The Race to the Bottom, From the Bottom*

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Abstract: The dominant perspective in discussions of labor and environmental standards and globalization is that of North-South competition and its impact on Northern standards. This paper presents an alternative perspective, that of South-South competition to export to the North, and its impact on Southern standards. It develops a simple model of Southern competition on standards, which can begin to provide insights into some key questions. A Southern race to the bottom is possible but not inevitable. It depends intricately on the Northern demand curve, the size of big exporters relative to each other, and the relative size of the competitive fringe of small exporters – a precise and complete characterization is developed in the paper. The paper also analyzes the effect of Northern tariffs on Southern strategic competition in standards. It is shown that Northern trade protectionism undermines Southern standards.

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Non-technical Summary

Does Chinese trade competition pose a threat to labor and environmental standards in other big developing countries such as India? Are standards in India and China pulled down by standards in small countries such as Myanmar, Honduras or South Africa? Does trade protectionism in the US protect standards in developing countries, or does it undermine them?

These are questions of extraordinary and growing importance to poor countries in a globalizing world. Yet one finds very little in the way of analysis which speaks to them. This is because the dominant perspective in present discussions is one of competition between the rich North and the poor South, and the consequences of this for standards in the North. Even the well worn phrase "race to the bottom" has typically come to be seen in terms of downwards pressure on Northern standards as a result of competition from the South. Not surprisingly, the dominant perspective has produced a large analytical literature. The perspective of South-South competition and its impact on Southern standards has produced far less. The purpose of this paper is to develop a simple model that can begin to provide insight into this perspective on the race to the bottom as seen from the bottom, and to provide preliminary answers to the three questions posed above.

Consider a world in which large and small Southern countries export to the North. Each Southern country has the choice of a high or a low standard. A high standard conveys direct benefits to workers, but has indirect costs through higher labor costs and hence reduced output, exports and revenues. These benefits and costs have to be balanced against each other in the choice of higher or lower standards.

A key issue is the effect on the terms of trade – actual, or perceived. If small exporters are individually too small to affect, or to perceive the effect on, terms of trade, considerations of expanding market share are likely to dominate. Thus small exporters will end up with lower standards. In contrast, each big exporter worries about terms of trade effects of its own output choices, the output of its rivals, and hence their choice of standards. We consider mutually consistent choice of standards in the strategic interaction between big exporters and ask whether and when these standards are likely to be high or low.

We find that among the big exporters, the bigger ones are more likely to end up with the higher standards since they suffer bigger terms of trade losses as result of adopting lower standards and thereby putting a large increase in output on the market. Putting this together with the finding that small exporters will always adopt the low standard thus suggests a positive association between export market share and high standards.

The competition on standards between the big exporters is framed by the total size of the "competitive fringe" of individually small exporters, and by the nature of Northern demand, in particular by its price responsiveness. A key question concerns the incentives to adopt high standards for a big exporter as a function of the output of those who have low standards. When a big exporter adopts high standards, its output and exports are reduced but its terms of trade improve. So the magnitude of the terms of trade improvement as output falls is important. Is this improvement bigger when total output of all exporters is bigger (as a result of low standards elsewhere), or is it smaller? The answer depends on the precise shape of the Northern import demand curve. Depending on this shape, standards across countries are either "complements" or "substitutes". When they are complements adoption of high standards by some increases the incentives for others to do the same. When they are substitutes, the opposite is the case. Complementarity or substitutability is an empirical matter for each commodity in question and in principle one is as likely as the other. The analysis therefore has to be conducted for each case.

When standards are complements, a larger competitive fringe of small exporters is more likely to produce lower standards in big exporters-the lower standards of the former reduce the incentives for the latter to adopt high standards. When standards are substitutes, a larger competitive fringe is likely to produce higher standards in big exporters.

If the big exporters end up with a situation where one or both of them has low standards, is it worthwhile coordinating to achieve high standards? The answer depends intricately on their relative sizes and on the size of the competitive fringe. In general, coordination is more likely to be desirable, and successful, the more equal are the big exporters in their market share. With very unequal market share the biggest exporter acts more and more like a monopolist and is unlikely to benefit from coordination. At the same time, coordination is more likely to be desirable when the competitive fringe gets smaller and standards are complements, or when the fringe gets bigger and standards are substitutes.

Consider now what happens when the North imposes an import tariff and Southern strategic interaction on standards takes place in the shadow of this tariff. With a given tariff, the revenue gains from undercutting on standards to expand market share are now lower than before. The incentives to undercut are reduced and the big exporters are more likely to adopt high standards (the small exporters will always perceive expansion of market share as their best policy, and hence will continue to choose low standards). In this sense, Northern protection could support high standards among the big exporters in the South. But this is only half the story. It supposes that the North does not in turn react to the choice of standards in the South by adjusting tariffs – indeed, adjusting them optimally in its own interest. If this is the case, and the hierarchy of decision making is reversed, the North can and will adjust tariffs to undo any terms of trade gains to the

South from adopting high standards, since the South's gain is mirrored by the North's loss. The result of such adjustment is that the big Southern exporters' incentives to adopt high standards are drastically reduced, and low standards outcomes are much more likely.

Let us return to the three questions posed at the outset. The answer to the first question depends on the relative size of an "India" or a "China". The larger country will tend to have higher standards but, in general, asymmetry in size makes coordination on high standards more difficult. The answer to the second question depends on the nature of Northern demand. If the price responsiveness of Northern demand makes standards complements, then low standards in small exporters do indeed exert a downward pull on standards in large exporters. But the opposite is true if standards are substitutes – this is an issue that can only be resolved empirically. Finally, the answer to the third question depends on the hierarchy of decision-making on tariffs in the North and standards in the South. In the more realistic scenario where Northern countries choose tariffs in their own interest taking into account Southern choice of standards, Northern protectionism undermines Southern standards.

1 Introduction

Does Chinese trade competition pose a threat to labor and environmental standards in other big developing countries such as India? Are standards in India and China pulled down by standards in small countries such as Myanmar, Honduras or South Africa? Does trade protectionism in the U.S. protect standards in developing countries, or does it undermine them?

These are questions of extraordinary and growing importance to poor countries in a globalizing world. Yet one finds very little in the way of analysis which speaks to them. This is because the dominant perspective in present discussions is one of trade competition between the rich North and the poor South, and the consequences of this for standards in the North:

> "Labor unions and human rights activists in developed countries argue that market access in the North should be conditioned on raising labor standards in the South to prevent social dumping and a "race to the bottom" in wages and benefits. Trade sanctions imposed in response to violations of labor standards are sometimes referred to as a "social clause". Developing countries tend to view such clauses as disguised protectionism and have fought vigorously against initiatives by the United States and other developed countries to give the WTO a role in the area of labor standards" (Kahn, 2000).

Thus even the well worn phrase "race to the bottom" has typically come to be seen in terms of downward pressure on Northern standards as a result of competition with the South. It should be clear that this dominant perspective cannot address the questions posed above. Recently, therefore, some commentators have begun to call for the shift of perspective that these questions demand – to a perspective which highlights South-South competition for export market share and its impact on Southern standards.

> "Consider the celebrated soccer ball industry .... The top five suppliers were Pakistan, China, Indonesia, India and Thailand, which together supplied 96.9 percent of soccer balls imported by the United States. It is also worth keeping in mind that the United States does not produce any soccer balls. If any of these countries is banned from exporting to the United States, it is highly unlikely that the demand will shift to another industrialized nation. It will be some other developing country which picks up the slack.... [L]abor standards are a great concern within the developing country. This concern is

> combined with a fear that any action on this front by any one country will cause a shift in production to some other developing country. Indians point out that China's lack of democracy enables it to use forms of forced labor, such as prison labor, that would not be feasible in India. China, on the other hand, worries about India's greater poverty pushing wages down and sending large numbers of children into forced labor" (Basu, 1999).

Not surprisingly, the dominant perspective has produced a large analytical literature.[1] The perspective of South-South trade competition and its impact on Southern standards has produced far less. There are isolated references in the literature to this perspective on the race to the bottom, from the bottom. For example, Brown, Deardorff and Stern (1996) discuss possible collusion among developing countries to raise standards. But there is very little analysis of the problem. Indeed, in their recent review Rollo and Winters (2000) note that "so far this argument has not figured at all in the debate."

Once the focus is shifted to trade competition among developing countries, it is no longer appropriate to treat them as an undifferentiated homogeneous group. In particular, there are big and small exporters in any commodity category. Basu's (1999) example of soccer balls shows exports to U.S. dominated by five "big" exporters. Similar size distribution patterns are present in exports to all countries, and in several commodity categories, as shown in Table 1. The sizeable shares of developing countries in major export markets suggest that there are potential price consequences when standards improve and output changes. In particular, Brown, Deardorff and Stern's (1996) suggestion to developing countries to collude on labor standards is based precisely on the possible terms of trade effects of collusion between such countries. However, while big exporters compete against each other, they also compete against smaller exporters who could take away market share. There have been dramatic instances of shifts of production – away from Iran in carpets, and towards textiles in Bangladesh, for example – which highlight

[1] Some recent contributions on labor standards are Bhagwati (1996), Brown, Deardorff and Stern (1996), Ehrenberg (1994), Kuruvilla (1996), OECD (1996), Krugman (1997), Mah (1997), Maskus (1997), Bagwell and Staiger (1998), Srinivasan (1998), Brown (2000). See Nordstrom and Vaughan (2000) for an excellent survey on the literature on environmental standards. Kanbur, Keen and Van Wijnbergen (1995) and Wilson (1996) examine the possibility of a race to the bottom in environmental regulations when capital is internationally mobile. Basu and Chau (2000) analyzes the race to the top in environmental standards in the presence of green consumerism.

the threat that the big exporters face. The thought which follows is that while big exporters will worry about the terms of trade consequences of their choice of standards and indeed about standards elsewhere, small ones will not. To extend Basu's (1999) analogy, while the competition between an India and a China in exports of soccer balls is important and needs to be analyzed, equally important is the interaction between this competition and the competition which the India's and the China's as a group face from the South Africa's and the Honduras' of the world.

One of the key features of the dominant perspective is the focus on the role of Northern protectionism and whether or not it is justified in light of North-South competition on standards. There is a fierce debate on whether requirements for higher standards in the South, as a part of trade agreements, are disguised protectionism, and whether Northern trade protection through tariffs is an appropriate response to a presumed downward pull on Northern standards. But the question which is not addressed in the dominant perspective is whether Northern trade protectionism hurts or benefits Southern standards, when the countries of the South are competing against each other in export markets. This is the third of the questions posed above, and on which there is again very little analysis.

The purpose of this paper is to develop a simple model that can begin to provide insight into this perspective on the race to the bottom as seen from the bottom, and to provide preliminary answers to the three questions posed at the beginning. Section 2 sets out the elements of a model of Ricardian trade, in which "big" and "small" Southern countries export into a Northern demand curve. Countries have the choice of adopting a high or a low "standard", which we will think of as a labor standard but which could equally be an environmental standard. The essential point is that there is an intervention which could directly enhance welfare but which also raises labor costs and hence reduces output and exports.

Section 3 explores the incentives that different countries have to adopt the high standard. Big exporters take into account the terms of trade effects, and standards in other countries, while the "competitive fringe" of small exporters do not. Given these incentives, Section 4 characterizes Nash equilibria in standards as a function of the

Northern demand curve, the size of the big exports relative to each other, and the size of the competitive fringe. It provides a precise and complete characterization of when high standards and low standards equilibria arise as the parameters vary.

Section 5 turns to welfare and asks if and when there exists the possibility of welfare improving coordination on high standards when the Nash equilibrium is a low standards equilibrium. Section 6 considers the consequences of a Northern tariff for the outcome of South-South competition on standards. In particular, it looks at whether the Northern tariffs increases or decreases the likelihood of low standards equilibrium in the South. It shows that the answer depends critically on the timing of whether the tariff is chosen before the standards are set in the South, or after.

Section 7 concludes. It revisits the three questions that motivated this paper, examines the answers which this paper provides, and suggests areas for further research.

2 The Model

We will develop the simplest trade model in which standards and competition among exporting countries can be analyzed. Let there be two internationally traded commodities, indexed by $j = 1, 2$, and a single internationally immobile but domestically mobile factor, labor. A single developed country imports good 1 from developing countries. The developing countries can be divided into two types. The first group of countries, labeled $i = 0$, is made up of many identical small open economies who take the world price of their exports as given. Without loss of generality, we normalize the number of these small countries to unity. The second group of exporters consists of two developing economies labeled $i = 1, 2$. We will refer to them as large exporters, in the sense that they take into account the terms of trade consequences of any changes in their exports. The Northern importing country is denoted by $*$.

Each exporting country, large or small, has the choice of a level of domestic standard s^i, where

$$s^i = \{s^-, s^+\}; s^+ > s^-; \quad i = 0, 1, 2 \tag{1}$$

so that s^+ denotes the higher standard. We think of this as a labor standard, but it could equally well be interpreted as an environmental standard. Choice of standard s^i affects production costs and the utility of workers in the country. Let us begin with the production costs story. Production technologies in the exporting and importing countries are assumed to be given by

$$\phi(s^i)a_j x_j = L_j; \ \ j = 1,2; \ \ i = 0,1,2 \tag{2}$$

$$a_j^* x_j^* = L_j^*, \ \ j = 1,2 \tag{3}$$

where L_j denotes labor employed in sector j, x_j is the output of sector j , a_j the input-output coefficient, and ϕ is a coefficient showing the cost consequences of adopting different standards (we focus solely on standards in the exporting countries). We assume

$$s^- = 1; \ \ \phi(s^-) = 1; \ \ \phi(s^+) > 1. \tag{4}$$

Thus we normalize the lower standard at unity, and normalize its effect on labor cost at neutrality. The higher standard lowers output per worker in each sector.

With technology as described by (2) and (3), the production frontiers of the exporting countries and the importing country are given by

$$\begin{aligned} \phi(s^i)a_1 x_1^i + \phi(s^i)a_2 x_2^i &= L^i; \ \ i = 0,1,2 \\ a_1^* x_1^* + a_2^* x_2^* &= L^*, \end{aligned} \tag{5}$$

where L^i denotes the labor endowment of country i. We assume that

$$\frac{a_1^*}{a_2^*} > \frac{a_1}{a_2} \tag{6}$$

so that developing countries have comparative advantage in production of good 1. Let good 2 be the numeraire and let p be the world price of good 1 relative to good 2. It is well known that if p lies in the range

$$\frac{a_1^*}{a_2^*} > p > \frac{a_1}{a_2} \tag{7}$$

then $i = 0,1,2$ will specialize in the production of good 1 and $*$ will specialize in the production of good 2. We will focus on this range of outcomes. With this pattern of specialization revenue functions can be written as

$$R^i(p, s^i) = \frac{pL^i}{\phi(s^i)a_1} \tag{8}$$

$$R^*(p) = \frac{L^*}{a_2^*}. \tag{9}$$

The production costs of higher standards are thus reflected in lower revenues as shown in (8), since $\phi(s^+) > \phi(s^-) = 1$.

The revenue losses associated with higher standards are to be set against the potential utility gains. We characterize these effects through the following utility function

$$U^i(c_1, c_2, s^i) = \alpha \log c_1 + (1-\alpha) \log c_2 + \log s^i; \quad i = 0, 1, 2 \tag{10}$$

where c_1 and c_2 represent consumption of the two commodities. Thus when $s^i = s^- = 1$, we have the base case of no effect on utility. But the higher standard $s^i = s^+ > 1$ raises utility directly. This utility function is of course restrictive. For example, it implies that the marginal rate of substitution in consumption between c_1 and c_2 is independent of the standard. But, as will be seen, the special form used in (10) serves to simplify the analytics and to provide sharp characterizations of equilibria.[2]

For exporting countries, maximizing (10) subject to the revenue constraint in (8) gives the following indirect utility function

$$V^i(p, s^i) = K + \log \frac{s^i L^i}{\phi(s^i)a_1} + (1-\alpha) \log p; \quad i = 0, 1, 2 \tag{11}$$

where $K = \alpha \log \alpha + (1-\alpha) \log(1-\alpha)$ is a constant in the analysis. The export supply functions are given by

$$X_1^i = (1-\alpha) \frac{L^i}{\phi(s^i)a_1}, \quad i = 0, 1, 2 \tag{12}$$

Notice from (12) that exports fall with the adoption of high standards, since $\phi(s^+) > 1$. For the importing country, denote utility, indirect utility and the inverse import demand function by

$$U^* = U^*(c_1, c_2), \quad V^* = V^*(p, R^*), \quad p = p^*(c_1^*, R^*). \tag{13}$$

[2]Without a doubt, standards are multifaceted (Fields, 2000). Brown, Deardorff and Stern (1996) points out that most labor standards are labor using, and effectively reduce the labor endowment of the country imposing the standard. In our model, these production effects of higher standards are subsumed under the term $\phi(s^i)$.

In what follows we drop the subscript representing commodity 1, it being understood that the focus is on exports and imports of $j = 1$. We also drop the superscript $*$ from $p^*(\cdot)$, it being understood that $p(\cdot)$ represents the inverse Northern import demand function for good 1.

From (12) it is clear that total exports depend critically on how many workers in the developing world fall under a high standards regime. Denote by ℓ the number of workers in all the exporting countries that have $s = s^+$. Also, define

$$L = L^1 + L^2 \tag{14}$$

as the labor endowment of the two big exporting countries. Then total exports can be written as

$$\begin{aligned} X_1(\ell) &= \sum_{i=0,1,2} X_1^i \\ &= \frac{1-\alpha}{a_1}\left[L^0 + L - \ell(1 - \frac{1}{\phi(s^+)})\right] \end{aligned} \tag{15}$$

World trade equilibrium is given by a market clearing relative price p, such that

$$p = p(X(\ell)) \tag{16}$$

where we have suppressed the dependence of p on R^*. Notice that

$$\frac{\partial X}{\partial \ell} = -\frac{1-\alpha}{a_1}\left(1 - \frac{1}{\phi(s^+)}\right) < 0. \tag{17}$$

since $\phi(s^+) > 1$. As more and more workers came under the high standards regime, production costs rise and output falls, as do exports. We assume that $p(\cdot)$ is downward sloping. Hence

$$\frac{\partial p}{\partial \ell} = \frac{\partial p}{\partial X}\frac{\partial X}{\partial \ell} > 0 \tag{18}$$

in other words, higher standards lead to an improvement in the terms of trade for exporters.

We can thus characterize world trade equilibrium when ℓ of the workers in the developing world come under the high standards regime. But what determines ℓ? The next section considers the incentives for each country to adopt or not adopt the high standard, and provides a precise characterization of the patterns of incentives as country size and import demand varies.

3 Incentives for Adopting Standards

We assume that country i adopts the higher standard if its welfare V^i with $s^i = s^+$, denoted V^{i+}, is greater than welfare with $s^i = s^- = 1$, denoted V^{i-}. Let the number of workers other than those of country i who have the higher standard be ℓ^{-i}. Then country i's adoption of the higher standard increases ℓ from ℓ^{-i} to $\ell^{-i} + L^i$. From (11), the gain in welfare from adopting the high standard is

$$\begin{aligned} \Delta^i(\ell^{-i}, \ell^{-i} + L^i) &= V^{i+} - V^{i-} \\ &= \log \frac{s^+}{\phi(s^+)} + (1-\alpha)\Big[\log p(X(\ell^{-i} + L^i)) \\ &\quad - \log p(X(\ell^{-i}))\Big]; \quad i = 0, 1, 2 \end{aligned} \tag{19}$$

where $p(X(\ell^{-i} + L^i))$ and $p(X(\ell^{-i}))$ are the equilibrium terms of trade from (16), as different numbers of workers come under the higher standard.

Expression (19) captures the different forces acting on welfare. First is the direct effect on welfare through s^+. Second is the production cost effect through $\phi(s^+)$. Third, there is the terms of trade effect

$$\log p(X(\ell^{-i} + L^i)) - \log p(X(\ell^{-i})).$$

Since p is increasing in ℓ from (18), the terms of trade effect is always positive. It follows that if the direct utility effect of the standard s^+ is bigger than the production cost effect $\phi(s^+)$, it is always worthwhile adopting the higher standard. In this case all countries would choose $s = s^+$ and there would be nothing left to analyze on choice of standard. To focus attention on the problems we are interested in, therefore, we assume

Assumption 1

$$\log \frac{s^+}{\phi(s^+)} < 0. \tag{20}$$

Thus the production cost effect has to be traded off against direct gains in utility and terms of trade gains.

The assumption in (20) immediately determines the outcome in our model for "small" exporters – in other words, those who take the terms of trade as given. For these countries $p(\ell^{-0} + L^0)$ is *perceived* to be the same as $p(\ell^{-0})$, so from (19) and (20)

$$\Delta^0 < 0 \tag{21}$$

and we have our first proposition.

Proposition 1 *Small exporters always adopt the lower standard.*

For small exporters, expanding market share improves welfare, so they always stick to the lower standard. As we shall see, the relative weight of small exporters in overall exports critically affects, in turn, the choice of standard in the big exporting countries.

We assume that the big exporting countries, $i = 1, 2$, fully perceive and take into account the terms of trade effect in evaluating the gains from adopting the higher standard. From (19), this gain depends on ℓ^{-i} and $\ell^{-i} + L^i$. A central issue is whether Δ^i increases or decreases with ℓ^{-i}, the number of workers in other countries who are already under the high standard. To this end, we propose the following definition:

Definition 1 *Standards are complements (substitutes) if the net gain to a country from adopting the high standard increases (decreases) with the number of workers in other countries who are already under the high standard.*

Complementarity or substitutability of standards, as defined above, will prove a crucial determinant of incentives and of equilibrium outcomes.[3] Since X is linear and decreasing in ℓ^{-i},

$$\frac{\partial \Delta^i(\ell^{-i}, \ell^{-i} + L^i)}{\partial \ell^{-i}} \begin{matrix} > \\ < \end{matrix} 0 \text{ according as } \log p(X) \text{ is} \left\{ \begin{matrix} \text{convex} \\ \text{concave} \end{matrix} \right\}. \tag{22}$$

(22) immediately gives us the following proposition.

[3]The discussion here is closely related to that of strategic complementarity and substitutability as in Bulow, Geanakoplos and Klemperer (1985).

Proposition 2 *Standards are complements (substitutes) if and only if the inverse import demand function is logconvex (logconcave).*

Logconcavity and logconvexity of the demand function can be related to standard demand functions as follows:

Lemma 1 *1. If $p(X)$ is a constant elasticity function, it is logconvex.*

2. If $p(X)$ is linear, it is logconcave.

The proof of this lemma is straightforward, but what it shows is that two commonly used demand functions give diametrically opposite answers to whether standards are complements or substitutes and thus, as we shall see in the next section, lead to very different equilibrium outcomes in patterns of standards.

Having delineated when gains from high standards increase or decrease with other adoptions of high standards, we are now in a position to characterize incentives in each of the two large exporting countries to adopt the high standard, conditional on the other country having, or not having, done so. We will be particularly interested in how their relative size affects these incentives. To this end, recall from (14) that $L = L^1 + L^2$ is the total labor endowment of the big exporters, and define

$$L^1 = \frac{L}{2} + \delta, \quad L^2 = \frac{L}{2} - \delta. \tag{23}$$

Thus as δ varies between $(-L/2, L/2)$ it measures the size of country 1 relative to that of country 2.

First of all, consider the gain for country 1 of adopting the high standard when country 2 has not done so. We denote this by Δ^1_- where the superscript refers to the country in question and the subscript denotes the level of standard in the other country ($-$ or $+$). Since from Proposition 1 the small exporters never adopt the high standard, in this case, $\ell^{-1} = 0$ and $\ell^{-1} + L^1 = L^1 = \frac{L}{2} + \delta$. From the definition of total exports $X(\ell)$ in (15) we have

$$\begin{aligned} X(\ell^{-1}) &= X(0) = \frac{1-\alpha}{a_1}(L^0 + L) \\ X(\ell^{-1} + L^1) &= X(L^1) = \frac{1-\alpha}{a_1}\left[L^0 + L - (\frac{L}{2} + \delta)(1 - \frac{1}{\phi(s^+)})\right]. \end{aligned}$$

Thus from (19)

$$\begin{aligned}
\Delta^1_- &= \Delta^1(0, \frac{L}{2} + \delta) \\
&= \log \frac{s^+}{\phi(s^+)} + (1-\alpha)\left[\log p(X(\frac{L}{2}+\delta)) - \log p(X(0))\right]. \qquad (24)
\end{aligned}$$

Now consider the gain for country 1 from adopting the high standard when country 2 has already done so. Denote this Δ^1_+. In this case $\ell^{-1} = L^2 = \frac{L}{2} - \delta$, and $\ell^{-1} + L^1 = L^2 + L^1 = L$,

$$\begin{aligned}
X(\ell^{-1}) &= X(L^2) = \frac{1-\alpha}{a_1}\left[L^0 + L - (\frac{L}{2} - \delta)(1 - \frac{1}{\phi(s^+)})\right], \\
X(\ell^{-1} + L^1) &= X(L) = \frac{1-\alpha}{a_1}\left[L^0 + L - L(1 - \frac{1}{\phi(s^+)})\right].
\end{aligned}$$

So from (19),

$$\begin{aligned}
\Delta^1_+ &= \Delta^1(\frac{L}{2} - \delta, L) \\
&= \log \frac{s^+}{\phi(s^+)} + (1-\alpha)\left[\log p(X(L)) - \log p(X(\frac{L}{2}-\delta))\right]. \qquad (25)
\end{aligned}$$

By similar reasoning we can derive the gains for country 2 from adopting higher standards when country 1 has not done so, denoted Δ^2_+ and when country 1 has already done so, denoted Δ^2_-:

$$\begin{aligned}
\Delta^2_+ &= \Delta^2(0, \frac{L}{2} - \delta) \\
&= \log \frac{s^+}{\phi(s^+)} + (1-\alpha)\left[\log p(X(L) - \log p(X(\frac{L}{2}-\delta))\right] \qquad (26) \\
\Delta^2_- &= \Delta^2(\frac{L}{2} + \delta, L) \\
&= \log \frac{s^+}{\phi(s^+)} + (1-\alpha)\left[\log p(X(L)) - \log p(X(\frac{L}{2}+\delta))\right]. \qquad (27)
\end{aligned}$$

Consider how the gains from adopting higher standards vary with two key parameters – L^0, the weight of small exporters as a group, and δ, which captures the size of the two big exporters relative to each other.[4] Inspection of (24) shows that as L^0 increases

[4] The basic thrust of the propositions of this paper is unaltered if we consider not L^0 but the share $L^0/(L^0 + L^1 + L^2)$.

Δ^1_- increases or decreases according as $p(X)$ is logconvex or logconcave. In fact, inspection of (25), (26) and (27) shows that the same is true for Δ^1_+, Δ^2_+ and Δ^2_-. This leads to our next proposition.

Proposition 3 *As the weight of small exporters increases, the gain to the large exporters from adopting high standards increases if the inverse demand function is logconcave and decreases if it is logconvex.*

The intuition behind this follows from Proposition 2. An increase in L^0 increases the number of workers falling under the low standards regime. If standards are complements ($p(\cdot)$ is logconvex) this will reduce incentives for others to adopt high standards. If on the other hand standards are substitutes ($p(\cdot)$ is logconcave), lower standards elsewhere will increase the incentive for the big exporters as a group to adopt high standards.

Let us turn to variations in δ for fixed L^0. Inspection of (24) shows that, since $\phi(s^+) > 1$ and $p(\cdot)$ is a decreasing function, Δ^1_- is increasing in δ. The intuition is as follows. With country 2 fixed at the low standard, when country 1 adopts the low standard the total number of workers in the low standard regime is zero, independent of δ. But when country 1 adopts the high standard the number of workers in the low standard regime is reduced by $(L/2 + \delta)$. This reduction is greater, output is lower, and price and welfare is higher, the bigger is δ. Hence the gains from country 1 adopting the higher standard are increasing in δ. Similar reasoning, or direct inspection of (25), (26) and (27), shows that Δ^1_+ is increasing in δ and Δ^2_+ and Δ^2_- are decreasing in δ. These are all captured in the following proposition:

Proposition 4 *As the relative size of a big exporter grows, its gain from adopting the higher standard increases.*

Propositions 3 and 4 characterize when the gains from adopting a high standard increase or decrease as L^0 and δ vary parametrically. But actual adoption or otherwise depends on whether the gains are positive or negative. To partition the (δ, L^0) space into regions where the high standard yields positive or negative benefits, we need the following four loci:

$$\Delta_-^1 = 0 \quad \Leftrightarrow \quad \delta = \delta_-^1(L^0) \tag{28}$$

$$\Delta_+^1 = 0 \quad \Leftrightarrow \quad \delta = \delta_+^1(L^0) \tag{29}$$

$$\Delta_-^2 = 0 \quad \Leftrightarrow \quad \delta = \delta_-^2(L^0) \tag{30}$$

$$\Delta_+^2 = 0 \quad \Leftrightarrow \quad \delta = \delta_+^2(L^0) \tag{31}$$

Proposition 3 suggests strongly that any partitioning of (δ, L^0) space will depend crucially on whether the inverse import demand curve is logconvex or logconcave. Let us develop the partitioning first of all for the case of logconvexity, that is, complementarity of standards. It follows immediately that the locus $\delta_-^1(L^0)$ is upward sloping in (δ, L^0) space, and that below this locus $\Delta_-^1 > 0$ and above it $\Delta_-^1 < 0$, as shown in Figure 1. To see the reasoning behind the partition shown there, start from a point on the locus, so that $\Delta_-^1 = 0$. Then from Proposition 4 increasing δ makes $\Delta_-^1 > 0$ and decreasing it makes $\Delta_-^1 < 0$. And from Proposition 3, starting form a point on the locus and increasing L^0 makes $\Delta_-^1 < 0$ and decreasing L^0 makes $\Delta_-^1 > 0$, given the assumption of complementarity (logconvexity of the demand function). It is then also easy to see that $\delta_-^1(L^0)$ must be upward sloping, as shown.

Figure 2 adds a partitioning into positive or negative gains for country 1 when country 2 has already adopted the higher standard, still under complementarity. By the same reasoning as before, using Propositions 3 and 4, the locus $\delta_+^1(L^0)$ is also upward sloping. But it must also lie above $\delta_-^1(L^0)$, except when $\delta = L/2$ as shown in Figure 3. To see this, start from any point on the $\delta_-^1(L^0)$ locus, so that Δ_-^1 in (24) is zero. We show that at this point Δ_+^1 in (25) must be positive for $\delta < L/2$ because by adding the amount

$$-(\frac{L}{2} - \delta)(\frac{1}{\phi(s^+)} - 1)$$

to each of the terms

$$L^0 + L - (\frac{L}{2} + \delta)(1 - \frac{1}{\phi(s^+)})$$

and

$$L^0 + L$$

in expression (24) converts it to expression (25). But by logconvexity of $p(\cdot)$ it follows that if (24) is zero, (25) must be positive for $\delta < L/2$. Now if $\delta = L/2$, $\Delta^1(L/2 - \delta, L) = \Delta^1(0, L) = \Delta^1(0, L/2 + \delta)$. Thus, the $\delta_-^1(L^0)$ locus and $\delta_+^1(L^0)$ locus coincide exactly at $\delta = L/2$. Intuitively, there is just one large country when $\delta = L/2$, and country 2's decision to adopt high or low standard has no impact on the net benefits of high standards to country i.

Thus with complementarity Figure 2 gives the exact partitioning of (δ, L^0) space into regions where country 1's gains from adopting high standards are positive or negative. It is seen that with L^0 low enough and δ large enough, country 1 benefits from adopting high standards no matter what country 2 does. With L^0 high enough and δ small enough, country 1 loses from the high standard no matter what country 2 does. In between these extremes, whether country 1 gains or loses from high standards depends on what country 2 does.

By reasoning similar to that which led to Figure 2, Figure 3 plots the loci $\delta_-^2(L^0)$ and $\delta_+^2(L^0)$. It can be shown that $\delta_-^2(L^0)$ and $\delta_+^2(L^0)$ are downward sloping and that $\delta_+^2(L^0)$ strictly lies above $\delta_-^2(L^0)$ for $\delta > -L/2$ under complementarity. In addition, $\delta_+^2(L^0)$ and $\delta_-^2(L^0)$ coincides at $\delta = -L/2$. Finally, Figures 2 and 3 can be overlaid to give Figure 4 which provides a complete account of the gains and losses for the two countries from adopting high standards under complementarity. As can be seen even our very simple model leads to a complex pattern of incentives for each country, conditional on the behavior of the other country.

The patterns may be complex, but they have an intuitive explanation based on the reasoning leading up to Figure 4. Consider first of all regions A, B, and C at the top of the Figure, where L^0 is "large". In these regions the predominant thrust of the incentives is in favor of the low standard, either because both countries lose from the high standard no matter what the other country does (region A), or because one country loses from the high standard no matter what the other country does and the other country loses from the high standard if the first country has a low standard (regions B and C). By similar and symmetric reasoning, in regions D, E and F, where L^0 is "small", the thrust of the incentives is in favor of the high standard.

In regions G and H, the incentives are dramatically opposite for the two countries depending on size. When country 1 is large enough, in region H, it has the incentive to adopt high standards no matter what country 2 does, while country 2 has the incentive to adopt low standards irrespective of what country 1 does. The situation is reversed in region G, where country 2 is the relatively large one. Regions G and H illustrate Proposition 4 further – relative largeness helps incentives for high standards for a big exporter. This leaves region I, where neither of the two big exporters is very large relative to the other, and the "small exporters" group is neither very large nor very small. In this intermediate region, incentives for either country to adopt the high standard are only positive if the country also adopts the high standard – otherwise the incentive is negative.

All of the above discussion is for the case of complementarity, or logconvexity of the inverse import demand function. How is the partitioning affected when standards are substitutes and the demand function is logconcave? The answer is that the reasoning is modified at several crucial steps, leading to a very different type of partitioning of (δ, L^0) space. To illustrate this, consider what the locus $\delta^1_-(L^0)$ would look like under substitutability. This is shown in Figure 5, which graphs $\delta^1_-(L^0)$ as a downward sloping curve such that above the curve $\Delta^1_- > 0$ and below it $\Delta^1_- < 0$. To see this, start from a point on this locus, where by definition $\Delta^1_- = 0$, and increase L^0 while holding δ constant. From Proposition 3, $\Delta^1_- > 0$ under logconcavity. Since standards are now substitutes, having more workers elsewhere with lower standards increases the benefit to country 1 from adopting the higher standard. Also, Proposition 4 tells us that increasing δ from the locus will make $\Delta^1_- > 0$. These two features together establish that the locus $\delta^1_-(L^0)$ is downward sloping.

With country 2 having the high standard, $\delta^1_+(L^0)$ partitions the (δ, L^0) space into regions of positive or negative gains for country 1. Reasoning similar to that used for Figure 2, but this time using logconcavity, establishes that $\delta^1_+(L^0)$ is downward slopping and lies above $\delta^1_-(L^0)$, and $\delta^2_-(L^0)$ lies above $\delta^2_+(L^0)$. $\delta^2_-(L^0)$ and $\delta^2_+ L^0$ characterize the incentive patterns for country 2 under the assumption of substitutability of standards analogously to Figure 3, and complete the characterization of incentives under substitutability for the two large countries.

Figure 5 presents some striking contrasts to Figure 4. In region A of Figure 5, where L^0 is high enough, the incentives are all skewed in favor of the high standard. This contrasts with the corresponding region A in Figure 4, where with high enough L^0 the incentives are all in favor of the low standard. A similar reversal is seen in comparing regions D in the two figures. This diametrically opposite outcome is one of the most striking consequences of the assumption of logconcavity or logconvexity of the demand curve.

With complementarity, in Figure 4, regions B and C presented a congruent thrust of incentives in favor of high standards, in the sense that while one country had positive gains from the high standard no matter what, the other country had positive gains from the high standard only if the first country had high standards. But regions B and C in Figure 8 do not present such congruence. In region C, for example, country 1 had positive gains from adopting the high standard no matter what country 2 does, but country 2 has positive gains from the high standard only if country 1 adopts the *low* standard. A similar incongruence is found in region B and in regions E and F in Figure 5, in contrast to the congruence in incentives in these regions in Figure 4.

Regions G and H are the two regions where incentive patterns are similar in the two figures. One country has the clear incentive to adopt the high standard, while the other country has the clear incentive to adopt the low standard in these regions, in both figures. But the intermediate region I in Figure 5 again presents a contrast with the corresponding region in Figure 4. In Figure 4, each country has the incentive to adopt the high standard if and only if the other country also adopts the high standard. However, in Figure 5, each country has the incentive to adopt the high standard if and only if the other country adopts the *low* standard. As might be guessed, these incentive patterns have major consequences for what patterns of standards emerge as an equilibrium under strategic interaction.

We have shown that the incentives for adoption of high standards depend intricately not only on the nature of the import demand function, but also on the size structure of exporting countries – the number of "small" exporters who take price as given, and the relative sizes of the "large" exporters, who take into account the terms of trade consequences of their action. We are now ready to apply these results to an analysis of strategic interaction and equilibrium in the choice of standards.

4 Equilibrium

Consider therefore the following simultaneous decision problem of the two large countries. Let $(q^i, 1-q^i)$ denote the mixed strategy in which country i adopts high standard with probability q^i, and low standard with the complementary probability $1-q^i$. The expected welfare of country i, $i = 1, 2$ is given by:

$$\begin{aligned} EV^i(q^i, q^j) &= q^i \left[q^j V^{i+}(p(X(L))) + (1-q^j) V^{i+}(p(X(L^i))) \right] \\ &\quad + (1-q^i) \left[q^j V^{i-}(p(X(L^j))) + (1-q^j) V^{i-}(p(X(0))) \right], \quad i \neq j. \end{aligned} \tag{32}$$

where E is the expectation operator. Making use of (24) - (27), (32) simplifies to

$$\begin{aligned} EV^i(q^i, q^j) &= q^i \left(q^j \Delta_+^i + (1-q^j) \Delta_-^i \right) \\ &\quad + \left[q^j V^{i-}(p(X(L^j))) + (1-q^j) V^{i-}(p(X(0))) \right]. \end{aligned} \tag{33}$$

Differentiating EV^i with respect to q^i, we have

$$EV^i_{q^i} = q^j \Delta_+^i + (1-q^j) \Delta_-^i \qquad i \neq j, i = 1, 2. \tag{34}$$

The sign of (34) thus depends crucially on combinations of

$$\Delta_+^i \ {>\atop<}\ 0 \ \text{ and } \ \Delta_-^i \ {>\atop<}\ 0, \qquad i = 1, 2.$$

Some combinations can be ruled out given the structure of the problem. Thus complementarity rules out

$$\Delta_+^i < 0 \ \text{ and } \ \Delta_-^i > 0, \qquad i = 1, 2.$$

since it requires that the gains from adopting the high standard be greater when the other country has already adopted the high standard. By analogous reasoning, substitutability rules out

$$\Delta_+^i > 0 \ \text{ and } \ \Delta_-^i < 0, \qquad i = 1, 2.$$

Let us start with the complementarity case. Table 2 sets out all nine possible sign patterns in this case. The cell labels A - I correspond exactly to regions A - I of Figure 4. In the cells are entries $(+,+)$, $(+,-)$ $(-,+)$ and $(-,-)$. These depict the Nash equilibrium outcomes. The first entry is for country 1, the second for country 2. A $+$ depicts high standard, and $-$ a low standard.

Table 3 provides a complete characterization of stable Nash equilibria. The reasoning is as follows. Whenever $\Delta_+^i > 0$ and $\Delta_-^i > 0$, then $q^i = 1$ from (34), and the high standard is the dominant strategy. This is why the first entries in the cells of the first row of Table 1 are all $+$, and the second entries in the cells of the first column are also $+$. By analogous reasoning, whenever $\Delta_+^i < 0$, and $\Delta_-^i < 0$, then low standard is the dominant strategy. Putting these together we get that $(-,-)$ is the unique Nash equilibrium for cell A (and therefore region A of Figure 4), while (+,+) is the corresponding equilibrium for cell D.

If the combination of sign patterns is

$$\begin{aligned} \Delta_+^i &> 0 \quad \text{and} \quad \Delta_-^i > 0 \\ \Delta_+^j &< 0 \quad \text{and} \quad \Delta_-^j < 0, \;\; i \neq j \end{aligned}$$

that is, a pattern of "opposing dominant strategies", then clearly we will get an equilibrium with

$$q^i = 1 = 1 - q^j, \;\; i \neq j.$$

Hence the asymmetric sign patterns in cells G and H. But if the sign patterns are

$$\begin{aligned} \Delta_+^i &> 0 \quad \text{and} \quad \Delta_-^i > 0 \\ \Delta_+^j &> 0 \quad \text{and} \quad \Delta_-^j < 0, \;\; i \neq j. \end{aligned}$$

then from (34) $q^i = 1$ and, considering (34) with i and j switched around, $q^j = 1$. Hence in this case both countries will end up with high standards, as shown in cells E and F. By similar reasoning if

$$\begin{aligned} \Delta_+^i &< 0 \quad \text{and} \quad \Delta_-^i > 0 \\ \Delta_+^j &> 0 \quad \text{and} \quad \Delta_-^j > 0, \;\; i \neq j. \end{aligned}$$

then $q^i = q^j = 0$, as shown in cells B and C.

This leaves the sign pattern in cell I:

$$\Delta_+^i > 0 \quad \text{and} \quad \Delta_-^i < 0, \;\; i = 1, 2.$$

From (34), by standard arguments there exists a unique $\tilde{q}^j$, such that

$$EV_{q^i}^i = \tilde{q}^j \Delta_+^i + (1 - \tilde{q}^j)\Delta_-^i = 0.$$

In addition, by complementarity, $EV_{q^i}^i$ is monotonically increasing in q^j since

$$EV_{q^i q^j}^i = \Delta_+^i - \Delta_-^i > 0. \tag{35}$$

Thus, for all $q^j > \tilde{q}^j$, $EV_{q^i}^i > 0$. The best-response function of country i, $q^i(q^j)$ is given by:

$$q^i(q^j) = \begin{cases} 0 & \text{if } q^j < \tilde{q}^j, \\ [0,1] & \text{if } q^j = \tilde{q}^j \\ 1 & \text{otherwise.} \end{cases} \tag{36}$$

By standard arguments, there are three possible equilibrium outcomes, respectively involving: (i) low standards in both countries, (ii) high standards in both countries, and (iii) a mixed strategy equilibrium with

$$\tilde{q}^i = \frac{-\Delta_-^j}{\Delta_+^j - \Delta_-^j}, \;\; i = 1, 2, \;\; i \neq j, \tag{37}$$

It is easy to show that this mixed strategy equilibrium is unstable via the standard adjustment process. We therefore show only the two pure strategy equilibrium in cell I of Table 1.

Figure 6 translates Table 2 back on to (δ, L^0) space. It shows the pattern of Nash equilibria across different regions $A-I$, which correspond exactly to the regions in Figure 4 and the cells in Table 2. There are five possible equilibrium configurations of standards, depending on δ and L^0. In particular, when L^0 is sufficiently small (region D), both countries benefit from adopting high standards, depicted $(+,+)$. Another symmetric outcome indicates just the opposite scenario, with $(-,-)$ when the market share of big exporters is sufficiently small relative to small countries (region A). Finally, asymmetries in labor endowments in the two large countries likewise imply asymmetries in the equilibrium strategies, with $q^i = 1 - q^j = 1$ whenever country i possesses significantly more market power than country j (regions G and H), depicted $(-,+)$ and $(+,-)$.

When export competition with the group of small countries with low standard is not too intense (L^0 is sufficiently small), regions E and F admit the symmetric Nash equilibrium $(+,+)$, even though the high standard is a dominant strategy for only one of the two countries. The intuition follows from strategic complementarity, as high standard in country i raises the benefits of high standard in j enough to justify setting $q^j = 1$. Similarly, as soon as export competition comes increasingly from countries with low standards, regions B and C admit yet another symmetric Nash equilibrium $(-,-)$, even though low standard is a dominant strategy for only one of the two countries. Finally, in region I, where L^0 and δ are of intermediate magnitude, there are two pure strategy equilibria wherein both of the above symmetric Nash equilibrium are possible.

We turn now to the case where standards are substitutes. Table 3 lays out the patterns of Δ^i_+, Δ^i_-, the cells of the Table corresponding exactly to the regions in Figure 5. As in the discussion of the complementarity case, when

$$\begin{array}{llll} \Delta^i_+ > 0 & \text{and} & \Delta^i_- > 0, & i = 1,2 \\ \Delta^i_+ < 0 & \text{and} & \Delta^i_- < 0, & i = 1,2. \end{array}$$

we get a dominant strategy equilibrium and the outcomes $(+,+)$ and $(-,-)$ respectively as shown in cells A and D. When there are opposing dominant strategies

$$\begin{array}{llll} \Delta^i_+ > 0 & \text{and} & \Delta^i_- > 0 & \\ \Delta^j_+ < 0 & \text{and} & \Delta^j_- < 0, & i \neq j \end{array}$$

then as before we get asymmetric Nash equilibria $(+,-)$ and $(-,+)$ as shown in cells G and H.

When only one of the countries has a dominant strategy:

$$\begin{array}{llll} \Delta^i_+ > 0 & \text{and} & \Delta^i_- > 0 & \\ \Delta^j_+ > 0 & \text{and} & \Delta^j_- < 0, & i \neq j. \end{array}$$

then from (34) $q^i = 1$. Switiching i and j in (34), and setting $q^i = 1$ gives us, since $\Delta^j_+ < 0$, $q^j = 0$. Thus in cells B and C, we get $(-,+)$ and $(+,-)$ as the outcomes. Similarly, when

$$\begin{aligned} \Delta^i_+ &< 0 \quad \text{and} \quad \Delta^i_- < 0 \\ \Delta^i_+ &< 0 \quad \text{and} \quad \Delta^i_- > 0, \qquad i \neq j. \end{aligned}$$

we get the asymmetric equilibria $(+,-)$ and $(-,+)$ in cells F and E.

Finally, consider cell I, with sign pattern

$$\Delta^i_+ < 0 \text{ and } \Delta^i_- > 0, \qquad i = 1, 2.$$

In this case, there exists a unique $\tilde{q}^j$ such that

$$EV^i_{q^i} = \tilde{q}^j \Delta^i_+ + (1 - \tilde{q}^j)\Delta^i_- = 0.$$

Also, by substitutability,

$$EV^i_{q^i q^j} = \Delta^i_+ - \Delta^i_- < 0. \tag{38}$$

Thus, for all $q^j > \tilde{q}^j$, $EV^i_{q^i} < 0$. The best-response function of country i, $q^i(q^j)$ is given by:

$$q^i(q^j) = \begin{cases} 0 & \text{if } q^j > \tilde{q}^j, \\ [0,1] & \text{if } q^j = \tilde{q}^j \\ 1 & \text{otherwise.} \end{cases} \tag{39}$$

Note that since $q^i(q^j)$ is downward sloping, there are three Nash equilibria, with $q^1 = 1 = 1 - q^2$, $q^2 = 1 = 1 - q^1$, and $q^1 = \tilde{q}^1$ and $q^2 = \tilde{q}^2$. But the mixed strategy equilibrium $(\tilde{q}^i, \tilde{q}^j)$ is unstable, with $\tilde{q}^i$ and $\tilde{q}^j$ given by (37). So we show only the $(+,-)$ and $(-,+)$ pure strategy equilibria in cell I of Table 3.

Figure 7 translates Table 3 into (δ, L^0) space for the substitutability case, with regions $A - I$ in Figure 7 corresponding exactly to cells $A - I$ in Table 2 and regions $A - I$ in Figure 5. Starting from (δ, L^0) combinations such that δ neither too large, nor too small, note that by substitutability, the symmetric Nash equilibrium $(+,+)$ applies for (δ, L^0) combinations in region A of Figure 7, when L^0 is large enough. However,

$(-,-)$ applies in region D only, when L^0 is sufficiently small. Region I admits two asymmetric Nash equilibria. Thus, contrary to the case of strategic complementarity, export competition from small countries with low standards in fact prompts both countries to adopt high standards. As such, under substitutability there is no presumption that export competition induces a race to the bottom in standards as competition arises from countries with low standards.

In contrast, combinations of (δ, L^0) in region G (H) are the circumstances under which the market power country 1 (2) is large enough relative to country 2 (1), so that the dominant strategy of the two countries are diametrically opposed, with $q^1 = 1 = 1 - q^2$ $(q^2 = 1 = 1 - q^1)$, shown as $(+,-)$ (or $(-,+)$). Note also that strategic interactions between the two countries yield asymmetric Nash equilibria even when one of the two countries does not have dominant strategy. In particular, in regions F and C where δ is relatively large, $q^1 = 1$ and $q^2 = 0$, shown as $(+,-)$. The intuition follows from strategic substitutability, as high standard in country 1 is sufficient to deter country 2 from raising standard. Regions E and F depicts the opposite scenario, and $q^1 = 0$ and $q^2 = 1$, shown as $(-,+)$.

Figures 6 and 7 provide a precise and complete characterization of equilibrium in the choice of standards as a function of the size of the big exporters relative to each other (δ), the size of the competitive fringe of small exporters (L^0), and the Northern demand curve (whether it is logconvex, or logconcave, leading to Figure 6 and Figure 7, respectively). Consider first of all the effect of varying δ on the nature of the equilibrium. In Figure 6, as δ increases, the tendency is to move from region G to region H, moving from $(-,+)$ through $(+,+)$ or $(+,-)$ to $(+,-)$. The same is true in Figure 7. In this sense, a higher δ makes $(+,-)$ outcomes "more likely." These observations lead to the following proposition.

Proposition 5 *As one of the big exporters becomes larger relative to the other, the likelihood of equilibria, in which the larger exporter has high standards and the other exporter has low standards, increases.*

This outcome should not be too surprising since the larger exporter increasingly acts as a single exporter and adopts higher standards not only for their direct benefit but also because output restriction is beneficial in the face of a downward sloping demand curve. More generally, since we have already established in Proposition 1 that the smallest exporters adopt low standards, Proposition 5 strengthens the argument that there should be positive correlation between market share and standards.

Consider now the impact of the size of the competitive fringe on equilibrium outcomes. As discussed earlier, when L^0 increases, the general movement is from region D to region A, moving from $(+,+)$, through $(+,-)$ or $(-,+)$, to $(-,-)$. This is the sense in which bigger L^0 makes low standards outcome "more likely". The opposite is true in Figure 7, where the movement is from $(-,-)$, through $(+,-)$ or $(-,+)$, to $(+,+)$. We capture these observations in the following proposition.

Proposition 6 *As the size of the competitive fringe of small Southern exporters grows, the likelihood of low standards equilibria increases if Northern demand is logconvex (so that standards are complements) and decreases if Northern demand is logconcave (so that standards are substitutes).*

That increasing competition from small countries which have low standards and care only about expanding output may not put downward pressure on the standards of big exporters is at first sight a surprising conclusion. But when the role of substitutability is made clear, it is not surprising at all. What is remarkable is that substitutability is not a curiosum but the implication of some commonly used demand functions which fit the data (e.g. linear demand). Moreover, the fact that the curvature of the demand curve plays such a key role highlights the need for parameterising and estimating the degree of curvature of the demand curves for specific exports of developing countries.

Our analysis so far identifies circumstances under which strategic responses to export competition induce one or both countries to adopt lower standards. It bears emphasis, however, that a low standard need not imply low welfare, particularly when terms of trade adjustments and direct utility benefits are small, relative to the increase in production costs that higher standard necessitates. Accordingly, an equilibrium in which both countries select low standards need not necessarily imply a *coordination failure*. We turn to this question in the next section, and investigate the potential welfare gains that can be achieved via South-South cooperation in standards.

5 Welfare and Coordination

In the previous section we have shown that low standards equilibria are not inevitable. We have provided a precise characterization of circumstances in which high standards equilibria can arise – for example, combinations of logconvexity of demand and a small enough competitive fringe, or logconcavity of demand and a large enough competitive fringe. But low standards equilibria do arise and in such cases an important question is whether welfare could be improved by both countries adopting high standards and whether such an outcome could be sustainable. This section considers, therefore, issues of welfare and coordination in standards.

Let us start by noting that in our model the small exporters always adopt low standards. If the small exporters as a group were to adopt high standards, they might benefit. But, by assumption, small exporters are too small individually to perceive any benefits from coordination. Our analysis will therefore focus on coordination between the big exporters. Suffice it to say that when the big exporters adopt high standards, the small exporters benefit indirectly through the terms of trade gains.

There are two cases to consider where both of the big exporters do not have high standards – symmetric equilibria with $(-,-)$, and asymmetric equilibria with $(+,-)$ or $(-,+)$. We begin with the symmetric equilibria. The first question is whether either or both countries are better off with a $(+,+)$ outcome than the actual outcome of $(-,-)$. Note from (19) that the gain to each country from both countries going to $(+,+)$, so that the number of workers in the world under the high standards regime goes from $\ell = 0$ to $\ell = L$, is given by

$$\begin{aligned} \Delta^1(0,L) &= \Delta^2(0,L) = \Delta(0,L) \\ &= \log\frac{s^+}{\phi(s^+)} + (1-\alpha)\left[\log(p(X(L))) - \log(p(X(0)))\right] \end{aligned} \tag{40}$$

In other words, if country 1 is better off when both countries switch from low to higher standards, country 2 must also be better off, regardless of the distribution of resources in the two countries. When, if at all, do the two countries benefit from coordinating on high standards? The answer depends on whether standards are substitutes or complements. Starting with complementarity, and recalling that in this case, $\Delta^i(\ell^{-i}, \ell^{-i} + L^i)$ is decreasing in L^0, it follows that

$$\begin{aligned}
0 &\leq \Delta^1(0, L) \\
\Leftrightarrow 0 &\leq \Delta^1(0, \frac{L}{2} + \delta) \text{ if } \delta = \frac{L}{2}, \\
\Leftrightarrow 0 &\leq \Delta^1(\frac{L}{2} - \delta, L) \text{ if } \delta = \frac{L}{2}, \\
\Leftrightarrow L^0 &\leq \{L^0 | \delta^1_-(L^0) = \delta^1_+(L^0) = \frac{L}{2}\} \equiv \bar{L}^0.
\end{aligned}$$

$\bar{L}^0$ thus denotes the critical level of labor endowment in small countries, such that for all $L^0 \leq \bar{L}^0$, country 1 is strictly better off when both countries switch from low to high standards. By similar reasoning,

$$\begin{aligned}
0 &\leq \Delta^2(0, L) \\
\Leftrightarrow L^0 &\geq \{L^0 | \delta^2_+(L^0) = \delta^2_-(L^0) = -\frac{L}{2}\} \equiv \bar{L}^0.
\end{aligned}$$

$\bar{L}^0$ divides the (δ, L^0) space into two regions. For all $L^0 \geq \bar{L}^0$, $\Delta^i(0, L) \leq 0$, $i = 1, 2$, and $\Delta^i(0, L) > 0$ otherwise. $\bar{L}^0$ is shown in Figure 8. Thus (δ, L^0) combinations in all of region B, C, and I and a subset of region A guarantee welfare improvements for both countries whenever the two countries move from the low standards equilibria in these regions to adopt high standards.

Turning now to the case of substitutability, and using reasoning similar to above, we can define

$$\underline{L}^0 \equiv \{L^0 | \delta^1_-(L^0) = \delta^1_+(L^0) = \frac{L}{2}\},$$

and,

$$\underline{L}^0 \equiv \{L^0 | \delta^2_+(L^0) = \delta^2_-(L^0) = -\frac{L}{2}\}.$$

Thus, $\underline{L}^0$ divides the (δ, L^0) space into two regions, and by virtue of strategic substitutability, $\Delta^i(0, L) < (\geq) 0$ whenever $L^0 < (\geq) \underline{L}^0$. The possibility of a welfare gain when both countries switch from low to high standard is therefore assured, whenever L^0 is larger than $\underline{L}^0$. $\underline{L}^0$ is shown in Figure 9. Thus (δ, L^0) combinations in all of region D guarantee welfare improvements for both countries whenever the two countries move from the low standards to high standards.

So much for symmetric low standards equilibria $(-,-)$. What about asymmetric equilibria in which one of the two countries has a high standard and the other the low standard? Can a move from $(+,-)$ or $(-,+)$ to $(+,+)$ lead to a welfare improvement? Clearly, such a move cannot lead to both countries being better off, since the country with the low standards in equilibrium prefers low standards when the other country has high standards. A Pareto improvement is thus ruled out. We can however consider a general utilitarian welfare function from (11),

$$\begin{aligned} W &= \sum_{i=1,2} V^i(p, s^i) \\ &= 2K + \sum_{i=1,2} \log \frac{s^i L^i}{\phi(s^i) a_1} + 2(1-\alpha) \log p(X(\ell)) \end{aligned} \tag{41}$$

Note once again that we are focussing attention on the joint welfare of the two big exporters – the small exporters will always benefit when the two big exporters adopt successively higher standards.

There are two cases to consider: $(-,+)$ and $(+,-)$. The welfare gain in moving from $(-,+)$ to $(+,+)$ is given by

$$\begin{aligned} \Delta^{++}_{-+} &= W^{++} - W^{-+} \\ &= \log \frac{s^+}{\phi(s^+)} + 2(1-\alpha) \left[\log p(X(L)) - \log p(X(\frac{L}{2} - \delta)) \right]. \end{aligned} \tag{42}$$

Similarly, the welfare gain in moving from $(+,-)$ to $(+,+)$ is given by

$$\begin{aligned} \Delta^{++}_{+-} &= W^{++} - W^{+-} \\ &= \log \frac{s^+}{\phi(s^+)} + 2(1-\alpha) \left[\log p(X(L)) - \log p(X(\frac{L}{2} + \delta)) \right]. \end{aligned} \tag{43}$$

Expressions (42) and (43) can be used to partition the (δ, L^0) space into regions of welfare improvement in the two cases. As might be expected, the partitioning is different for the cases of complementarity and substitutability. Starting with complementarity, consider the locus

$$\Delta^{++}_{-+} = 0 \Leftrightarrow \delta = \delta^{++}_{-+}(L^0). \tag{44}$$

Above the locus $\Delta^{++}_{-+} < 0$, and below it $\Delta^{++}_{-+} > 0$. Comparing (42) with (25), it is clear that with complementarity, the locus $\delta^{++}_{-+}(L^0)$ will be upward sloping in (δ, L^0) space and lie everywhere above the locus δ^1_+. Now consider the locus

$$\Delta^{++}_{+-} \Leftrightarrow \delta = \delta^{++}_{+-}(L^0). \tag{45}$$

Comparing (45) with (27) establishes that $\delta^{++}_{+-}(L^0)$ will be downward sloping and lie everywhere above the locus δ^2_+. Above the locus, $\Delta^{++}_{+-} < 0$, and below it $\Delta^{++}_{+-} > 0$.

The same analysis can be repeated for substitutability. In this case, the locus $\delta^{++}_{-+}(L^0)$ will be downward sloping and lies everywhere below the locus δ^1_+, while $\delta^{++}_{+-}(L^0)$ will be upward sloping and lies everywhere below the locus δ^2_+. And above the loci there is welfare improvement, below them a welfare decrease.

Putting together the analysis for the symmetric and asymmetric case, Figures 8 and 9 provide a complete characterization of when welfare improvement occurs in moving from $(-,-)$, $(+,-)$ or $(-,+)$ to the high standards outcome $(+,+)$, respectively for the case of complementarity and substitutability. The shaded areas give us (δ, L^0) combinations where such improvements are possible – note that when the starting equilibrium is symmetric $(-,-)$ the welfare improvement is moreover a Pareto improvement.

Looking at Figures 8 and 9 the role of L^0 and δ in determining whether a welfare improvement is possible in moving from low to high standards should be clear. Consider the regions A, H, G, B, C and I in Figure 8 (the low standards regions under complementarity); starting from any point in these regions, for given L^0, a move of δ closer to 0 increases (or does not decrease) the likelihood of getting to an area where welfare improvement is possible as a result of high standard adoption by both countries. The same is true of regions D, E, F, G, H, B, C and I in Figure 9 (the low standards regions under substitutability). These observations prompt the following proposition:

Proposition 7 *Starting from an equilibrium in which at least one country has low standards, the joint adoption of high standards is more likely to improve joint welfare the* *more equal the two countries are in size.*

Proposition 5 shows that greater disparity in size is more likely to lead to an equilibrium in which one of the countries has high standards and the other low standards. Proposition 7 argues that greater disparity also makes it more unlikely that adoption of common high standards leads to a welfare improvement.

Now consider variations in L^0. Starting from any point in region A, H, G, B, C, or I in Figure 8, a decrease in L^0 which leaves the countries in the same region increases (or does not decrease) the likelihood of getting into an area where joint high standards lead to a joint welfare improvement. However, in Figure 9, starting from any point in regions D, E, F, G, H, B, C, or I, an increase in L^0 which leaves the countries in the same region increases (or does not decrease) the likelihood of getting into an area of joint welfare improvement through joint high standards. These observations lead to the following proposition:

Proposition 8 *Starting from an equilibrium in which at least one country has low standards, joint adoption of high standards is more likely to lead to a joint improvement of welfare in the big exporters if (i) the competitive fringe gets a little smaller in the case of logconvex demand, or (ii) if the competitive fringe gets a little larger in the case of logconcave demand.*

Proposition 8 brings out the interaction between the nature of Northern demand and the size of Southern small exporters as a group, in determining the benefits from coordination to the big exporters. When the shape of the Northern demand curve makes Southern standards complements, then a decrease in the relative weight of the small (low standards) exporters increases the benefits of coordinating on high standards. But when the shape of the Northern demand curve makes Southern standards substitutes, the opposite is the case. Once again, this highlights the importance of getting good empirical estimates of the curvature of the demand curve for specific commodities.

In each of the shaded areas in Figures 8 and 9, the Nash equilibrium outcome is welfare dominated by a coordinated outcome with high standards in both countries. But can this coordinated outcome itself be sustained? Clearly, it cannot be sustained as a static Nash equilibrium. But it is well-known that coordinated outcomes can sometimes be sustained in the context of repeated games where deviation from the coordinated outcome is punished appropriately. We focus on a game structure where if both countries cooperate and adopt high standards up till time t, each country adopts high standards. Otherwise, each country adopts the pure Nash equilibrium standard. With multiple pure strategy equilibria, we allow for any one of the pure strategy equilibria to be chosen. As always, small exporters stick to low standards.

The discounted welfare of country i over the infinite horizon is given by

$$\sum_{t=0}^{\infty} r^t V^i.$$

where $0 < r < 1$ is the common subjective discount factor. We look for the conditions under which there is a subgame perfect Nash equilibrium which supports $q^1 = q^2 = 1$, given the static Nash equilibrium choices of standards elaborated in section 4.

Let us start with asymmetric Nash equilibria. Suppose we have $(-,+)$. Then deviation from $(+,+)$ by country 1 to the lower standard will certainly increase its welfare in the period of deviation. By the hypothesis of Nash reversion, in the period after the deviation, the countries play $(-,+)$ as strategies, but this is the same as the outcome in the period of deviation. Country 1 therefore always benefits from deviation and $(+,+)$ cannot be sustained as a subgame perfect Nash equilibrium when $(-,+)$ is the asymmetric Nash equilibrium. A similar argument holds for the case when $(+,-)$ is a Nash equilibrium. We thus have the following proposition

Proposition 9 *When the size of the competitive fringe and the relative sizes of the big exporters are such as to produce an asymmetric equilibrium in standards, the joint high standards outcome cannot be sustained as a subgame perfect Nash equilibrium (under conventional assumptions) even when it leads to higher joint welfare.*

Consider now symmetric equilibria $(-,-)$ and the prospects for cooperating to achieve $(+,+)$. Starting from $(+,+)$ if country i deviates its change in welfare in the deviation period is simply

$$-\Delta^i_+, \quad i = 1, 2$$

that is, minus the gain from adopting the high standard when the other country sticks to the high standard. In subsequent periods, the loss to the deviating country is the welfare loss from being at a $(-,-)$ rather that a $(+,+)$ outcome. From (40), this is simply

$$\Delta(0, L)$$

for the two countries. Thus country i will not deviate from $(+,+)$ if

$$-\Delta_{+}^{i} - \frac{r}{1-r}\Delta(0, L) < 0.$$

Using the fact, from (25), (27) and (40), that $\Delta_{+}^{i} < \Delta(0, L)$, this can be rewritten as

$$r > \hat{r}^{i} = \frac{\Delta_{+}^{i}}{\Delta_{+}^{i} - \Delta^{i}(0, L)}. \tag{46}$$

It follows that

$$r > \max\{\hat{r}^{1}, \hat{r}^{2}\} \tag{47}$$

ensures that neither country deviates from the $(+,+)$ outcome. Now, notice that at $\delta = 0$, $\Delta_{+}^{1} = \Delta_{+}^{2}$, and therefore $\hat{r}^{1} = \hat{r}^{2}$. A small change in δ starting from zero introduces a gap between $\hat{r}^{1}$ and $\hat{r}^{2}$ and therefore reduces the range of r in (47) which allows the dynamic equilibrium to be sustained. In fact, it can be shown that the gap between Δ_{+}^{1} and Δ_{+}^{2}, increases monotonically in δ, so this range of r is reduced as δ goes further and further away from zero. These observations lead to the following proposition:

Proposition 10 *When the size of the competitive fringe and the relative size of the big exporters are such as to produce a symmetric low standards equilibrium, welfare improving joint high standards outcome can be sustained as a dynamic equilibrium (under conventional assumptions) provided that countries are patient enough. As the two big exporters become more asymmetric in size, the permissible range of patience shrinks, making it less likely that the joint high standards outcome can be sustained.*

Propositions 9 and 10 highlight the damaging impact that size asymmetry between the two big exporters can have on the possibility of sustaining a high standards outcome. Starting from equality, and assuming the weight of the competitive fringe to be such that there is a symmetric low standards equilibrium, Proposition 10 shows that as the disparity grows, the range of patience required to sustain the welfare improving high standards outcome shrinks, making it less likely. Beyond a certain point, the disparity is so great that there is an asymmetric standards equilibrium. But then, from Proposition 9, the joint high standards outcome is not sustainable at all, even when it would improve joint welfare.

6 Northern Protectionism and Southern Standards

The question of whether Northern trade protectionism could or should protect Northern standards is at the heart of the current controversies on globalization. But, whatever its impact on Northern standards, does Northern protection protect Southern standards, or does it undermine them? Does it put a floor under a Southern race to the bottom, or does it acclerate the race?

The model and analysis developed so far can be put to further work to answer these questions. Let t be a specific tariff levied by the North on the exports of the South. Recalling that the Northern inverse import demand function is $p(X, R^*)$, where R^* is the Northern revenue function, with a specific tariff t the new terms of trade are given by

$$p(X(\ell), R^* + tX(\ell)) - t$$

where $X(\ell)$ is Southern exports as a function of ℓ, the number of Southern workers under the high standards regime. It is easy to check from (15) that Southern exports are unaffected by the tariff.

With the tariff in place, the incentives for country i to adopt high standards, the analogous expression to (19), is now given by

$$\begin{aligned}\Delta^1(\ell^{-i}, \ell^{-i} + L^i, t) \quad = \quad & \log \frac{s^+}{\phi(s^+)} + (1-\alpha)\Big[\log(p(X(\ell^{-i} + L^i), R^* + tX(\ell^{-i} + L^i)) - t) \\ & - \log(p(X(\ell^{-i}), R^* + tX(\ell^{-i})) - t)\Big] \qquad (48)\end{aligned}$$

and thus

$$\frac{\partial \Delta^i(\ell^{-i}, \ell^i + L^i)}{\partial t} \quad = \quad (1-\alpha)\left[\frac{m(\ell^{-i} + L^i) - 1}{p(\ell^{-i} + L^i) - t} - \frac{m(\ell^{-i}) - 1}{p(\ell^{-i}) - t}\right] \qquad (49)$$

where

$$m(X(\ell)) = \frac{\partial(pX(\ell))}{\partial R^*} \tag{50}$$

is the marginal propensity to import in the North. We make the following standard assumption.

Assumption 2 *The Northern propensity to import as its income increases is less than one and decreasing in total imports.*

With this assumption it follows immediately from (49) that $\partial\Delta^i/\partial t > 0$. In other words, a Northern tariff increases Southern incentives to adopt high standards.

To see the intuition here, note that the marginal export revenue of country i is given by $p_x(X(\ell))X^i + p(X) - t$, that is, marginal export revenue decreases one-for-one with the import tariff. Thus, the extent of export revenue gains that can be achieved by expanding exports is lower, the higher the import tariff, regardless of whether standards are strategic complements, or substitutes. In addition, import restrictions also generate an income effect, via the tariff revenue. In particular, the income effect reinforces incentives to raise standards (lower exports), so long as the marginal propensity to consume is decreasing in total exports.

Since a tariff increases the incentives to adopt high standards, it might be expected that the likelihood of low standards equilibria would increase. In Figure 6, the loci δ^1_+, δ^1_-, δ^2_+ and δ^2_- all shift upwards. The effect on the size of regions G and H (the regions of asymmetric equilibria) is ambiguous. Region I contracts but both $(+,+)$ and $(-,-)$ equilibria are possible here. However, regions A, B, and C (low standards) contract and regions D, E, and F (high standards) expand. In Figure 7, the loci δ^1_+, δ^1_-, δ^2_+ and δ^2_- all shift downwards. Thus region D in this Figure (the region of low standards in both countries) contracts and region A (the region of high standards) expands. It is in this sense, the expansion of $(+,+)$ regions and the contraction of $(-,-)$ regions, that an import tariff makes the emergence of high standards more likely.

Moreover, from (46),

$$\frac{\partial \hat{r}^i}{\partial t} = \frac{1}{\Delta^i_+ - \Delta^i(0,L)}\left((1-\hat{r}^i)\frac{\partial \Delta^i_+}{\partial t} + \hat{r}^i\frac{\partial \Delta^i(0,L)}{\partial t}\right) < 0 \tag{51}$$

since $\Delta^i_+ - \Delta^i(0, L) < 0$ and

$$\frac{\partial \Delta^i_+}{\partial t} > 0 \ \text{ and } \ \frac{\partial \Delta^i(0, L)}{\partial t} > 0$$

from (49) and Assumption 2. In other words, using Proposition 10, a sustainable welfare improving joint high standards outcome becomes more likely, in the sense that the range of r for which this occurs is expanded.

It would appear, then, that Northern protectionism aids the emergence of high standards in the South. However, the implicit assumption in the previous analysis is that the importing country will not further vary t, once the standard choices of the two large exporters are made. But this is not entirely credible. We might expect the North to optimally set its tariff given the outcomes in the South. In particular, consider the following scenario. The importing and exporting countries play a two-stage game. In the first stage, exporting countries compete in setting standards. In the second stage, the importing country has the liberty to maximize the national welfare by selecting an optimal import tariff, taking into account Southern choices. What happens in this case?

Beginning with the second-stage, recall from (7) and (5) that aggregate export supply is a step function, with

$$X(\ell) = \begin{cases} 0 & \text{if } \ p < a_1/a_2, \\ [0, (1-\alpha)[L^0 + L + \ell(1/\phi - 1)]/a_1] & \text{if } \ p = a_1/a_2 \\ (1-\alpha)[L^0 + L + \ell(1/\phi - 1)]/a_1 & \text{otherwise.} \end{cases} \tag{52}$$

Let the optimal import tariff be $t(p, \ell)$, where p is the market clearing world price of good 1. Thus, as long as a positive amount of trade takes place between the two countries,

$$t(p, \ell) = \begin{cases} 0 & \text{if } \ p = a_1/a_2 \\ p(\ell) - a_1/a_2 & \text{if } p > a_1/a_2. \end{cases} \tag{53}$$

respectively corresponding to the perfectly elastic and the perfectly inelastic segments of the export supply curve. It follows, therefore, that the terms of trade that the two exporting countries can anticipate, given ℓ, is just $p(\ell) - t(p, \ell)$.

Turning to the first stage problem of the two large countries, the gain to country i ($i = 1, 2$) from adopting the high standard with probability q^i is:

$$EV^{i+} - EV^{i-}$$

$$= \log \frac{s^+ L^i}{\phi(s^+) a_1} + (1-\alpha) q^i \left(q^j [\log[p(L) - t(p, L)] + (1-q^j) \log[p(L^i) - t(p, L^i)] \right)$$
$$- \log \frac{L^i}{a_1} - (1-\alpha)(1-q^i) \left(q^j \log[p(L^j) - t(p, L^j)] + (1-q^j) \log[p(0) - t(p, 0)] \right)$$

where q^j is the probability that country j $(i \neq j)$ adopts the high standard, and $t(p, \ell)$ is the Northern tariff. Using (53), the gain from adopting the high standard becomes

$$EV^{i+} - EV^{i-} = \log \frac{s^+}{\phi(s^+)} < 0.$$

We therefore have the remarkable result that in this case all incentives to adopt the high standard are removed. It follows that the only possible equilibria are low standards for all in the South.

Whether Northern protectionism protects or undermines Southern standards is therefore a subtle matter. We summarize our analysis in the following proposition.[5]

Proposition 11 *When Southern Standards are set after Northern tariffs are imposed, Northern protectionism makes high standards equilibria more likely, and coordination on high standards more likely to be sustainable. But when Northern tariffs are chosen optimally after Southern standards are set, the choice of these tariffs will be such as to totally eliminate high standards equilibria in the South.*

If Northern tariffs are set optimally in the Northern interest, therefore, they are no friend of Southern standards. In this case, far from protecting them, Northern protectionism undermines Southern standards.

7 Conclusion

Let us return to the three questions posed at the start of this paper. Does Chinese trade competition pose a threat to environmental and labor standards in India, and vice versa? Propositions 5, 7 and 9 clarify the sense in which this might be the case. The equilibrium outcome and welfare consequences depend on the size of the exporters relative to each

[5] It can be shown that the thrust of the proposition holds also for the case of an ad valorem tariff.

other. Proposition 5 says that as one country becomes relatively big, it is that country which is more likely to adopt high standards. Proposition 7 tells us that the greater the disparity in size, the more unlikely it is that the joint adoption of high standards will lead to an improvement in joint welfare, and Proposition 9 concludes that it is less likely that the joint high standards outcome can be sustained as a dynamic equilibrium. The answer to the question depends entirely, therefore, on the relative size of "China and India". The bigger country will tend to have higher standards, but asymmetry in size is more likely to lead to outcomes detrimental to joint welfare.

Are standards in India and China pulled down by standards in small countries such as Myanmar, Honduras or South Africa? Proposition 1 tells us that the competitive fringe of small exporters always adopt low standards. But do these act as a drag on big exporters' standards? Proposition 6 tells us that the answer depends on very specific properties of the Northern demand curve. In a general sense, a larger competitive fringe of small exporters is detrimental to standards of the big exporters if standards are complements, but it is beneficial if they are substitutes. In the specific model, this depends on whether the Northern demand curve is logconvex or logconcave. More generally, it depends on the curvature of the demand curve. A larger competitive fringe is also less likely to lead to situations where joint adoption of high standards by the big exporters will lead to (i) an increase in joint welfare if demand is logconvex, and (ii) a decrease in joint welfare if demand is logconcave (Proposition 8). That central properties on equilibrium outcomes and welfare should depend on such specific properties of the demand curve is in one sense no surprise. But what this does is to highlight the need for empirical work on parameterising and estimating the curvature of commodity specific Northern import demand functions.

Does trade protectionism in the U.S. protect standards in developing countries, or does it undermine them? Proposition 11 provides a surprisingly sharp, but intuitively clear, answer to this question. When Southern standards are set after Northern tariffs, these tariffs aid the adoption of high standards because they reduce the potential revenue gain to any Southern country from undercutting standards to increase exports. However, if Northern tariffs are chosen after Southern standards are set, and moreover are chosen optimally to advance Northern interests, then the situation is completely reversed – all incentive to set high standards in the South is creamed off by the optimal tariff. Since the North choosing Northern tariffs in the Northern interest is the more likely scenario, we reach our final conclusion. Northern protection undermines Southern standards.

The model we have developed is rich enough to allow certain key questions to be posed, but simple enough to allow specific answers to be given, and intuitions to be further sharpened. Clearly, the direct applicability of the model is limited by its special assumptions. But it does suggest areas for empirical research. For example, it calls for an investigation of the correlation between market share in exports and standards, the estimation of demand curvature for developing country exports, and the connection between tariffs in the importing country and standards in the exporting country. Further research is called for not only in testing the robustness of our theoretical results in more general models, but also in empirical investigations of export competition and standards in developing countries.

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Table 1: Labor Intensive Exports and Developing Countries

Country	Textiles US $ mill. 1997	Country	Carpets US $ mill. 1998	Country	Balls* US $ mill. 1998
China	4954.14	China	216.70	Pakistan	1754.59
India	3141.01	India	168.76	China	1680.25
Korea, Rep. of	2341.05	Mexico	65.20	Thailand	596.22
Pakistan	2138.06	Israel	62.34	India	348.57
Turkey	1995.85	Egypt	47.27	Indonesia	79.61
Canada	1618.41	Turkey	46.37	Vietnam	66.12
Indonesia	1433.83	Australia	30.54	Mexico	48.42
Mexico	1312.85	Brazil	30.30	Philippines	38.79
Israel	851.57	South Africa	20.22	Dominican Rep.	28.13
Thailand	844.66	Indonesia	19.14	Malaysia	20.17
Czech Rep.	634.57	Morocco	11.89	Brazil	17.85
Iran, Islamic Rep. of	633.94	Thailand	11.07	Morocco	12.35
Egypt	515.34	Hungary	10.14	Panama	11.35
Poland	413.92	Pakistan	8.13	Czech Rep.	11.13
Brazil	359.28	Czech Rep.	6.93	Belarus	10.63
Malaysia	345.99	Saudi Arabia	6.27	Paraguay	6.35
Tunisia	272.73	Poland	5.31	Colombia	5.49
Hungary	232.54	Colombia	4.09	Peru	4.48
Slovak Rep.	198.10	Chile	3.18	Poland	3.93
Slovenia	194.87	Argentina	3.00	Romania	2.96
Bangladesh	184.31	Sri Lanka	2.57	Hungary	2.37
Nepal	170.17	Vietnam	2.50	Saudi Arabia	1.81
Philippines	167.28	Malaysia	2.28	Uruguay	1.77
Sri Lanka	165.75	Russian Fed.	2.11	Estonia	1.74
Romania	131.91	Panama	1.45	Turkey	1.11
Russian Fed.	129.68	Romania	1.41	Argentina	1.05
South Africa	117.16	Estonia	0.81	Sri Lanka	0.94
Estonia	112.85	Venezuela	0.73	Chile	0.83
Morocco	99.32	Philippines	0.63	South Africa	0.70
Lithuania	95.85	Nepal	0.57	Guatemala	0.59
Bulgaria	92.69	Lebanon	0.38	Venezuela	0.56
Viet Nam	84.24	Kazakhstan	0.36	Israel	0.44
United Arab Emirates	67.93	Belize	0.34	Ukrainian	0.42
Australia	59.82	Bangladesh	0.27	Costa Rica	0.23
Croatia	59.19	Slovenia	0.27	Ecuador	0.20
Peru	44.40	Turkmenistan	0.27	Egypt	0.18
Dominican Republic	40.12	Tunisia	0.26	Latvia	0.16
Colombia	36.76	Peru	0.20	Mauritius	0.14
El Salvador	25.82	Ecuador	0.16	Russian Fed	0.12
Costa Rica	19.15	Uruguay	0.14	Honduras	0.12
Guatemala	15.55	Zimbabwe	0.14	Nepal	0.11
Uruguay	7.00	Guatemala	0.13	Jamaica	0.10

*(excl. tennis and golf balls.)

Source: WTO (1998), UNCTAD-TRAINS (Trade Analysis and Information System) (2000).

Table 2. Incentive Patterns and Nash Equilibrium Under Complementarity

	$\Delta^2_+ > 0$ $\Delta^2_- > 0$	$\Delta^2_+ > 0$ $\Delta^2_- < 0$	$\Delta^2_+ < 0$ $\Delta^2_- < 0$
$\Delta^1_+ > 0$ $\Delta^1_- > 0$	*D* (+, +)	*F* (+, +)	*G* (+, -)
$\Delta^1_+ > 0$ $\Delta^1_- < 0$	*E* (+, +)	*I* (+, +) (- , -)	*C* (- , -)
$\Delta^1_+ < 0$ $\Delta^1_- < 0$	*H* (- , +)	*B* (- , -)	*A* (- , -)

Note: Rows show country 1 incentives, columns country incentives. Cell labels A to I correspond to the regions in Figure 4. The first entry in (. , .) refers to country 1's standard, the second entry to country's standard. A + denotes high standard in equilibrium, a - denotes low standard. Region I also has a mixed strategy equilibrium, but it is unstable under the standard adjustment process.

Table 3. Incentive Patterns and Nash Equilibrium Under Substitutability

	$\Delta^2_+ > 0 \quad \Delta^2_- > 0$	$\Delta^2_+ < 0 \quad \Delta^2_- > 0$	$\Delta^2_+ < 0 \quad \Delta^2_- < 0$
$\Delta^1_+ > 0 \quad \Delta^1_- > 0$	*A* (+, +)	*C* (+, -)	*H* (+, -)
$\Delta^1_+ < 0 \quad \Delta^1_- > 0$	*B* (- , +)	*I* (- , +) (+ , -)	*F* (+ , -)
$\Delta^1_+ < 0 \quad \Delta^1_- < 0$	*G* (- , +)	*E* (- , +)	*D* (- , -)

Note: Rows show country 1 incentives, columns country incentives. Cell labels A to I correspond to the regions in Figure 8. The first entry in (. , .) refers to country 1's standard, the second entry to country's standard. A + denotes high standard in equilibrium, a - denotes low standard. Region I also has a mixed strategy equilibrium, but it is unstable under the standard adjustment process.

Figure 1. Incentives for Country 1 under Complementarity when Country 2 has Low Standard

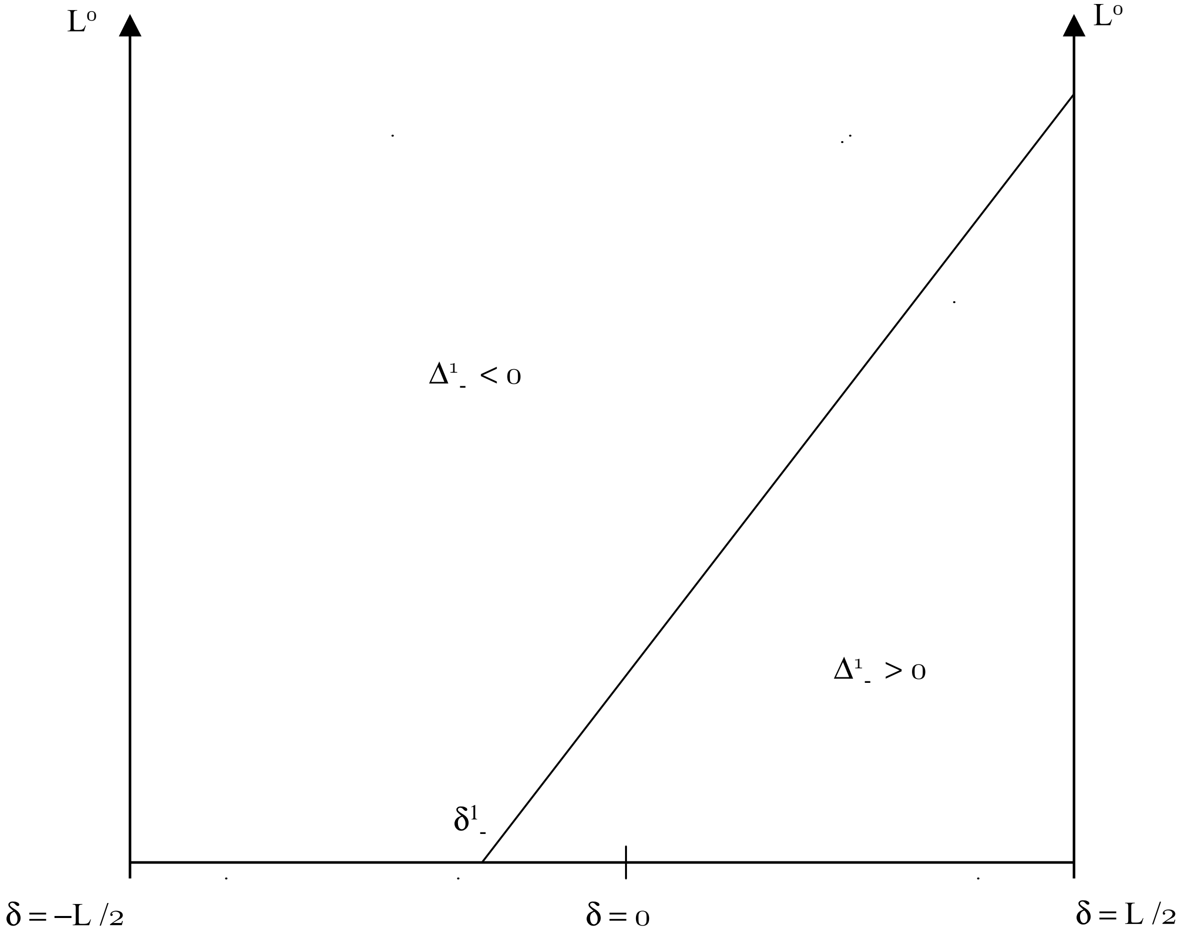

Figure 2. Incentives for Country 1 under Complementarity

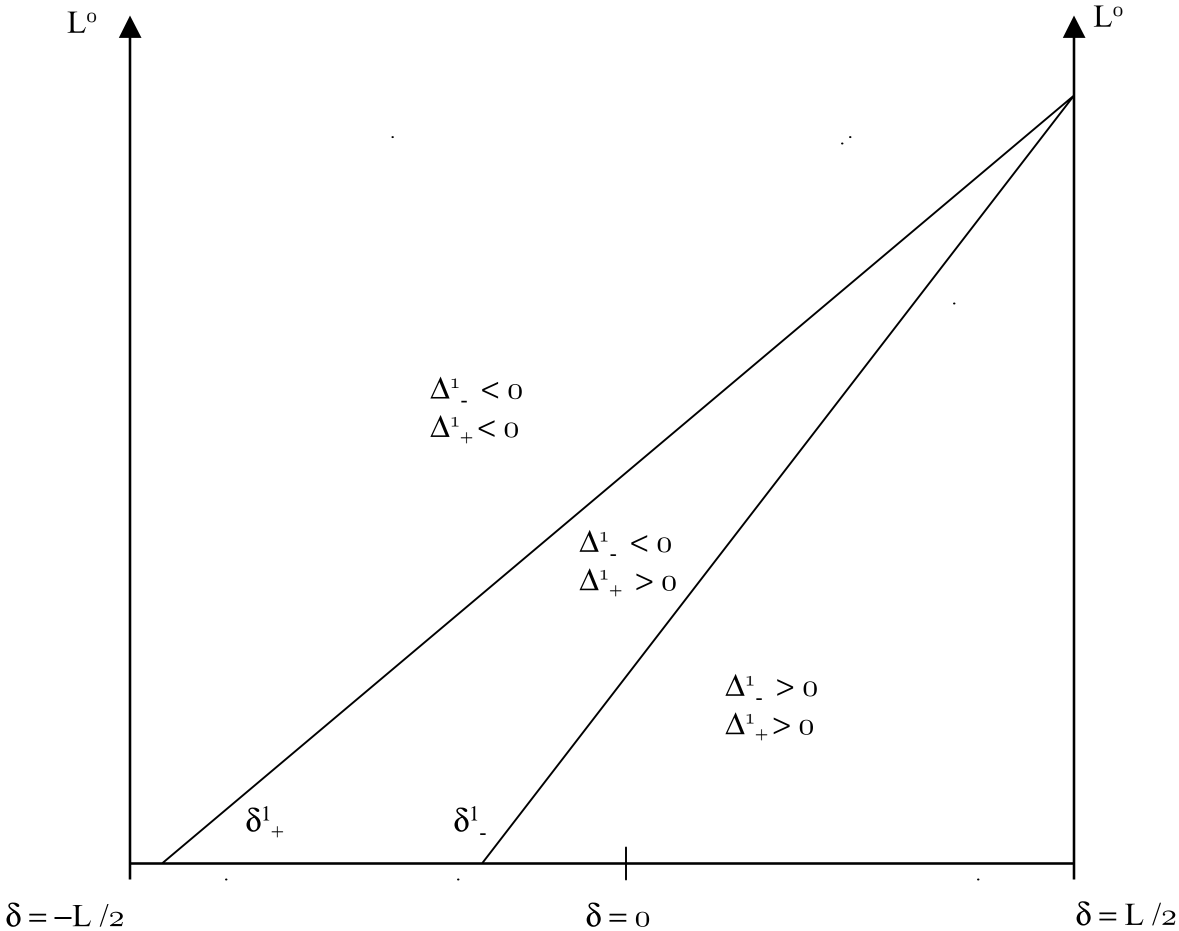

Figure 3. Incentives for Country 2 under Complementarity

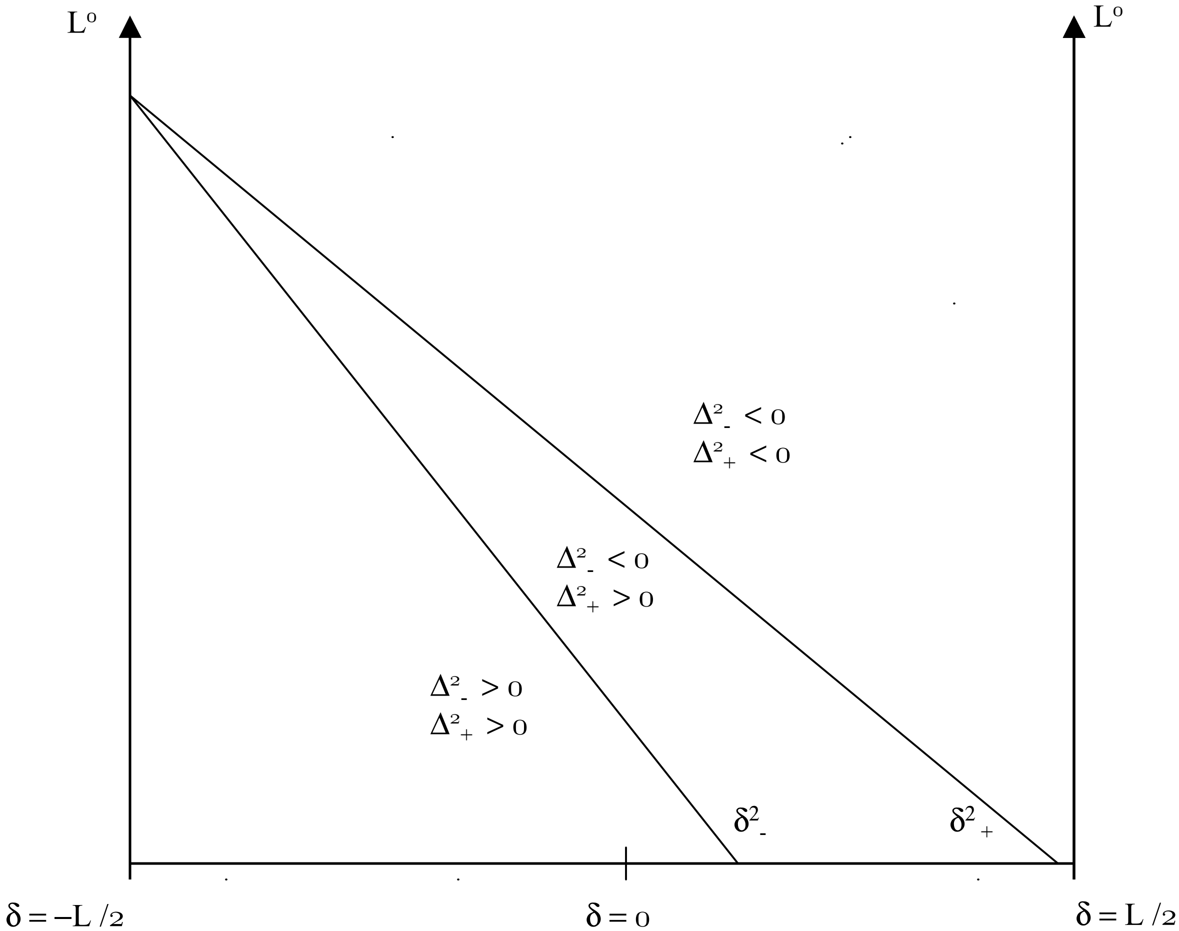

Figure 4. Incentives under Complementarity

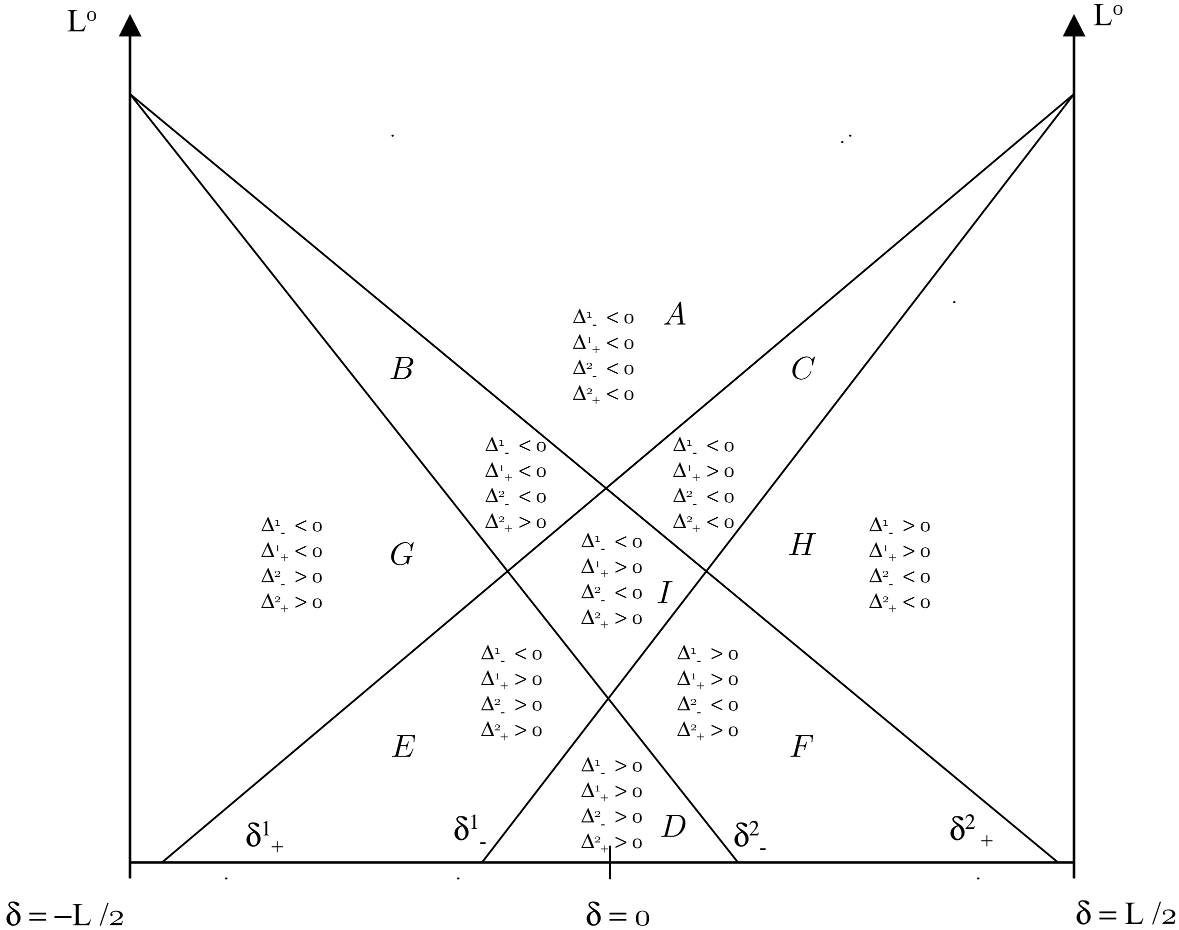

Figure 5. Incentives under Substitutability

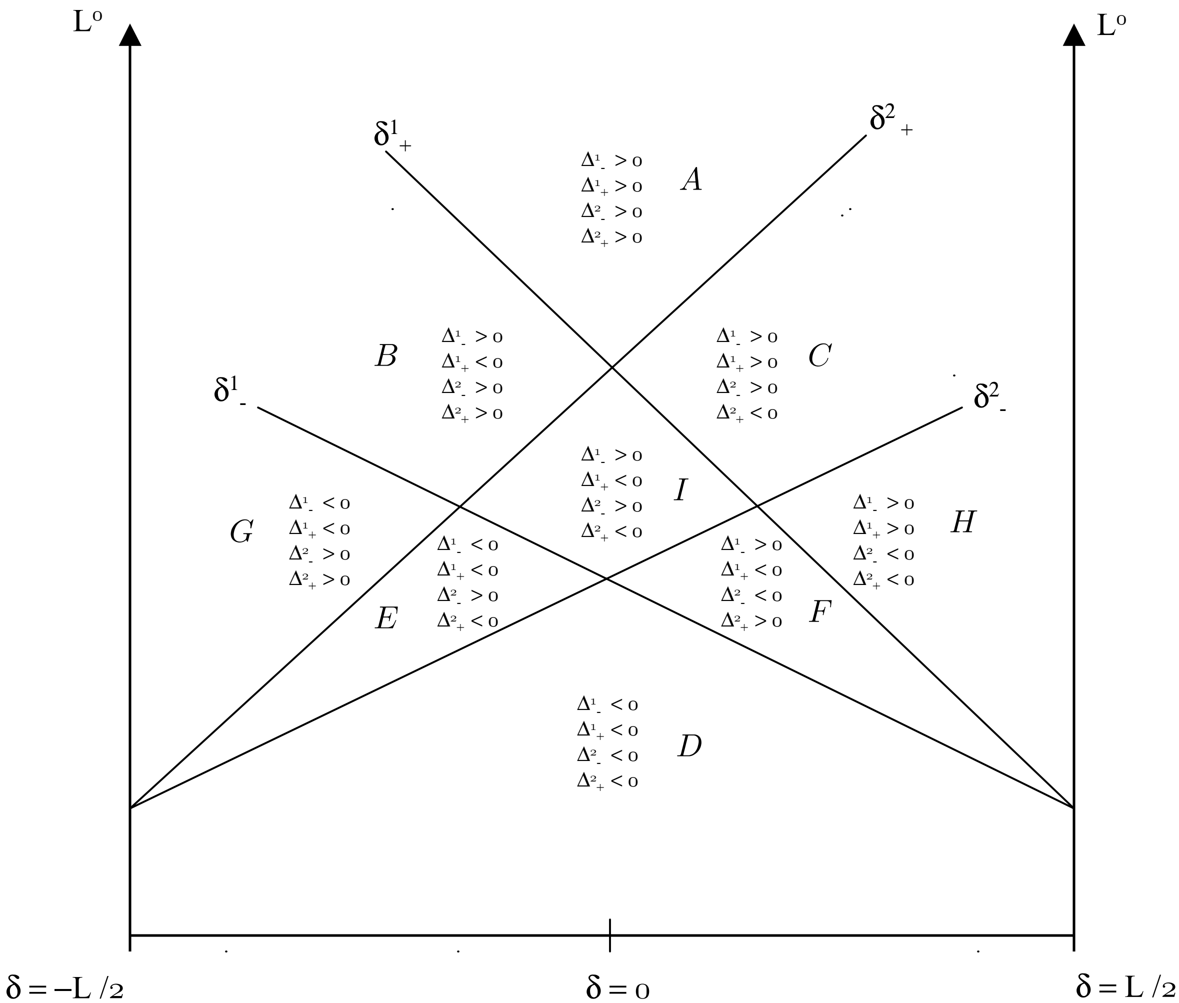

Figure 6. Nash Equilibria under Complementarity

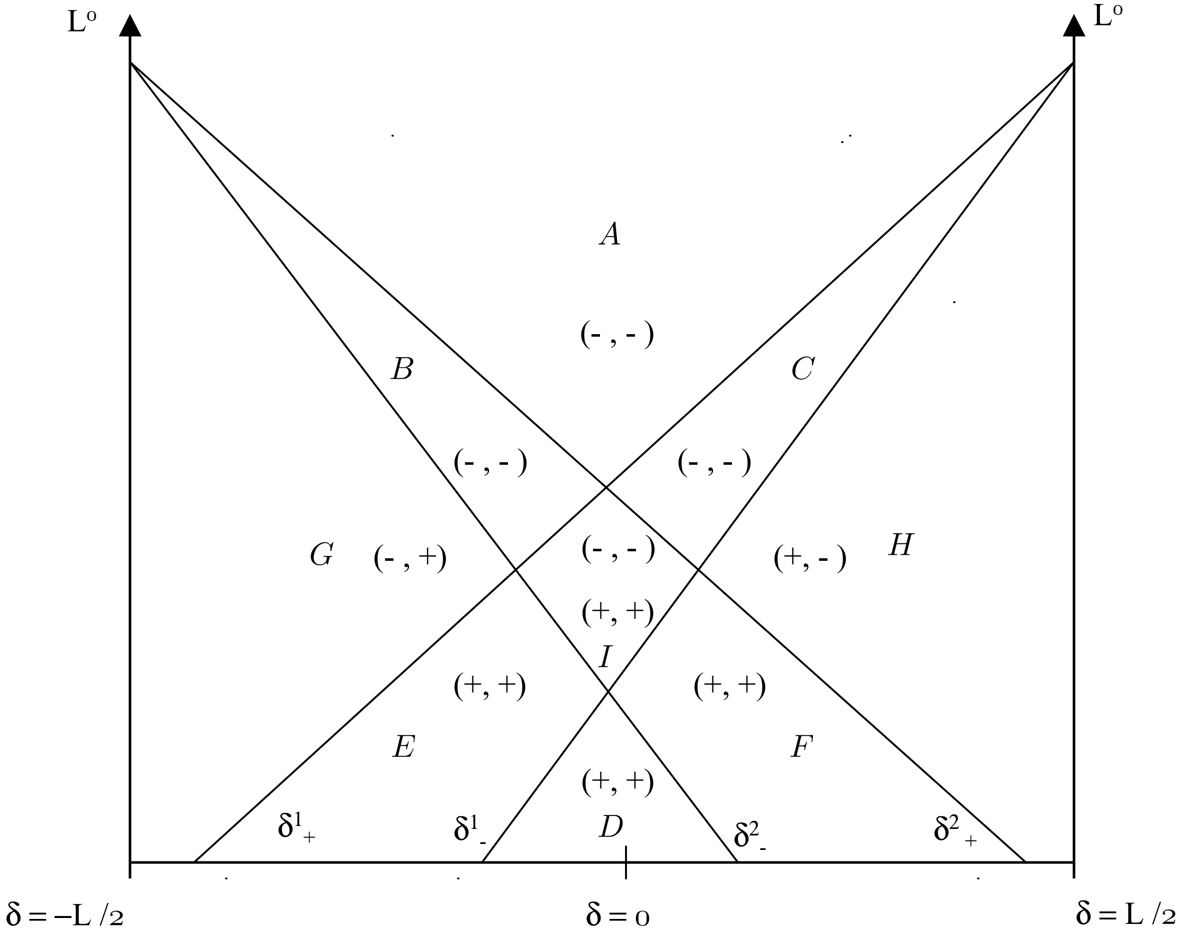

Figure 7. Nash Equilibria under Substitutability

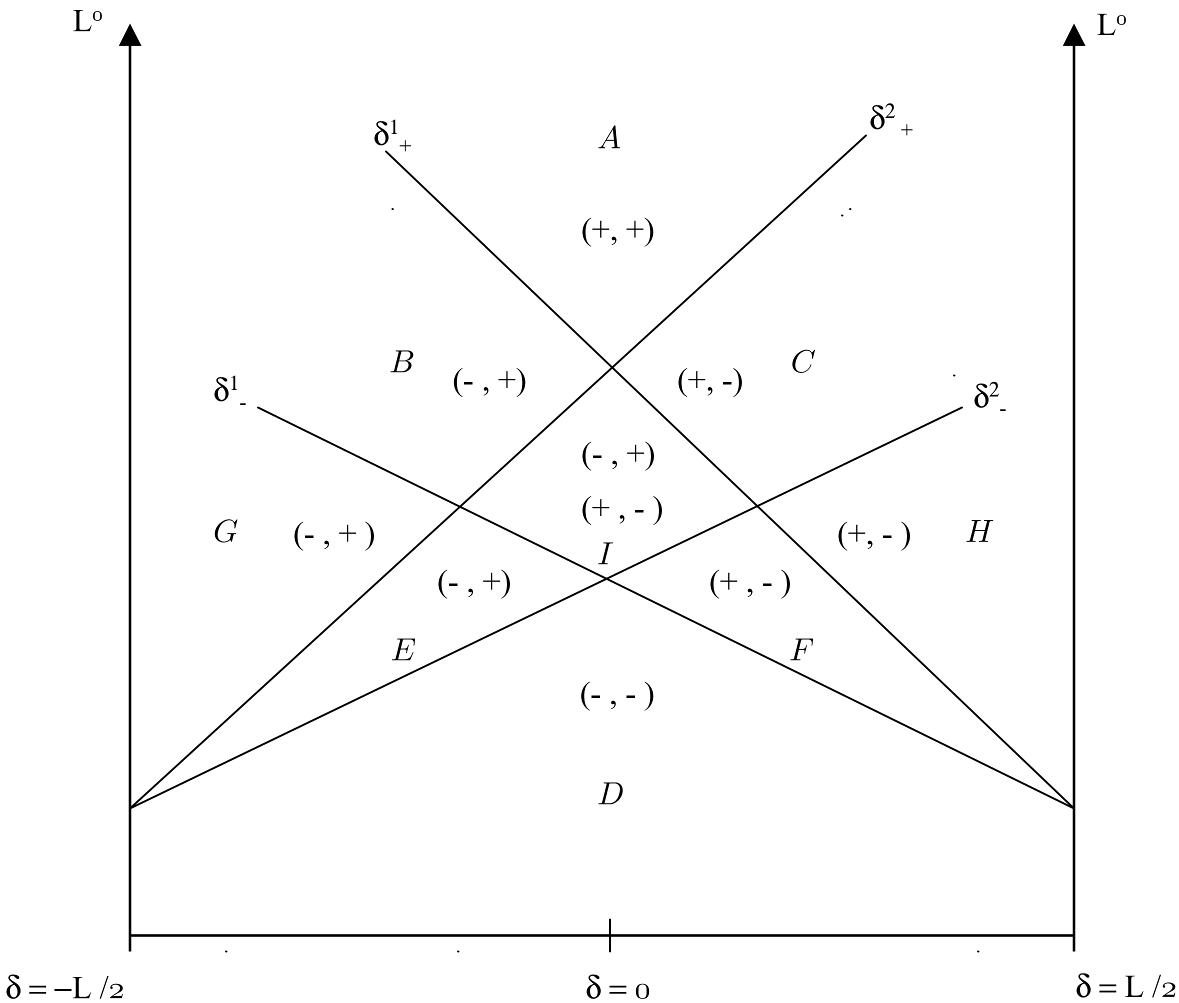

Figure 8. Areas of Welfare Improvement from Joint Adoption of High Standards under Complementarity

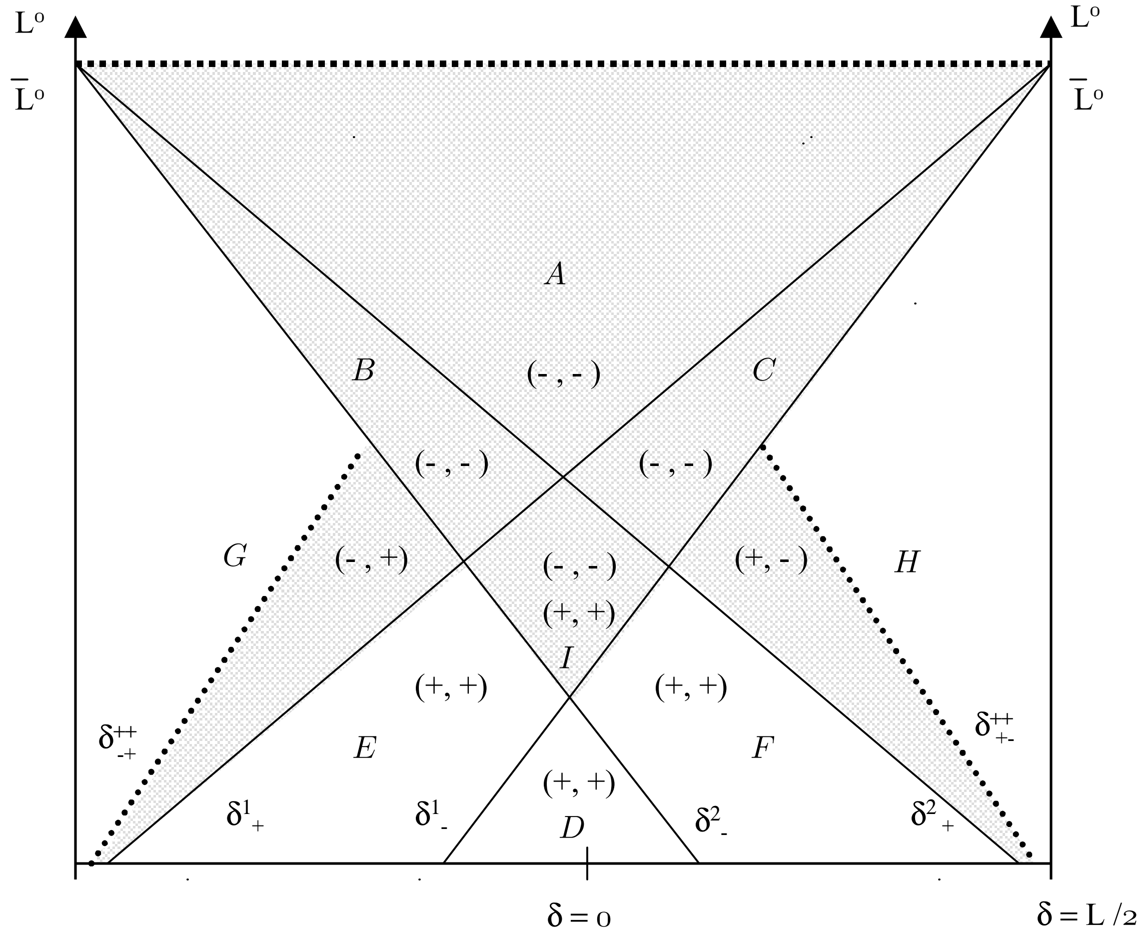

Figure 9. Areas of Welfare Improvement From Joint Adoption of High Standards under Substitutability