and consumers concerning food product characteristics, e.g., the extent of pesticide residues in a product which consumers are unable to ascertain either before or after its consumption.

While the theory of optimal intervention prescribes that market distortions should be targeted at source (Bhagwati 1984), there is acknowledgement that they may also provide protection for domestic producers and are, therefore, subject to 'regulatory capture' (Roberts 1999; Fischer and Serra 2000; Sturm 2006; Essaji 2008; Swinnen and Vandemoortele 2009). Given the potential for standards and technical regulations to distort international trade, a key outcome from formation of the World Trade Organization (WTO) in 1994 was the Agreement on the Application of Sanitary and Phytosanitary Measures (SPS), and the revised Agreement on Technical Barriers to Trade (TBT). The objective of these agreements is to ensure that standards and technical regulations, while potentially meeting legitimate economic objectives, are not disguised restrictions on international trade (Josling 2008).

Although the focus of this paper is not the intricacies of trade law and food standards, it is interesting to note that between 1995 and 2002, WTO members filed thirty-two requests for formal consultations related to food regulation trade barriers under the WTO's dispute settlement process (Josling *et al*. 2004). These covered a wide range of sectors and technical regulations, and involved both developed and developing countries as petitioners and respondents. Perhaps the most analyzed Panel and Appellate Board rulings were those involving the US complaint against the European Community's (EC) use of measures concerning the use of hormones in meat and meat products (Roberts, 1998), and India, Malaysia, Pakistan and Thailand's complaint against the US prohibition of imports of certain shrimp and shrimp products (Charnowitz 2002). More recently, the introduction of genetically modified (GM) crops and the European Union (EU) requirement for labeling of food products containing genetically modified organisms (GMOs) has attracted a good deal of attention (Sheldon 2002).

The tension between the notion that standards and technical regulations are, on the one hand consumer-driven, but on the other, may provide protection to domestic producers, characterizes much of their economic analysis. For example, early theoretical work by Casella (1996), examines standards in the context of provision of public goods. Given that demand for public goods will depend on economic primitives such as factor endowments, consumer preferences, and technology, necessarily provision will differ between countries depending on their stage of development. Using a simple model, Casella (1996) shows that with international trade, standards of developed and developing countries will converge over time, if demand is a function of the level of income. The implication of this result is that if trade itself eventually results in countries establishing similar standards for the provision of public goods, there is no need for such standards to be harmonized as a pre-condition for trade liberalization.

In contrast to this benign view of standards, there has been considerable discussion of the problems of regulatory compliance faced by developing countries in accessing developed country markets, given the latter typically have higher levels of regulatory intensity than the former (Jaffee and Henson 2004; World Bank 2005; Essaji 2008). Testing the hypothesis of 'standards as barriers' has been a dominant feature of the empirical research on the impact of food safety regulations on trade flows of specific food and agricultural commodities, e.g., Calvin and Krissoff (1998); Paarlberg and Lee (1998); Otsuki, Wilson and Sewadeh (2001); Wilson and Otsuki (2004); Peterson and Orden (2005); and Anders and Caswell (2009). A common finding of these empirical studies is that more stringent standards imposed by developed countries act as barriers to trade (Wilson, 2008).

What is somewhat surprising about the extant literature on food standards and international trade is the lack of any extensive theoretical underpinnings for what has essentially been either

descriptive or empirical analysis. The objective of this paper, therefore, is to explore in more detail the link between international trade and standards based on resolution of a public good problem. In the first section, a general equilibrium setting is developed, drawing extensively on existing work in the trade and environmental economics literature. This analysis is designed to capture some key stylized facts and basic hypotheses concerning North-South trade where standards and technical regulations are targeted at negative externalities in food production. In the second section, the competing hypotheses of standards as "barriers to trade" vs. "catalysts for trade" are considered. Finally, the discussion in the paper is summarized, and some conclusions are drawn concerning potential future research on food standards and international trade.

1. A Model of North-South Trade and Food Standards

As noted above, standards are often justified as a means of solving specific market failures such as externalities. However, it is typically claimed that developing countries are hampered in their ability to meet such standards due to a lack of necessary human capital and poor governance (Maskus and Wilson 2001; Essaji 2008). Essaji (2008) also presents empirical evidence to support the hypothesis that the capacity to satisfy standards is correlated with real GDP per capita, developing countries specializing away from industries with heavier regulatory burdens. It is interesting therefore to see how far one can get with a general equilibrium model of North-South trade with food standards that captures these stylized facts.

In order to do this, a model of trade and standards in the presence of environmental externalities originally due to Copeland and Taylor (1994), is adapted. Assume there is a bloc of countries representing the developed North, and a bloc representing the developing South, producing along a continuum of consumption goods, $z \in [0,1]$ with one primary input, effective

labor *l*. Part of this continuum consists of food consumption goods, the remainder being other non-food goods. Assume that a local public bad *b* is produced jointly with each consumption good *z* in the continuum. In the case of food production, use of pesticides generates a local public bad if there are health risks associated with on-farm ingestion by agricultural labor, as well as air and drinking-water contamination, and dietary exposure to pesticide residues (Segerson 1990; Wilson and Otsuki, 2004). The output *y* of any good *z* in the continuum is a function of combining both effective labor *l* and the bad *b* via the following constant returns to scale Cobb-Douglas technology:

$$y(l,b;z) = \begin{cases} l^{1-\alpha(z)}b^{\alpha(z)} & \text{if } b \le \lambda l \\ 0 & \text{if } b > \lambda l \end{cases}, \qquad (1)$$

where $\lambda > 0$, $\alpha(z)$ varies across goods, and $\alpha(z) \in [\bar{\alpha}, \hat{\alpha}]$, with $0 < \bar{\alpha} < \hat{\alpha} < 1$. The interpretation of (1) is that effective labor *l* and the bad *b* can be substituted for one another in production of any good *z*, but there are limits to these substitution possibilities, i.e., any point above the production ray $b = \lambda l$ is not feasible for any given labor input *l*. This follows from the bad *b* being a by-product of production. This technology is illustrated in figure 1 where $y(z)$ is an isoquant for good *z*. Note that the more intensive a good is in terms of the public bad, the shallower the isoquant.

On the consumption side, consumers in the North and South have identical utility functions, consumption goods *z* and the public bad *b* being separable in utility; and given homothetic preferences, the share of spending on each consumption good *z* in the continuum is a constant. The utility function of a representative consumer is given as:

$$U = \int_0^1 f(z)\ln[x(z)]dz - \frac{\beta D^{\gamma}}{\gamma}, \qquad (2)$$

where $x(z)$ is consumption of z, $f(z)$ is the budget share for each good in the continuum, and the sum of budget shares is $\int_0^1 f(z)dz = 1$; D is aggregate production of the public bad; β measures the representative consumer's disutility associated with the public bad; and $\gamma \geq 1$, implying consumers' willingness to pay for a reduction in the level of the public bad is non-decreasing in its aggregate level. The public bad is also defined as $b = (b^1 + b^2)$, where b^1 is a measurable local public bad, and a b^2 is either a measurable or perceived public bad embodied in goods traded across borders. The latter notion captures the idea that consumers may treat imported goods as credence goods, e.g., they cannot verify the level of pesticide residues contained in foreign food products either before or after consumption. For the remainder of this section, it is assumed that $b^2 = 0$, but this is relaxed in the following section of the paper.

Without government regulation, firms in neither North nor South have an incentive to abate the public bad, always choosing a point along the production ray $b = \lambda l$. However, if it is assumed that a public standard s is set for an allowable level of the public bad, there will be an interior solution. In enforcing the standard, it is assumed that the government essentially imposes a per unit compliance cost c_b on firms that utilize the public bad in production, the compliance cost consisting of abatement, certification and monitoring costs.

Given a return on a unit of effective labor w_e, and the per unit compliance cost c_b, cost minimization for any good in the continuum z implies that the ratio of input prices will equal the marginal technical rate of substitution:

$$\frac{w_e}{c_b} = \frac{1-\alpha(z)}{\alpha(z)}\frac{b}{l}. \qquad (3)$$

Expression (3) indicates that the share in production costs of the compliance cost is a constant $\alpha(z)$, so that goods in the continuum can be ordered in terms of their intensity in generating the

public bad, $\alpha'(z) > 0$. Importantly, both food and non-food consumption goods are assumed to be spread along this continuum in terms of their generation of the public bad. This ensures that both North and South will produce both food and non-food consumption goods in equilibrium. The equilibrium in (3) is shown in figure 1 as the tangency point between the isoquant and the isocost curve at *E'*, where the input *b* is being appropriately priced, which compares to the equilibrium at *E* where firms have no incentive to abate the public good in the absence of a standard.

Suppose the technology in (1) is available to firms in both North and South, and each has the same endowment of workers $L = L^*$, but the supply of effective labor is greater in the North than the South, $A(h)L > A(h^*)L^*$, where h is the human capital/worker, and $h > h^*$ (* denoting the South). This assumption captures the empirical observation that developing countries are lacking in human capital. Given that the return to effective labor is higher in the North than the South, income per capita in the North exceeds that in the South, and if demand for the public good is income elastic, then the North will set both a higher standard *s* and, higher per unit compliance costs c_b will be incurred to cover the costs of abatement, monitoring and enforcement.

By minimizing total costs subject to the Cobb-Douglas production function in (1), the average (unit) cost function for a good *z* in the continuum can be written as:

$$a(w_e, c_b; h, z) = \Omega(z) c_b^{\alpha(z)} [w / A(h)]^{1-\alpha(z)}, \qquad (4)$$

where $\Omega(z) \equiv \alpha^{-\alpha}(1-\alpha)^{-(1-\alpha)}$ is a good-specific constant, and w is the wage rate for raw labor. For given wages and compliance costs, a good *z* in the continuum will be produced in the North if $a(w_e, c_b; h, z) \leq a^*(w_e^*, c_b^*; h^*, z)$, such that:

$$\tilde{\omega} \equiv \frac{w}{w^*} \leq \frac{A}{A^*}\left(\frac{c_b^*}{c_b}\right)^{\alpha(\tilde{z})/(1-\alpha(\tilde{z}))} \equiv T(\tilde{z}). \qquad (5)$$

While expression (5) assumes that standards in the North and South are exogenously given, it is possible to derive what would be the optimal level of production of the public bad if policymakers maximize a representative consumer's indirect utility subject to per capita income. Writing the indirect utility function as:

$$V = \int_0^1 f(z)\ln[x(z)]dz - \int_0^1 f(z)\ln[p(z)]dz + \ln\left(\frac{I}{L}\right) - \frac{\beta D^{\gamma}}{\gamma}, \qquad (6)$$

where $p(z)$ is the continuum of prices for the consumption goods z, and the first-order condition for the level of the public bad is, $V_p dp/dD + V_I dI/dD + V_D = 0$. Assuming North and South are too small to influence world goods prices, $dp/dD = 0$, the first-order condition can be re-arranged as $dI/dD = -V_D/V_I$, the latter part of the expression measuring marginal damage incurred by the representative consumer. If the government acts optimally, compliance costs faced by producers should be set equal to the aggregate marginal damage generated by the public bad, i.e., $c_b = -L.V_D/V_I = \beta D^{\gamma-1} I$. Given this, the level of compliance costs, and by implication the standard s, vary positively in income I in the North, and likewise in the South, $c_b = \beta D^{*\,\gamma-1} I^*$, the ratio of North and South compliance costs being given as: $c_b^*/c_b = (I^*/I)(D^*/D)^{\gamma-1}$. The argument that standards for say pesticide use in the South will eventually rise as their per capita income rises, assumes that demand for environmental quality is a normal good. Support for this assumption draws on the literature on the environmental Kuznets curve which hypothesizes an inverse U-shaped relationship between per capita incomes and environmental quality (Copeland and Taylor, 2004).

Given this setting, balanced trade requires that $I = \psi(\tilde{z})(I + I^*)$ and $I^* = \psi^*(\tilde{z})(I^* + I)$, where $\psi(\tilde{z}) \equiv \int_0^{\tilde{z}} f(z)dz$ and $1 - \psi(\tilde{z}) = \psi^*(\tilde{z}) \equiv \int_{\tilde{z}}^1 f(z)dz$ are the shares of world spending on Northern

and Southern goods respectively. Solving for $I(I^*)$ and $D(D^*)$ in terms of $\tilde{z}$, an expression for relative compliance costs as a function of $\tilde{z}$ can be derived as:

$$\frac{c_b^*}{c_b} = \left(\frac{\psi^*(\tilde{z})}{\psi(\tilde{z})}\right)^{1/\gamma}\left(\frac{\phi^*(\tilde{z})}{\phi(\tilde{z})}\right)^{(\gamma-1)/\gamma} \equiv C(\tilde{z}), \tag{7}$$

where $\phi(\tilde{z}) \equiv \int_0^{\tilde{z}} \alpha(z) f(z) dz \left(\phi^*(\tilde{z}) \equiv \int_0^{\tilde{z}} \alpha(z) f(z) dz\right)$ are the portions of the shares of world spending on Northern (Southern) goods that contribute to Northern (Southern) compliance costs, $C(\tilde{z}) < 1$ if compliance costs are higher in the North than the South. Substituting (7) into expression (5) gives:

$$\tilde{\omega} \equiv \frac{w}{w^*} \leq \frac{A}{A^*}[C(\tilde{z})]^{\alpha(\tilde{z})/(1-\alpha(\tilde{z})} \equiv T(\tilde{z}), \tag{8}$$

where $d\ln T(\tilde{z})/d\tilde{z} < 0$, and $T(1) = 0$. From this it can be stated that: a good *z* in the continuum is produced in the North if $\omega \leq T(\tilde{z})$ and is produced in the South if $\omega \geq T(\tilde{z})$. Given $C(\tilde{z}) < 1$, and also that α'(*z*) > 0, $T(\tilde{z})$ is decreasing in *z*, i.e., the North's comparative advantage in producing any good *z* falls as compliance costs become a larger fraction of total production costs. Therefore, for any given value of relative wages ω, there will be a critical industry $\tilde{z}$ on the $T(\tilde{z})$ schedule where goods are either produced in the North on the interval $z \in [0, \tilde{z}]$, or they are produced in the South on the interval $z \in [\tilde{z}, 1]$, with the North (South) producing the goods that are least (most)-intensive in their production of the local public bad.

In order to determine equilibrium relative wages $\tilde{\omega}$, and hence the critical industry $\tilde{z}$, the demand side of the economy is introduced through a balance of trade schedule, defined as:

$$\psi^*(\tilde{z})wL = \psi(\tilde{z})w^*L^*, \tag{9}$$

i.e., total imports of Southern goods by the North have to equal total exports of Northern goods to the South. Rearranging (9) generates a balance of trade schedule:

$$\tilde{\omega} = \frac{\psi(\tilde{z})}{\psi^*(\tilde{z})} \equiv B(\tilde{z}), \tag{10}$$

where $B(0) = 0$, $B(1) = \infty$, and $dB/d\tilde{z} > 0$, $B(\tilde{z})$ sloping upwards to reflect the fact that as the range of goods produced in the North increases, its exports increase and its imports fall, so that relative wages ω have to increase to balance trade. Combining both $T(\tilde{z})$ and $B(\tilde{z})$ determines the equilibrium relative wage $\tilde{\omega}$ and critical industry $\tilde{z}$ - see figure 2.

Given that the public bad b is local, $h > h^*$, and $s > s^*$, the trading equilibrium is one where the North specializes in goods that are intensive in their use of effective labor $z \in [0, \tilde{z}]$, while the South specializes in goods that are intensive in their use of the public bad $z \in [\tilde{z}, 1]$. This reflects both the North's comparative advantage in producing goods that generate less of the local public bad, as well as the fact that it sets higher standards, which follows from the fact that it has a higher income per capita than the South.

Over time, if there is labor-augmenting technological change in the South, their human capital h^* increasing, then the $T(\tilde{z})$ schedule in figure 2 will rotate downwards to $T'(\tilde{z})$, the South increasing its production of goods that are intensive in their use of effective labor from $\tilde{z}$ to $\tilde{z}'$. Due to the fact that the South's exports will increase and its imports fall, relative wages have to fall from $\tilde{\omega}$ to $\tilde{\omega}'$ in order that trade balances. At the same time as per capita incomes rise in the South, their level of standards s^* will also increase. In the limit, if North and South end up with similar levels of effective labor, $h = h^*$, and therefore similar levels of standards, $s = s^*$, the pattern of trade will be indeterminate. However, if $A/A^* > 1$, then the North will be a net exporter of embodied labor services, while the South will be a net exporter of the embodied public bad.

2. Standards as "Barriers" vs. "Catalysts" to Food Trade

By assumption, the result presented in figure 2 is based on aggregate damage *D* only resulting from a local public bad, $[D; b^1 > 0; b^2 = 0]$, food standards being benign in that their level simply reflects the relative development of the North versus the South. Suppose, however, that the public bad produced in the South also has measurable or perceived effects in the North, i.e., $[D; b^1 > 0; b^2 > 0]$. For example, while the local public bad in the South is measurable pesticide runoff into drinking water supplies, consumers in the North may also be concerned about the potential for pesticide residues on food consumption goods imported from the South. It has been noted, for example, that Northern consumers' perceptions of risk may be strongly influenced by the structure and organization of their media (Swinnen and Vandemoortele 2009). As a result, consumers in the North demand that Northern standards *s* also be applied to goods imported from the South.

These standards can either be supplied publicly, or they could be private standards established for example by coalitions of food retailers in the North (Henson 2008). It should be noted that in this model, firms producing consumption goods in both North and South have no private incentive to reduce production of the public bad. However, if retailers of consumption goods in the North are allowed for, they may have an incentive to establish private standards either as a means of mitigating reputational and commercial risks (see Fulponi 2007; Henson and Jaffee 2008; Maertens and Swinnen 2008) or because they have an incentive to pre-empt public with private standards (see McCluskey and Winfree 2009).

Empirical evidence suggests that higher standards facing exporters can have a significant impact on their compliance costs, resulting in substantial reductions in exports (Otsuki *et al.* 2001; Essaji 2008; Wilson 2008). Following Dornbusch, Fischer and Samuelson (1977), the

additional compliance costs due to application of the higher Northern standard *s* on the range of goods imported by the North, are modeled as iceberg transport costs, g^*. This implies that only a fraction $g^*(z)$ of any commodity *z* actually arrives, the relationship between unit costs in the North and South being re-written as $a(w_e, c_b; h, z) \leq [a^*(w_e^*, c_b^*; h^*, z)] / g^*$.

Graphically, introducing such costs results in a new schedule $T'(\tilde{z}) / g^*$ in figure 3, such that for a given relative wage $\tilde{\omega}$, there will be a set of non-traded goods between $(\tilde{z} - \tilde{z}')$. In other words the North continues to produce and export goods in the range $z \in [0, \tilde{z}]$, for which it has a comparative advantage, but it also produces goods in the range $(\tilde{z} - \tilde{z}')$ as it is cheaper than importing those goods, although it cannot export these goods to the South as they can still be produced more efficiently in the South. The South also produces non-traded goods in the range $(\tilde{z} - \tilde{z}')$, but its exports are reduced to the range $z \in [\tilde{z}', 1]$.

This result also provides a motive for firms in the North to lobby for higher standards to be imposed on imports from the South, thereby allowing them to produce the range of non-traded goods that they otherwise would not produce. Therefore, introducing iceberg transport costs into the model can be interpreted as broadly capturing the 'standards as barriers' hypothesis, illustrating the concerns developing countries have about proliferation of food standards and technical regulations in developed countries (both public and private), and why calls for harmonization of standards by the North are often regarded with suspicion by developing countries (Bhagwati 1996).

Recently, however, several authors have put forward the hypothesis that rather than barriers, higher food standards in developing countries may be a 'catalyst to trade' (Henson and Jaffee 2008; Maertens and Swinnen 2008; Anders and Caswell 2009). Henson and Jaffee (2008) argue that being forced to comply with higher standards provides an incentive to firms and regulators

in developing countries to invest in their ability to meet such standards, i.e. to increase h^*. Specifically, Henson and Jaffee (2008) appeal to Porter and van de Linde's (1995) argument that there will be regulatory-induced innovation at the firm level. Crudely, the 'standards as catalysts' hypothesis is represented in figure 3 by the shift in the $T'(\tilde{z})/g^*$ schedule to $T''(\tilde{z})/g^*$ as an increase in effective labor h^* in the South offsets the costs of complying with higher standards in the North.

Anders and Caswell's (2009) recent analysis of the impact of US food safety standards on imports of seafood provides some early empirical support for the hypothesis of 'standards as catalyst'. Specifically, they find that among their sample of developing exporters to the US, standards appear to act as a catalyst for larger exporters and a barrier for smaller exporters. These results are somewhat surprising in light of Palmer, Oates and Portney's (1995) critique of the hypothesis of regulatory-induced innovation – *a priori*, if it is unprofitable for firms to invest in abating a public bad prior to implementation of tougher standards, there will be no incentive for firms to invest after implementation of said standards.

Why else might there be an increase in effective labor in the South h^* in the presence of higher standards in the North? In principle, greater international economic integration could result in developing countries having greater access to technology, allowing them to better comply with higher standards in developed countries. For example, there is empirical evidence that private standards are already being implemented in developing countries by multinational food retailers (Reardon and Berdegue, 2002).

Therefore rather than assuming uniform labor-augmenting technological change, the latter case can be captured by treating technical progress in the South as a transfer of technology in the form of more effective human capital from the North to the South (Dornbusch *et al*., 1977).

Specifically, if the level of human capital *h* necessary for goods to meet the higher Northern standard is transferred from North to South this will narrow the gap in average costs of production for all goods in the continuum *z*, thereby rotating the $T(\tilde{z})$ schedule to $T'(\tilde{z})$ as in figure 2. As a result, the South will increase the range of goods it produces and exports to the North, i.e., from $\tilde{z}$ to $\tilde{z}'$. In other words, the empirical inference that, higher standards in the North are a catalyst to improving the quality of human capital in the South, could be observationally equivalent to an equivalent transfer of human capital from North to South due to the activities of multinational firms.

Finally, in the absence of private technology transfer by Northern firms, suppose that development aid from the North to the South is tied to abatement of the public bad - see for example, Chao and Yu (1999). This possibility captures the argument that aid should aim to improve developing countries' ability to meet higher standards (Essaji, 2008). Assume tied aid comes in the form of a transfer of the necessary human capital *h* for goods to meet higher Northern standards, and the cost of this transfer τ is reflected in a decrease in Northern income, (I-τ), i.e., tied aid improves productive capacity in the South, but has a redistributive effect in the North. Compliance costs in the North become $c_b = \beta D^{\gamma-1}(I-\tau)$, which leads to (7) being re-written as:

$$\frac{c_b^*}{c_b} = \left(\frac{\psi^*(\tilde{z})}{\psi(\tilde{z})} + h(\tau,\tilde{z})\right)^{1/\gamma}\left(\frac{\phi^*(\tilde{z})}{\phi(\tilde{z})}\right)^{(\gamma-1)/\gamma} \equiv C(\tilde{z},\tau), \qquad (7')$$

where $h(\tau,\tilde{z}) = D/\psi(\tilde{z})(I-\tau)$, and after substitution, (8) becomes:

$$\tilde{\omega} \equiv \frac{w}{w^*} \le \frac{A}{A^*}[C(\tilde{z},\tau)]^{\alpha(\tilde{z})/(1-\alpha(\tilde{z})} \equiv T(\tilde{z},\tau). \qquad (8')$$

Tied aid has two effects: first, there is a productive effect in the South due to the transfer of *h*, i.e., $T(\tilde{z},\tau)$ rotates down, the South increasing its production of goods that are intensive in their use of effective labor; second there is an income effect in the North resulting in a lower compliance costs c_b, causing $T(\tilde{z},\tau)$ to rotate up, the North increasing its production of goods that are intensive in their use of the public bad. The overall impact on trade depends on relative factor prices, which in turn depends on the strength of the income effect in the North and the elasticity of supply of the public bad in the South. This compares with the case of untied aid to the South where there is only an income effect, the $T(\tilde{z},\tau)$ schedule rotating up.

3. Summary and Conclusions

Given the proliferation of food standards and technical regulations in the past two decades, the focus of this paper has been on the interaction between such standards and international trade. Specifically, this interaction was set in the context of the tension between food standards as a response to market failures and the potential for protection to domestic producers. The analytical results presented reinforce an observation made by Wilson (2008): food standards are not like tariffs if their objective is to take care of market failures, however, it is important that not only are they applied in a non-discriminatory manner, but also any agreement between countries about standards has to ensure the benefits of economic integration are realized, without undermining the resolution of market failures.

Based on production of local public bad(s), a model of international trade was presented showing that compared to developing countries (the South), if developed countries (the North) have more effective labor, and higher standards, the North specializes in producing and exporting food consumption goods intensive in their use of effective labor, while the South

specializes in producing and exporting food and consumption goods intensive in their use of the public bad. With an increase in effective labor in the South, their standards converge on those of the North, reinforcing Casella's (1996) original argument that harmonization of standards as a pre-condition for trade liberalization is unnecessary.

If the public bad produced in the South has the potential to impose actual or perceived damage on consumers in the North, exports of food consumption goods from the South are likely to face higher standards (public or private) imposed in the North. Treating higher standards on Southern exports as iceberg transport costs, results in a range of non-traded goods – the hypothesis of 'standards as barriers', one that has support in much of the empirical work on food standards and trade. In principle, the competing hypothesis of 'standards as catalysts' can be characterized in the model as an increase in effective labor in the South, allowing it to better comply with higher Northern standards - although an increase in effective labor in the South, might also come about due to the transfer of human capital from the North, either through multinational firms or through tied aid.

In conclusion, the general equilibrium model outlined is pretty robust in terms of its analysis of standards, providing a theoretical basis for the extensive empirical work that supports the hypothesis of 'standards as barriers' to trade. However, there is need for more rigorous modeling of two issues that have received increasing attention, and which are now being included in empirical analysis. First, private standards need to be more thoroughly embedded into models where by assumption firms have no private incentive to reduce their production of public bad(s). Second, the rather *ad hoc* hypothesis of 'standards as catalysts', for which there is so far only limited empirical support, also requires an underlying dynamic theory of why developing countries innovate in the face of higher standards in developed countries.

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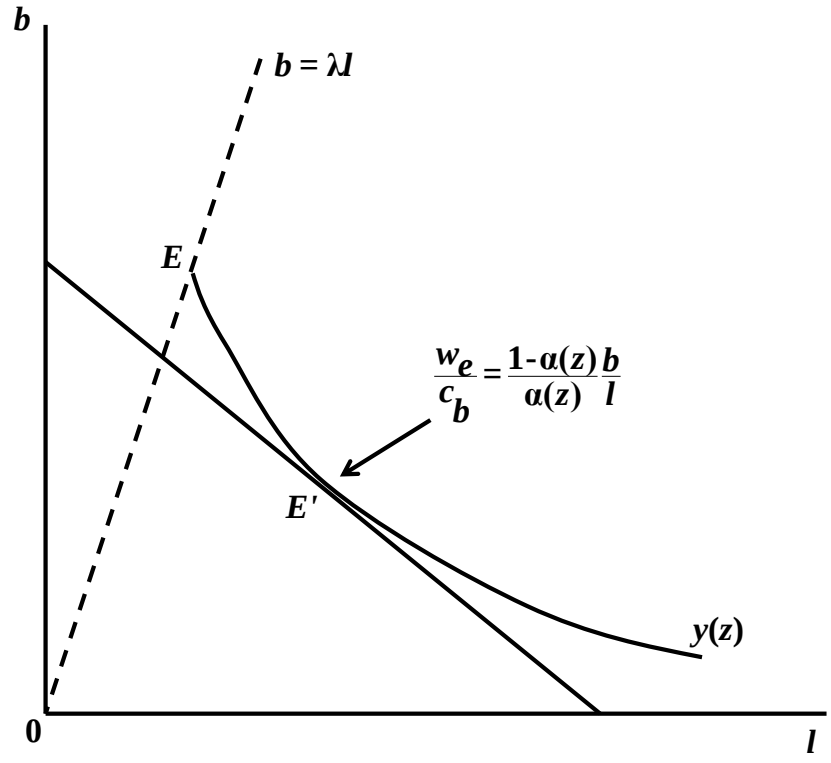

Figure 1

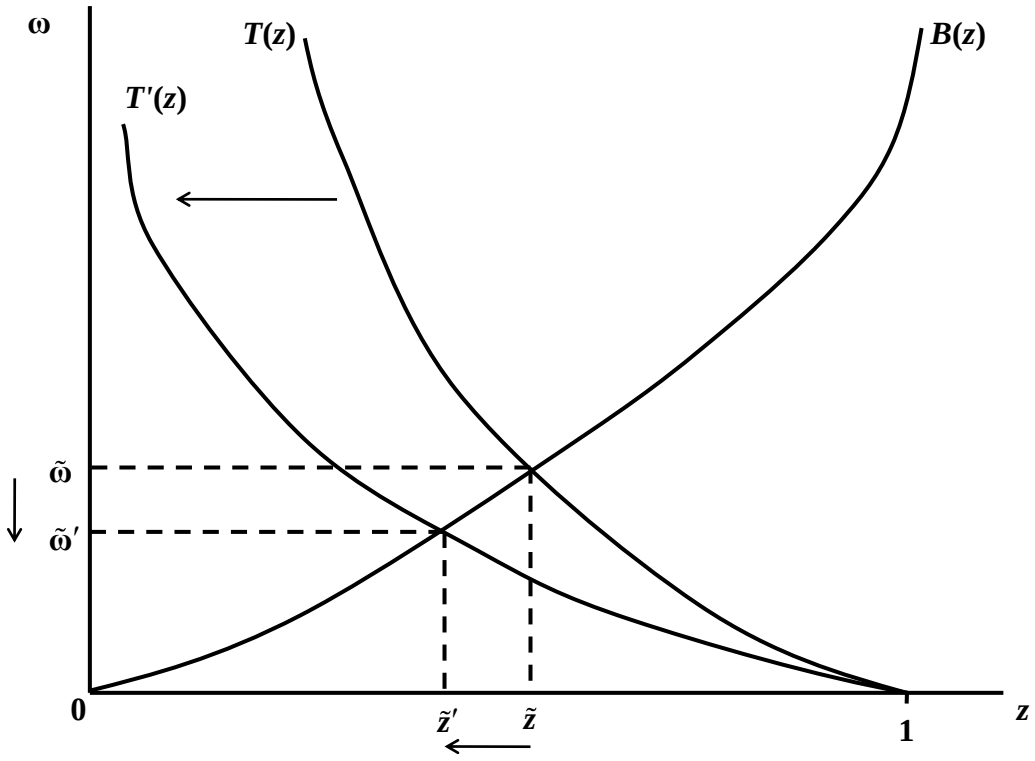

Figure 2

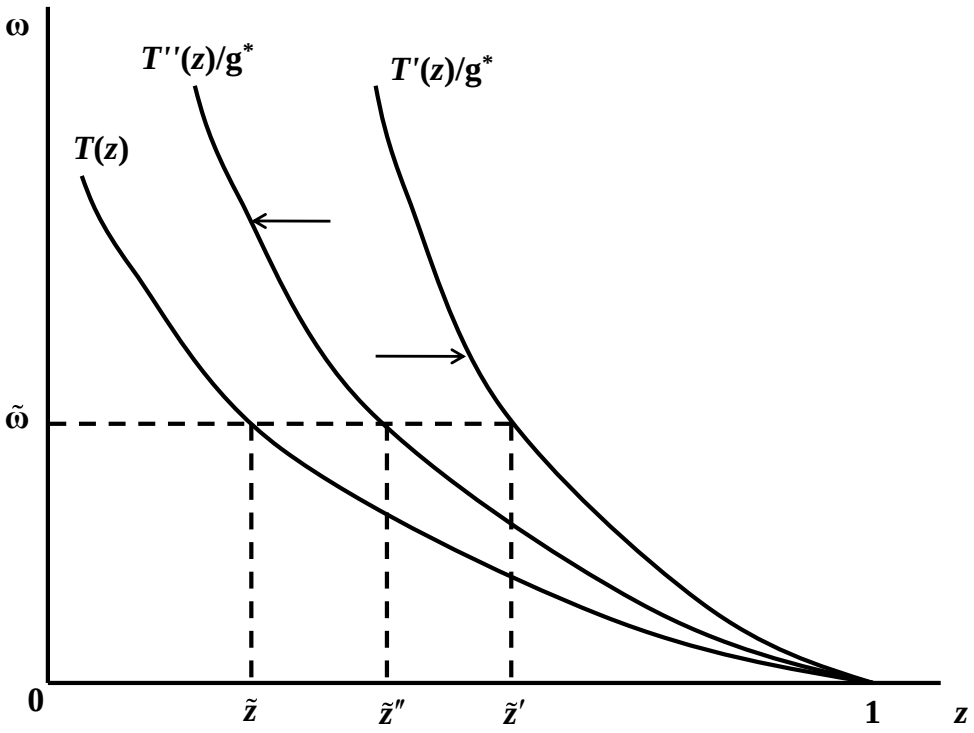

Figure 3