The case for non-discrimination in the international protection of intellectual property*

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First draft: February 2013
This version: July 2014

Abstract

We evaluate the case for non-discrimination in the international protection of intellectual property. If trade is not subject to any frictions then requiring national treatment (NT) in patent protection does not have any consequences for innovation (and welfare) since unfavorable discrimination abroad is fully offset by favorable discrimination at home. In the presence of trade frictions, however, such international offsetting in patent protection is incomplete and innovation incentives are actually lower under NT.

*For helpful comments and discussions, we thank seminar audiences at the following venues: Fifth Annual Conference of the International Economics and Finance Society of China (Shanghai; June 2013), Fall DISETTLE Workshop at ECARES, Université Libre de Bruxelles (Brussels; September 2013), Fall Midwest International Economics Meetings at the University of Michigan (Ann Arbor; October 2013), InstTED Conference at the University of Exeter Business School (Exeter; May 2013), and the University of International Business and Economics (Beijing; June 2013).
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1 Introduction

One of the most important and controversial outcomes of the Uruguay Round of multilateral trade negotiations (1986-95) was the Agreement on the Trade Related Aspects of Intellectual Property (TRIPS). This far-reaching agreement calls for WTO members to adopt certain minimum standards of protection for all major types of intellectual property such as copyrights, patents, and trademarks. For example, TRIPS requires that the duration of patent protection granted by all WTO members must be at least 20 years. In addition to such harmonization, an equally important aspect of TRIPS is that it requires member countries to adopt certain fundamental principles, such as non-discrimination in the protection of intellectual property. The non-discrimination requirement in TRIPS manifests itself in two forms: the principle of national treatment (NT) that forbids discrimination between domestic and foreign firms/nationals with regard to the protection of intellectual property and the most favored nation (MFN) clause that prohibits discrimination between foreign nationals originating from different countries. Our primary objective in this paper is to evaluate the case for NT in the protection of intellectual property. To achieve this objective, we utilize an adapted version of the Grossman and Lai (2004) model of endogenous patent protection with ongoing innovation. While the model focuses on patent policy, the insights it yields are relevant for other instruments of intellectual property protection such as copyrights and trademarks.

In accordance with Article 3 of TRIPS, Grossman and Lai (2004) focus on non-discriminatory patent policies in an open economy setting and show two major results. First, countries tend to offer too little protection to intellectual property in an open economy setting. Second, the harmonization of intellectual property protection across

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1 See Maskus (2000) for a comprehensive discussion of the economics of intellectual property rights protection in the global economy and the international externalities that a multilateral agreement such as TRIPS attempts to internalize.

2 To be sure, the principle of non-discrimination predates TRIPS but historical international intellectual property treaties (such as the Paris and Berne Conventions) were not backed by a powerful dispute settlement procedure like the one that is available to WTO members today.

3 The NT requirement is specified in Article 3 of TRIPS which says that “Each Member shall accord to the nationals of other Members treatment no less favorable than that it accords to its own nationals with regard to the protection of intellectual property.” MFN is contained in Article 4 which says that “any advantage, favour, privilege or immunity granted by a Member to the nationals of any other country shall be accorded immediately and unconditionally to the nationals of all other Members.” These twin principles of non-discrimination are found in some shape or form in every multilateral trade agreement of the WTO.

4 Their work builds on Nordhaus (1969) who first addressed the question of optimal patent policy in a closed economy.
countries is neither necessary nor sufficient for achieving efficiency since it does not address the underlying problem of under-protection. In the present paper, we build on their insights by examining the implications of the non-discrimination constraints on national patent policies imposed by NT thereby adding to our understanding of the economic consequences of TRIPS.\(^5\)

Issues surrounding the international protection of intellectual property have most frequently been examined in the literature through the lens of North-South models of international trade and technology transfer.\(^6\) However, such models do not derive optimal patent policies: instead they either consider the effects of marginal changes in an exogenously given rate of Southern imitation or examine policies that, on the margin, lower incentives for (endogenous) imitation. Thus, they do not address the implications of core TRIPS principles such as NT for equilibrium patent policies and welfare.

While non-discrimination in the use of domestic tax instruments such as sales taxes has received significant attention in the literature, little is known about its effects in the realm of intellectual property protection. Horn (2006) makes the important point that while NT with respect to internal taxes and other such domestic instruments can prevent countries from pursuing legitimate objectives, trade agreements that do not contain such a clause can be easily subverted by national governments who are invariably inclined to favor domestic firms over foreign ones. Thus, according to this view, NT serves as a line of defense against beggar-thy-neighbor tendencies of individual nations.\(^7\)

Horn’s (2006) basic query is no less relevant in the realm of intellectual property: when and why does it make sense to constrain national policies in the manner specified by NT? To be sure, incentives to pursue beggar-thy-neighbor policies are pervasive in the context of intellectual property.\(^8\) After all, a key reason the US and the EU

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\(^5\)In Grossman and Lai (2004) as well as in our model, all innovation is conducted by the private sector. See Scotchmer (2004) for an analysis of intellectual property treaties in a model where R&D is conducted by both the private and the public sector.

\(^6\)Much of this literature follows Grossman and Helpman (1991) who provide a comprehensive and unified treatment of the two leading approaches – i.e. the variety expansion model and the quality ladders model. Further building on this work, Helpman (1993) analyzes how a decline in Southern imitation affects global welfare both in the steady state and during the transition path.

\(^7\)Saggi and Sara (2008) take Horn’s analysis further by studying the role of NT when countries are heterogeneous in market size and/or the quality of goods produced and the mutual agreement over NT is endogenously determined. A recent paper by Horn, Maggi, and Staiger (2010) examines the role of NT from the perspective of incomplete contracts.

\(^8\)Lerner (2002) notes that prior to the emergence of major international agreements on intellectual property, discrimination against foreign patent applications was quite common during the mid 19th century across the world. Discriminatory measures used against foreigners included shorter duration of patents, higher fees, shorter extensions, and premature patent expirations. See also Goldstein (2001).
(to a lesser extent) pushed hard for a multilateral agreement on intellectual property during the Uruguay round negotiations was that major developing economies such as Brazil, China, and India were offering little or no intellectual property protection to their firms, a policy environment that fostered widespread imitation and reverse-engineering of Western technologies by local firms in such countries. But does the presence of such beggar-thy-neighbor incentives necessarily provide a rationale for requiring non-discrimination in the protection of intellectual property? Our analysis below shows that it does not.

Our baseline model considers a world comprised of two countries and analyzes the effects of NT under the assumption that there exist no trade frictions between them. Somewhat expectedly, we find that in the absence of a NT requirement, each country finds it optimal to grant weaker protection to foreign firms relative to domestic ones. This discrimination arises because governments do not care about the effects of their policies on foreign firms. However, we show that such discrimination against foreign firms on the part of both countries does not have any welfare consequences. To understand the intuition for this surprising result, first note that a firm’s incentive for innovation depends upon the level of effective global protection available to it under alternative policy regimes, where the level of effective global protection is defined as the sum of each country’s national index of patent protection multiplied by its market size. The reason NT fails to generate any welfare improvement in our model is that what each firm gains in terms of protection abroad if discrimination is replaced by NT is exactly offset by what it loses at home so that effective global protection facing firms remains unchanged.

In section 4, we show that this invariance of innovation incentives and welfare to NT does not obtain in the presence of trade frictions. When international trade is subject to frictions (such as transportation and communication costs), NT actually lowers innovation incentives by reducing the effective global protection enjoyed by firms. The intuition is that even though trade frictions lower export profits thereby making foreign patent protection relatively less important for incentivizing innovation in each country, NT calls for each country to provide more of such protection rather than less. Indeed, from the viewpoint of firms, favorable discrimination granted at home in the absence of NT more than offsets the negative incentive effects of unfavorable discrimination suffered abroad. Consumer welfare considerations reinforce the argument in favor of discrimination: trade frictions reduce the volume of trade so that consumer surplus generated by foreign innovations is smaller than that generated by domestic ones.  

9 The empirical link between the protection of intellectual property and the volume and pattern of
that with any positive level of trade frictions, it is jointly optimal for each country to offer a relatively lower level of patent protection to foreign firms, a policy configuration precluded by NT.

We also investigate how changes in the level of trade frictions between countries alter patent protection and the effects of NT. Here we find that a reduction in trade frictions between countries lowers each country’s incentive to discriminate against foreigners since domestic consumers derive greater benefits from foreign innovations when trade frictions are smaller. Our analysis also shows that differences in market size across countries can affect incentives for discrimination in rather surprising ways. An important result in this regard is that if the market size of a country increases relative to the other, its incentive to discriminate against foreign firms \textit{declines} while its level of patent protection increases. Intuitively, as a country’s market size increases, its weight in determining the level of effective global protection increases as does the benefit it enjoys from foreign innovations. Therefore, a larger market has a weaker incentive to discriminate against foreign nationals, a result that seems to accord quite well with the fact that multilateral disciplines on intellectual property were pushed strongly by the two largest economies in the world (EU and the USA) during the Uruguay round. From the perspective of these economies, TRIPS was primarily a means for getting developing countries to accept disciplines such as NT and MFN along with an increase in the degree of intellectual property protection that they had to extend to innovators.

Since an increase in market size asymmetry reduces the degree of discrimination in the larger market while it raises it in the smaller market, the average degree of discrimination declines in our model as markets become more unequal in size. For analogous reasons, the degree of effective global protection increases with market size asymmetry. Both of these factors imply that the global welfare loss generated by NT declines as markets become more asymmetric in size rather than less. This aspect of our model contrasts sharply with analyses of international trade agreements over conventional policy instruments such as tariffs and internal taxes since coordination over these traditional instruments as well as non-discrimination requirements with respect to their use generally become harder to implement as countries become less similar to each other—see, for example, Park (2000), Horn (2006), and Sara and Saggi (2008). In such models, as a country gets larger (i.e. has more market power) it tends to typically increase its tariff or tax but such a change immiserizes the other country. By contrast, in the present context, as the larger country increases its patent protection and lowers international trade was first established by Maskus and Penumarti (2001). See Maskus and Yang (2013) for a more recent investigation of related issues.
its discrimination against foreign firms, the smaller country’s welfare increases as does its ability to lower its own protection since innovation incentives of firms depend only on the effective global protection that they receive, and not on its composition across countries. Thus, the type of international spillovers that an international agreement over intellectual property helps internalize are fundamentally different in character from those internalized by trade agreements over tariffs and other trade policies.\textsuperscript{10} However, the different nature of spillovers in the context of patent protection is not the key driving force behind our surprising findings. Positive international spillovers created by patent protection only imply that there exists global under-protection of patents. The key reason discriminatory patent policies dominate NT in the presence of trade frictions is that such frictions make each country’s innovation relatively less response to foreign patent protection and by forcing each country to offer the same level of protection to domestic and foreign firms, NT reduces the overall effectiveness of patent protection in encouraging innovation.

Our paper echoes an emerging empirical literature that examines how effectively countries practice non-discriminatory IPR policies during the post-TRIPS era. Rather surprisingly, existing evidence suggests that even WTO members tend to discriminate against foreign innovators in practice. For example, Webster et. al. (2014) find that, all else equal, both European and Japanese patent offices are more likely to grant patents to domestic applicants relative to foreign ones. In similar vein, using data for Canada, Mai and Stoyanov (2014) find that domestic firms are substantially more likely to win litigations with foreign firms than with Canadian firms. Consistent with these empirical findings, our paper shows that countries indeed have incentives to use discriminatory IP policies in the absence of NT. More importantly, our paper establishes that the use of such discriminatory IP policies can be welfare-enhancing relative to NT when international trade is subject to frictions.\textsuperscript{11}

2 Baseline model

To study NT in the international protection of intellectual property, we utilize the open economy model of ongoing innovation developed by Grossman and Lai (2004). Before

\textsuperscript{10}Bagwell and Staiger (1999 and 2002) argue that the GATT/WTO principles of MFN and reciprocity help achieve efficiency when international trade agreements are motivated by the presence of terms of trade externalities between countries.

\textsuperscript{11}Lai (2007) also examines incentives for discriminatory patent policies in the absence of NT. However, he only considers a world of free and does not analyze how innovation and welfare differ across the two types of patent regimes (i.e. discrimination and NT).
describing policy choices, we summarize the underlying economic environment. The world consists of two countries: Home ($H$) and Foreign ($F$). Each country has two sectors: a traditional sector that produces a homogeneous good and a modern one that invents a variety of differentiated goods through research and development (R&D). An invented differentiated good has a finite life span ($\tau$) during which it generates positive utility for consumers. At the end of its life span, the differentiated good produces zero utility and exits the market.

In both countries, the representative consumer maximizes her lifetime utility

$$U(t) = \int_t^\infty e^{-\rho z} u(z) dz$$

where $\rho$ is the subjective discount rate and $u(\cdot)$ is the instantaneous utility function given by

$$u(z) = y(z) + \int_0^{n(z)} h(x(i, z)) di$$

where $y(z)$ and $x(i, z)$ represent respectively the consumptions of the homogeneous good and the $i$th differentiated good at time $z$ and $n(z)$ denotes the measure of differentiated goods that are still alive at time $z$. As in Grossman and Lai (2004), $h(.)$ is assumed to satisfy the following regularity conditions (i) $h' > 0$ and $h'' < 0$; (ii) every variety of differentiated goods is purchased in equilibrium (i.e. $h'(0) = \infty$); and (iii) optimal monopoly price of a typical differentiated good is finite (i.e. $-xh''/h' < 1$).

Given the preferences in (1) and (2), the representative consumer first chooses the consumption of differentiated goods and then purchases the homogeneous good with the remainder of her income (which is assumed to be positive). There are $M_i$ consumers in country $i$, where $i = H, F$, so that $M_i$ measures country $i$’s market size for differentiated goods.

On the production side, differentiated goods are invented by firms via R&D which requires a combination of labor ($L$) and human capital ($K$). For simplicity, the research technology in country $i$ is assumed to take the Cobb-Douglas form:

$$\phi_i(z) = F_i[L_{ii}(z), K_i] = A[L_{ii}(z)/a_i]^{\alpha}(K_i)^{1-\alpha}$$

where $\phi_i(z)$ is the flow of innovations at time $z$, $A > 0$ is a constant, $L_{ii}(z)$ is the labor input into innovation, $a_i$ represents labor productivity, and $K_i$ represents the fixed stock of human capital.\footnote{Our major results continue to hold when the production function for research has a CES form of the type $\phi_i(z) = A[a_iL_{ii}(z)/a_i]^{\beta} + (1-\alpha)K_i^{-\beta}1/\beta$ with $\beta \leq 0$. As is well-known, the Cobb-Douglas function $\phi_i(z) = A[a_iL_{ii}(z)/a_i]^{\beta} + (1-\alpha)K_i^{-\beta}1/\beta$ with $\beta \leq 0$.}
The amount of labor needed to produce one unit of each good (either homogeneous or differentiated) in country $i$ equals $a_i$. The total labor resource in country $i$, $L_i$, is assumed to be sufficiently large so that a positive amount of the homogeneous good is produced in equilibrium in each country. Labor is mobile between sectors but not across countries. We take the homogeneous good as the numeraire. Since the market for the homogeneous good is assumed to be perfectly competitive, the wage rate in country $i$ simply equals the marginal product of labor in the traditional sector: i.e. $w_i = 1/a_i$.

Given the technology specified for innovation in (3), $\phi_i(z) + \phi_j(z)$ newly invented goods enter country $i$’s market during each time period $z$, while a measure of $\phi_i(z - \tau) + \phi_j(z - \tau)$ existing goods die and exit the market. As a result, the growth in the measure of differentiated good at a given point in time is $\dot{n}_i(z) = \phi_i(z) - \phi_i(z - \tau) + \phi_j(z) - \phi_j(z - \tau)$. We focus on the steady state of the world economy where $\dot{n}_i(z) = 0$, that is, the measure of differentiated good in both markets remains constant over time.

A differentiated good can be targeted by imitators after being invented. To protect goods from imitation, the government in each country grants patent rights to inventing firms. As in Grossman and Lai (2004) patent is assumed to have two dimensions: the length $\tau$ and the degree of enforcement $\omega$ where $\omega \in [0, 1]$. While the patent is in effect the patenting firm charges its optimal monopoly price. Let $\pi$ be the instantaneous per capita profit of a monopoly firm producing a patented differentiated good so that $\pi = (p_m - aw)x_m$. Also define the index of patent protection as $\Omega = \omega(1 - e^{-\rho\tau})/\rho$ where $\rho$ is the rate of time preference. By design, the present value of expected per capita profits from patenting a newly invented good equals $\Omega\pi$.

A patented good, however, is imitated free of cost after the patent expires. Imitation drives the price of the good to its competitive level so that post imitation profits of an innovator equal zero. Let $\overline{T} = \omega(1 - e^{-\rho\tau})/\rho$ be the present value of a 1 dollar flow over the entire useful life of a typical patented product.

When analyzing optimal patent protection policies in the economic framework described above, Grossman and Lai (2004) focus on policies that abide by the non-discrimination principle of NT. As we noted earlier, Article 3 of TRIPS indeed requires countries to extend equal patent protection to all firms regardless of their national origin. One of our key objectives, however, is to examine the implications of the constraint production function obtains when $\beta = 0$. Restricting $\beta$ to be non-positive has two implications. First, the responsiveness of innovation to patent protection decreases as the latter rises. Second, patent protection policies of different countries are strategic substitutes for one another. We consider both these features to be quite realistic.

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13 Positive consumption of good $y$ and perfect intertemporal substitutability of $y$ in consumer preferences ensure that the interest rate is constant and equal to $\rho$. 
that NT places on the patent policies of individual nations. To do so, we allow countries to discriminate between domestic and foreign firms by formulating and implementing patent protection levels that depend upon the national origin of firms. Accordingly, let country \(i\) extend protection \(\Omega_{ii}^R\) to domestic firms and \(\Omega_{ij}^R\) to foreign ones under regime \(R\), where \(R = D\) (discrimination) or \(NT\) and \(\Omega_{ii} = \Omega_{ij}\) under \(NT\).

Under regime \(R\), a firm from country \(i\) that is successful in innovation earns total profit \(\pi M_i \Omega_{ii}^R\) in the home market and \(\pi M_j \Omega_{ij}^R\) overseas. The value of a typical innovating firm from country \(i\) under regime \(R\) therefore equals \(v_i^R = (M_i \Omega_{ii}^R + M_j \Omega_{ij}^R)\pi\). Firms make decisions about their labor inputs for R&D based on the expected total profits they can earn on the global market. The first-order condition determining demand for labor in country \(i\) under regime \(R\) where \(R = D\) or \(NT\) is

\[
v_i^R \frac{\partial F_i(L_{ii}, K_i)}{\partial L_{ii}} = w_i
\]

Let \(C_m\) and \(C_c\) be the instantaneous (per capita) consumer surplus levels under monopoly and competition respectively, i.e. \(C_m = h(x_m) - p_m x_m\) and \(C_c = h(x_c) - p_c x_c\). The discounted surplus over the entire life of a domestic differentiated product enjoyed by a typical consumer in country \(i\) equals \(C_m \Omega_{ii}^R + C_c (\bar{T} - \Omega_{ii}^R)\) whereas that derived from a foreign differentiated good is \(C_m \Omega_{ij}^R + C_c (\bar{T} - \Omega_{ij}^R)\).

Let \(\Lambda_0\) denote the welfare derived from goods invented prior to the implementation of the patent policy. We may then write country \(i\)'s national welfare under regime \(R\) where \(R = D\) or \(NT\), as

\[
W_i^R = \Lambda_0 + \frac{w_i}{\rho} (L_i - L_{ii}^R) + \frac{M_i \phi_i^R}{\rho} [C_m \Omega_{ii}^R + C_c (\bar{T} - \Omega_{ii}^R)] \\
+ \frac{M_j \phi_j^R}{\rho} [C_m \Omega_{ij}^R + C_c (\bar{T} - \Omega_{ij}^R)] + \frac{\pi \phi_i^R}{\rho} (M_i \Omega_{ii}^R + M_j \Omega_{ij}^R)
\]  

Similarly, let aggregate world welfare be defined simply the sum of national welfare of each country:

\[
WW^R = \sum_i W_i^R
\]

We proceed by deriving equilibrium policies under discrimination and then impose the NT constraint on each country to see how it affects equilibrium policies and welfare. It is obvious that the unilateral imposition of NT on a country in our framework can only make it worse off since a country can always choose not to discriminate in patent protection if it is welfare-maximizing to do so. But the more subtle issue, and the one that we address below, is how the simultaneous adoption of NT by both countries affects market outcomes and welfare.
3 Effects of NT in the absence of trade frictions

We begin with the scenario where international trade between Home and Foreign is not subject to any frictions or barriers. An important implication of this assumption is that from a social planner’s view, patent protection abroad is just as valuable to firms as patent protection in their domestic market. Later, in section 4 we will see that the introduction of trade frictions breaks this equivalence which, in turn, has implications for equilibrium policies and welfare under the two regimes.

3.1 Discriminatory patent protection

In what follows, we focus on the non-cooperative Nash equilibrium where each country simultaneously and independently determines its domestic and foreign patent protections, treating these protections in the other country as given. The objective of each government is to maximize national welfare. In particular, we assume interior solutions for both the NT and discrimination regimes, meaning that patent protections implemented by governments lie strictly between 0 and $T$. To this end, we need to derive the best response curves for each country from their welfare levels given in (4).

Let us first consider the case where countries are free to implement discriminatory patent policies. Following Grossman and Lai (2004), it turns out to be more intuitive to derive the best response curves of countries by equating each country’s marginal benefit of extending patent protection to the associated marginal cost, taking the policies of the other country as given.

Consider the patent policies of country $i$. A marginal increase in its domestic protection $\Omega_{ii}$ raises the value of all local firms. This leads to more R&D investment and a greater variety of differentiated goods invented by such firms. Each differentiated good generates a discounted per-consumer surplus of $C_m\Omega_{ii} + C_c(T - \Omega_{ii})$. It follows that country $i$’s marginal benefit of raising domestic protection is

$$\frac{M_i \partial \phi_i^D}{\rho} \frac{\partial^2 \Omega_{ii}}{\partial \Omega_{ii}^2} [C_m\Omega_{ii} + C_c(T - \Omega_{ii})]$$

(6)

where $\frac{\partial \phi_i^D}{\partial \Omega_{ii}}$ represents the response of local innovation to the change in domestic patent protection.

One can show that (see appendix)

$$\frac{\partial \phi_i^D}{\partial \Omega_{ii}} = \frac{\gamma \phi_i M_i}{M_i \Omega_{ii} + M_j \Omega_{ji}}$$

10
where $\gamma = \frac{\alpha}{1-\alpha}$ represents the responsiveness of innovation to the value of an innovation in elasticity form. Plugging this expression into (6), one obtains country $i$’s marginal benefit of raising domestic protection

$$\frac{1}{\rho} \frac{\gamma \phi^D_i M_i^2}{M_i \Omega_{ii} + M_j \Omega_{ji}} [(C_m - C_c)\Omega_{ii} + C_c T]$$

(7)

On the other hand, a marginal increase in domestic patent protection allows local firms to charge monopoly prices for a longer time period. This causes a loss of consumer surplus, which is partially offset by the greater monopoly profits accruing to domestic firms. Since $\phi^D_i$ new goods are invented per unit of time, country $i$’s discounted marginal cost of strengthening domestic patent protection $\Omega_{ii}$ equals

$$\frac{M_i \phi^D_i (C_c - C_m - \pi)}{\rho}$$

(8)

Equating the marginal benefit (7) to the marginal cost (8) and rearranging terms gives the first order condition determining country $i$’s patent protection $\Omega_{ii}$ to its domestic firms:

$$C_c - C_m - \pi = \frac{\gamma M_i}{M_i \Omega_{ii} + M_j \Omega_{ji}} [(C_m - C_c)\Omega_{ii} + C_c T]$$

(9)

Equation (9) describes country $i$’s best response $\Omega_{ii}$ to the degree of patent protection that country $j$ extends to country $i$’s firms ($\Omega_{ji}$). It is easy to see from (9) that $\Omega_{ii}$ varies inversely with $\Omega_{ji}$ since $C_m - C_c < 0$: country $i$’s protection to its own firms declines if they receive more protection from country $j$. The intuition behind this is straightforward. An increase in $\Omega_{ji}$ increases the value of country $i$’s firms and thereby encourages them to invest more in R&D activity. Due to diminishing returns in R&D, country $i$’s marginal benefit of extending more patent protection to its own firms is lower when $\Omega_{ji}$ is larger. As a result, $\Omega_{ii}$ has to fall in order to bring the marginal benefit back to the level of the marginal cost, namely, $C_c - C_m - \pi$. This implies that $\Omega_{ii}$ and $\Omega_{ji}$ are substitutable patent policies.

Observe that in the absence of NT, changing country $j$’s domestic protection ($\Omega_{jj}$) has no direct effect on country $i$’s decision regarding its domestic protection ($\Omega_{ii}$). This is not the case under NT, since a country cannot choose its domestic and foreign patent policies separately.

14 The second-order conditions can be shown to hold for both countries.
Similarly, the best response curve for country $i$’s foreign protection, $\Omega_{ij}$, can be obtained as

$$C_c - C_m = \frac{\gamma M_i}{M_i \Omega_{ij} + M_j \Omega_{jj}} [(C_m - C_c) \Omega_{ij} + C_c T]$$

(10)

It is important to note from the above equation that the marginal cost of strengthening foreign protection $\Omega_{ij}$ is not mitigated by $\pi$, because the monopoly profits generated by extending such patent protection end up accruing to foreign firms. It follows that a country’s marginal cost of foreign patent protection is always larger than that of domestic protection, which is the sole reason for why it has an incentive to implement discriminatory patent policies (as shown below). It is also clear from (10) that $\Omega_{jj}$ and $\Omega_{ij}$ are substitutes for each other: if country $j$ increases its domestic patent protection ($\Omega_{jj}$) then country $i$ will find it optimal to lower its foreign protection $\Omega_{ij}$.

We can show the following:\textsuperscript{15}

**Proposition 1:** In the absence of NT, each country’s patent policy discriminates in favor of domestic firms: $\Delta \Omega_{i}^* \equiv \Omega_{ii}^* - \Omega_{ij}^* > 0$ for $i, j = H, F$.

Proposition 1 is similar in spirit to the findings of Horn (2006) and Saggi and Sara (2008) who focus on NT in the context of tax policies. In particular, they show that if NT is not binding then each country will tax foreign firms more because their profits do not count as part of national welfare. The logic here is the same: discriminatory patent policies arise naturally from the fact that countries care about profits accruing to domestic firms but not foreign ones. The key question that follows is whether eliminating such discrimination via NT brings about efficiency gains, which will be addressed in the analysis below.

Firms make R&D decisions based on the duration of patent protection in each country as well as its market size. The level of effective global protection received by firms from country $i$ under discriminatory patent policies equals

$$P_i^* = M_i \Omega_{ii}^* + M_j \Omega_{ji}^*$$

where $i = H, F$. How does the level of effective global protection $P_i^*$ vary with the national origin of firms? We can show the following:

**Lemma 1:** When countries implement discriminatory patent policies, the effective patent protection available to firms is equal across countries: $P_i^* = P^*$, $i = H, F$.

\textsuperscript{15}Proofs of all propositions that are not in the text are provided in the appendix.
Lemma 1 implies that the incentives for innovation are the same for firms in either country, even if one country is relatively more efficient in innovation. Intuitively, when country $i$ protects its own firms more than country $j$ protects its own firms – as would be true if the market size of country $i$ is larger – then country $i$ also protects foreign firms more than country $j$. Indeed, if country $i$ is much larger than country $j$, it is possible for it to grant better protection to foreign firms than they receive from their own government even when country $i$ discriminates against foreign firms. Such international offsetting of patent protection equalizes incentives for innovation across countries.

Since
\[ M_H \Omega_{HH}^* + M_F \Omega_{FH}^* = M_F \Omega_{FF}^* + M_H \Omega_{HF}^* \]
it follows that
\[ M_i \Delta \Omega_i^* = M_j \Delta \Omega_j^* \iff \frac{\Delta \Omega_i^*}{\Delta \Omega_j^*} = \frac{M_j}{M_i} \]
which we state as:

**Proposition 2:** The relative degree of discrimination \( \frac{\Delta \Omega_i^*}{\Delta \Omega_j^*} \) practised by a country is inversely proportional to its relative market size \( \frac{M_i}{M_j} \), \( i = H, F \).

As a country’s relative market size increases, its weight in determining the level of effective global protection increases as does the benefit it enjoys from foreign innovations. Therefore, a larger market has a weaker incentive to discriminate against foreign nationals. As we noted earlier, in typical models of international trade agreements, as a country gets larger (i.e. has more market power) it tends to typically increase discrimination against foreign sellers. By contrast, the opposite happens here and the smaller country benefits from a reduction in discrimination its firms face abroad as well as an increase in overall patent protection.

### 3.2 Patent protection under NT

Now suppose that each country has to choose a non-discriminatory patent protection level that applies to every firm in the world. A detailed analysis of the NT regime is provided in Grossman and Lai (2004). Here, we focus on comparing outcomes under NT with those under discrimination. The best response curve for country $i$ under NT can be written as follows
\[ C_c - C_m - \mu_i \pi = \gamma \frac{M_i}{\Pi_i(\Omega_i, \Omega_j)} \left[ (C_m - C_c) \Omega_i + C_c T \right] \quad (11) \]
where $P_i(\Omega_i, \Omega_j) = M_i \Omega_i + M_j \Omega_j$ and $\mu_i = \frac{\phi_i^{NT}}{\phi_i^{NT} + \phi_j^{NT}}$ is the proportion of innovation that occurs in country $i$. Given our assumption that the R&D production function is Cobb-Douglas in nature, it turns out that $\mu_i = \frac{K_i}{K_i + K_j}$, i.e., $\mu_i$ is determined solely by the relative human capital stocks of countries and is unaffected by their patent policies.

Observe from above that the marginal cost of patent protection in country $i$ under NT is strictly in between the marginal costs of granting patent protection to domestic firms and foreign firms under discrimination:

$$C_c - C_m - \pi < C_c - C_m - \mu_i \pi < C_c - C_m$$

This inequality follows from the fact that a country only cares about profits of local firms while NT forces it to treat all firms symmetrically. As a result, the profit of a typical firm is discounted by $\mu_i$ which increases in its home country’s human capital ($K_i$). This means that when a large share of the global innovation is carried out by local firms, the marginal cost of patent protection perceived by a country declines. In general, since NT forces countries into a scenario where the marginal cost of patent protection is a weighted average of the marginal costs associated with the discriminatory protection levels accorded to domestic and foreign firms, intuition suggests that NT might induce countries to select a level of protection that lies in the interval $(\Omega_{ii}, \Omega_{ij})$ – a conjecture we formally confirm below.

**Proposition 3:** (i) Under NT, each country selects a level of patent protection that exceeds the protection it grants to foreign firms under discrimination but falls short of that which it gives to its domestic firms: $\Omega_{ij}^* < \Omega_{ii}^{NT} < \Omega_{ii}^*$. If countries are symmetric then $2\Omega_{ii}^{NT} = \Omega_{ii}^* + \Omega_{ij}^*$ for $i, j = H, F$.

(ii) The effective global protection available to firms as well as global welfare under NT is the same as that under discrimination: $P^{NT} = M_i \Omega_i^{NT} + M_j \Omega_j^{NT} = P^*$. 

To see more explicitly why welfare under NT is the same as that under discrimination, from (5) we can rewrite world welfare under regime $R$ as

$$WW^R = \sum_i \lambda_{i0} + \frac{1}{\rho} \sum_i w_i (L_i - L_i^R) + \frac{C_c^T}{\rho} \sum_i \phi_i^R M_i - \sum_i \phi_i^R P_i \left[ \frac{C_c - C_m - \pi}{\rho} \right]$$

Observe from this that in the absence of NT, world welfare depends only upon the effective protection levels $P_i^R = M_i \Omega_i^R + M_j \Omega_{ji}^R$ available to firms from both countries under
regime $R$ (where $R = NT$ or $D$) since $P_i^R$ pins down all the other endogenous variables such as the allocation of resources to R&D ($L_{ii}^R$) and the rates of innovation ($\phi_i$). But from Proposition 3 we already know that $P_i^* = P^{NT}$. As a result, world welfare is invariant to whether or not the underlying patent regime abides by NT. Therefore, mandating NT is neither necessary nor sufficient for achieving efficiency provided international trade is not subject to any frictions.

Grossman and Lai (2004) showed that the Nash equilibrium under NT gives rise to under-protection of intellectual property relative to the socially optimal levels due to the positive internalities externalities generated by national patent protection policies. From the above analysis, it is not hard to see that the free rider problem that plagues the Nash equilibrium under NT continues to exist even when countries institute discriminatory patent policies.

The welfare neutrality of NT in our model is a rather novel finding in the context of the literature on NT. As we noted earlier, models in which NT applies to taxation typically find results favorable to NT. Further, even in the context of patent protection, in a two period model Bond (2005) has shown that, holding constant the level of protection granted to domestic firms, an increase in the level of patent protection granted to foreign firms that eliminates discrimination increases global welfare. The driving force behind this result is as follows: since each country offers too little protection to foreign firms, a NT policy that leaves domestic protections unchanged essentially increases overall patent protection thereby alleviating the inefficiency of aggregate under-protection in the global economy.

While there is under-protection of patent protection in our model as well, what our analysis highlights is that a move towards increasing patent protection to foreigners driven by NT does not occur in isolation since each country simultaneously lowers the protection it grants to domestic firms. In fact, such changes in patent protection granted to domestic firms as a result of NT offsets the increased protection granted to foreign firms so that NT does not alter the effective global protection available to firms. In this way, our model is able to separate the impact of NT on welfare from the increase in overall patent protection that results if NT is interpreted as a policy that brings up the patent protection granted to foreign nationals holding constant the protection granted.

It is worth emphasizing that our model considers the simultaneous adoption of NT by both countries. One might also be interested in knowing the welfare consequences of a unilateral violation of NT by a single country. We can show that holding constant the patent protection of one country at a non-discriminatory level, unilateral violation of NT by the other country can indeed lower overall patent protection and welfare. This implies that the strategic substitutability of patent policies across countries is key to understanding Proposition 3 (ii).
to domestic firms.

4 NT in the presence of trade frictions

Since the welfare neutrality of NT in the benchmark model is driven by the complete offsetting of patent protection across countries when discriminatory policies are eliminated via NT, it is worth asking whether such international offsetting also obtains when frictions arising from the existence of transportation costs and costs of coordination and communication hamper international trade. We now address this issue and show that when trade frictions exist, NT induces incomplete offsetting of patent protection across countries and actually ends up lowering the effective level of global patent protection.

4.1 Trade frictions and discrimination

Before deriving the effect of trade frictions on the incentives for discrimination in patent protection, we make three simple observations. First, trade frictions reduce the surplus consumers derive from foreign goods. Second, by making it costlier for firms to export, trade frictions lower export profits of firms (while having no effect on their domestic profits). Third, trade frictions do not affect the consumer surplus derived from goods whose patents have expired since such goods are imitated and produced locally in each market.

Denote the (inverse of) the degree of trade frictions between countries by $\theta$, where $0 \leq \theta \leq 1$ and $\theta = 1$ represents free/costless trade while $\theta = 0$ indicates the complete absence of trade. In the presence of trade frictions, denote the consumer surplus derived from a patented imported good by $\theta C_m$ while the export profits earned by a firm by $\theta \pi$. This parsimonious formulation of trade frictions (i.e. as being captured by a single parameter $\theta$) is adopted purely for expositional simplicity.\(^{17}\) Our results below hold as long as both consumer surplus and export profits decrease with trade frictions even if they do so at very different rates.

\(^{17}\)Suppose $h(x) = \frac{\zeta^{1/\varepsilon}}{\varepsilon - 1} x^{\frac{\varepsilon - 1}{\varepsilon}}$ where $\varepsilon > 1$ and $\zeta > 0$. This utility function yields a constant elasticity demand curve of the form $x(p) = \zeta p^{-\varepsilon}$ for each differentiated good. If, in addition, trade barriers are assumed to be of the ice-berg type, then it is straightforward to show that consumer surplus from imports and overseas profits earned by firms equal $\theta C_m$ and $\theta \pi$ respectively. Lai and Yan (2013) embed this formulation of trade costs in a model of patent protection with firm heterogeneity and FDI and show that trade liberalization helps alleviate the problem of under-protection in Nash equilibrium. Even in their model, trade frictions lower overseas profits and consumer surplus derived from imported goods. Thus, allowing for firm heterogeneity and FDI does not affect the main channel that renders foreign patent protection less effective than domestic protection in our model.
It is worth noting that in the context of patent protection, a world with prohibitive trade frictions ($\theta = 0$) is not the same as a fully autarkic economy that is shut off from the world in every way. In particular, if technology transfer does not depend on trade (i.e. if trade in ideas can occur without trade in goods – see Rivera-Batiz and Romer, 1991), then even when there is no trade in goods (i.e. $\theta = 0$) a country is free to imitate foreign goods. As a result, one would expect a country to have less incentive to protect intellectual property under $\theta = 0$ relative to the autarky case. Indeed it is possible to show, for example, that patent protection under NT when $\theta = 0$ is lower in both countries relative to the autarkic level.

The key question we address below is: How do trade frictions affect incentives for discrimination? The overseas profit earned by a firm from country $i$ equals $\theta M_j \Omega_{ji} \pi$ so that the corresponding firm value equals

$$v_i^D(\theta) = (M_i \Omega_{ii} + \theta M_j \Omega_{ji}) \pi$$

As is clear from above, due to the presence of trade frictions ($\theta < 1$) patent protection in export markets (i.e. $\Omega_{ji}$) is relatively less valuable for firms than protection in their domestic markets (i.e. $\Omega_{ii}$).

Now consider government $i$’s decision regarding patent protection. The marginal cost of extending domestic protection remains unchanged relative to free trade since trade frictions do not affect the consumption of domestic goods and thus the profit firms make in their domestic markets. A country’s marginal benefit of domestic protection, however, is different as trade frictions do affect the value of domestic firms by reducing their export profits and therefore the influence of foreign patent protection $\Omega_{ji}$ on their innovation incentives.

The marginal benefit of extending domestic protection $\Omega_{ii}$ equals

$$\frac{1}{\rho M_i \Omega_{ii} + \theta M_j \Omega_{ji}} \left[ (C_m - C_c) \Omega_{ii} + C_c T \right]$$

Note that holding constant $\Omega_{ji}$ (i.e. the protection domestic firms get abroad), the marginal benefit of increasing $\Omega_{ii}$ (i.e. the protection to domestic firms) decreases with $\theta$. All else equal, a reduction in trade frictions makes $\Omega_{ji}$ a more effective substitute for $\Omega_{ii}$ due to increased export profits of firms.

Country $i$’s best response curve for domestic protection $\Omega_{ii}$ can be written as

$$C_c - C_m - \pi = \frac{\gamma M_i}{M_i \Omega_{ii} + \theta M_j \Omega_{ji}} \left[ (C_m - C_c) \Omega_{ii} + C_c T \right]$$

(12)
Regarding the protection extended to foreign firms, note that consumers in country $i$ only derive a surplus of $\theta C_m$ units from buying a patented foreign good. Since consumers always buy the good from domestic imitators once the patent expires, the corresponding surplus post imitation equals $C_c$. Thus, the marginal cost of raising foreign protection equals

$$M_i \phi_j^D (C_c - \theta C_m) \rho$$

As is clear, holding constant the rate of innovation, the marginal cost of protecting foreign firms decreases with trade frictions.

Country $i$’s marginal benefit of protecting foreign firms can be written as

$$\frac{1}{\rho} \frac{\gamma \theta \phi_j^D M_i^2}{\theta M_i \Omega_{ij} + M_j \Omega_{jj}} [\theta C_m - C_c] \Omega_{ij} + C_c T$$

Note that holding constant $\Omega_{jj}$ (i.e. the protection foreign firms get from their own government), the marginal benefit of increasing $\Omega_{ij}$ (i.e. the protection given by country $i$ to foreign firms) increases as trade frictions fall.

The best response curve for $\Omega_{ij}$ is given by

$$C_c - \theta C_m = \frac{\gamma \theta M_i}{\theta M_i \Omega_{ij} + M_j \Omega_{jj}} [\theta C_m - C_c] \Omega_{ij} + C_c T$$

(13)

Using the above best response curves, we can show the following:

**Proposition 4:** As trade frictions between countries fall (i.e. $\theta$ increases), each country increases the degree of patent protection granted to foreign firms $\Omega_{ij}^*(\theta)$ while decreasing that granted to domestic firms $\Omega_{ii}^*(\theta)$. Furthermore, a reduction in trade frictions increase the degree of effective global patent protection in both countries, i.e., $\frac{\partial P_i^*(\theta)}{\partial \theta} > 0$ where $P_i^*(\theta) = M_i \Omega_{ii}^*(\theta) + \theta M_j \Omega_{jj}^*(\theta)$.

We now compare NT and discrimination in the presence of trade frictions. As before, a typical firm’s value under the NT regime equals

$$v_i^{NT}(\theta) = (M_i \Omega_i + \theta M_j \Omega_j) \pi$$

It is important to note that due to the existence of trade frictions, $v_i$ will in general be different from $v_j$ even under NT, which further implies that firms in different countries may face different levels of effective patent protection.\textsuperscript{18}

\textsuperscript{18}Recall that when trade is free, all firms receive the same effective level of global patent protection under NT.
Under NT, the cost and benefit of a marginal change in patent protection depend upon the level of trade frictions. As the derivation is similar to before, we simply report country $i$’s best response curve for $\Omega_i$ without presenting the details:

$$C_c - (\mu_i + \theta \mu_j)C_m - \pi = \frac{\gamma M_i \mu_i}{M_i \Omega_i + \theta M_j \Omega_j} \left[ (C_m - C_c) \Omega_i + C_c T \right]$$

$$+ \frac{\gamma \theta M_i \mu_j}{\theta M_i \Omega_i + M_j \Omega_j} \left[ (\theta C_m - C_c) \Omega_i + C_c T \right]$$

(14)

To investigate the efficiency impact of NT, we now introduce the assumption that countries are symmetric in all respects ($M_i = M$, $K_i = K$ and $a_i = a$). This is a useful simplification for three reasons. First, it helps isolate the effect of trade frictions on the international patent regimes. Second, the issue of non-discrimination is as relevant, if not more, in a North-North type setting of relatively similar countries as it is in a North-South setting where there are significant differences across countries with respect to market size and human capital. Third, analytical solutions under NT are difficult to calculate when countries are asymmetric. As a result, in section 4.3, we use numerical examples to study the case of asymmetry and show that our results do not require countries to be symmetric.

Denote the symmetric Nash equilibrium level of patent protection under NT by $\Omega^*(\theta)$. Under discrimination, let $\Omega^*_d(\theta)$ be the patent protection granted by each country to domestic firms and $\Omega^*_f(\theta)$ that given to foreign firms. We can then show the following:

**Proposition 5:** Suppose countries are symmetric and there exist trade frictions between them (i.e. $0 \leq \theta < 1$). Then the following hold:

(i) The degree of effective global protection received by firms under NT is lower than that under discrimination:

$$P^NT(\theta) = M(1 + \theta)\Omega^*(\theta) < P^*(\theta) = M(\Omega^*_d(\theta) + \theta \Omega^*_f(\theta))$$

(ii) The gap between the degree of effective patent protection under discrimination and NT decreases as trade frictions fall (i.e. $P^*(\theta) - P^NT(\theta)$ declines with $\theta$).\(^{19}\)

When trade frictions exist, from the viewpoint of firms, protection abroad matters less for profitability than protection at home. As a result, trade frictions make foreign protection relatively less effective in inducing innovation in each country. However, NT...

\(^{19}\)The analysis for the case of asymmetric countries is a bit more subtle and is presented in Section 5.
forces each country to treat firms the same even though their innovation incentives respond more to domestic protection. As a result, *NT blunts the effectiveness of patent protection for incentivizing innovation* so that, in equilibrium, the effective degree of protection chosen by countries under NT ends up being lower. This result is important because it shows that while there is under-protection of intellectual property under both NT and discrimination in our model, this problem is *more* severe under NT. Thus, somewhat paradoxically, in the presence of trade frictions allowing countries to discriminate against foreign nationals with respect to patent protection actually leads to stronger innovation incentives in the global economy.

The intuition behind Proposition 5 can also be understood by examining the marginal benefit and cost of strengthening patent protection. Suppose that \( P_{NT}(\theta) \leq P^*(\theta) \). Then from the right-hand sides of (A6) and (A7) in the Appendix, we can see that the marginal benefit of raising patent protection is larger under discrimination for both countries. Moreover, it exceeds the marginal cost of patent protection so that each country would want to extend its total patent protection. This implies that \( P_{NT}(\theta) = P^*(\theta) \) cannot be sustained as a Nash equilibrium. As a result we must have \( P^*(\theta) > P_{NT}(\theta) \).

### 4.2 Jointly optimal policies under trade frictions

We now consider the problem of choosing jointly (or socially) optimal domestic and foreign patent protection for country \( i \)'s firms (i.e. \( \Omega_{ii} \) and \( \Omega_{ji} \)). The jointly optimal policies solve

\[
\max_{\Omega_{ii}, \Omega_{ji}} WW_D(\theta) \text{ where } WW_D(\theta) = \sum_i W_i^D(\theta)
\]

We show in the appendix that

\[
\frac{\partial WW_D(\theta)}{\partial \Omega_{ii}} - \frac{1}{\theta} \frac{\partial WW_D(\theta)}{\partial \Omega_{ji}} = \frac{\phi_i^D M_i(1 - \theta) C_c}{\theta} > 0 \text{ for all } 0 < \theta < 1 \tag{15}
\]

i.e. the net marginal social benefit of extending domestic patent protection to firms is strictly higher than the marginal benefit of foreign patent protection so long as their exist trade frictions between countries. Using this key relationship, we prove the following result:

**Proposition 6:** *In the presence of trade frictions (i.e. \( 0 < \theta < 1 \)), social optimality calls for each country to discriminate against foreign firms, i.e. \( \Omega_{ij}^W < \Omega_{ii}^W \) for \( i, j = H, F \).*\(^{20}\)

\(^{20}\)Since under this scheme of jointly optimal protection firms receive less protection abroad than they do at home, for any given innovation, foreign consumers begin to enjoy greater surplus (arising from
Furthermore, if it is optimal to offer firms less protection in their domestic markets than the useful lifetime of products (i.e. $\Omega_{ii}^w < T$), then it is optimal to give them no patent protection in their export markets (i.e. $\Omega_{ji}^w = 0$).21

The central point of Proposition 6 is that trade frictions drive a wedge between the social value of domestic and foreign patent protections and social optimality calls for assigning a higher priority to domestic protection in each country. In other words, not only the level of protection but also its composition matters. In contrast, Grossman and Lai (2004) show that under free trade efficiency depends on the level of total protection but not the compositional feature. In our model, this is easily verified by taking $\theta = 1$ in (15), so that domestic and foreign protections have equal net benefit.

Proposition 6 shows that, in the realm of patent protection, discriminatory policies are desirable even when beggar-thy-neighbor incentives are completely missing (as they are when countries maximize joint welfare). Bond (2005) has shown that it can be socially efficient to internationally discriminate with respect to patent protection if the elasticity of innovation with respect to patent protection differs across countries. Our results imply that this is not necessary for discrimination to be desirable since we allow the elasticity of innovation with respect to patent protection to be the same across countries.22

Comparing the first-order conditions determining the Nash equilibrium with those under joint welfare maximization, it is easy to see that the marginal cost of patent protection under the Nash equilibrium (as perceived by each country) is larger than the true social cost while the marginal benefit of such protection is smaller if effective protection under the two scenarios is the same (i.e. if $M_i\Omega_{ii}^w = M_i\Omega_{ii}^* + \theta M_j\Omega_{ji}^*$). Thus, in an interior solution we must have $M_i\Omega_{ii}^* + \theta M_j\Omega_{ji}^* < M_i\Omega_{ii}^w$, i.e. there is under-protection in Nash equilibrium even in the presence of trade frictions, although the magnitude

local imitation) sooner than domestic ones. Indeed, if markets are unequal in size we can show that the degree of jointly optimal protection for firms in each country is increasing in the relative size of the other country’s market: $\frac{\partial \Omega_{ii}^w}{\partial (M_j/M_i)} > 0$.21

21A corner solution for foreign protection might not arise if there exist enforcement costs that are increasing in the level of patent protection. Under such costly enforcement, foreign protection may be utilized even if domestic protection does not reach the boundary $T$. Even so, the rationale for discrimination would remain since such enforcement costs would presumably also apply to foreign protection, and might even be higher than those for domestic protection.

22An interesting implication of the presence of trade frictions is that discrimination could be more desirable for goods that are harder to trade. Specifically, in an extreme case where goods are non-tradable (i.e. $\theta = 0$), there would be no reason to protect foreign firms as their innovation incentives are unresponsive to patent protection granted by countries other than their own. As a result, when $\theta = 0$ protecting foreign innovation only delays domestic consumption by the duration of the patent without affecting the rate of innovation.
of the externality from foreign protection is reduced. Another interesting observation about discriminatory patent policies is that while coordination always leads to weaker foreign protection, in an asymmetric Nash equilibrium the North’s foreign protection may exceed the South’s domestic protection. This is because the larger country tends to discriminate less while the smaller country free rides more. Notably, even though the South may be "sheltered" by the North, Proposition 6 indicates that this is not justified from an efficiency point of view.

It is also useful to consider the socially optimal protection levels assuming that NT must be followed. If countries must abide by NT while choosing jointly optimal policies, the common protection level in each country solves:

$$\max_{\bar{\Omega}_i, \bar{\Omega}_j} WW^{NT}(\theta) \text{ where } WW^{NT}(\theta) = \sum_i W_i^{NT}(\theta)$$

It is straightforward that world welfare cannot be higher under NT as additional constraints are imposed on the same maximization problem. Then the natural question would be whether NT yields strictly lower world welfare. Proposition 6 implies that this is indeed the case as long as there exist interior solutions under NT. The reason is straightforward: by maintaining the level of total patent protections under NT, efficiency can be improved by substituting domestic protection for foreign, which necessarily creates discrimination. Thus we arrive at the following:

**Proposition 7**: Suppose interior solutions are obtained under NT. Then the imposition of a NT constraint on the social planner lowers welfare: $$WW^{NT}(\theta) < WW^{D}(\theta)$$.

### 4.3 NT in a North-South setting

In what follows, we discuss how the relative performance of NT and discrimination depends upon the degree of asymmetry across countries. This issue is important because what made TRIPS negotiations especially difficult was the clash between the views of developing and developed countries regarding the desirability of multilateral disciplines in the area of intellectual property. Furthermore, the WTO is comprised of countries with markedly different economies and it is important to know how NT operates in such an environment. Note that the last section showed that, in the presence of trade frictions NT is socially less efficient than discrimination, regardless of the degree of asymmetry across countries. What is interesting to know is whether this is also true in a noncooperative Nash equilibrium when countries are asymmetric in terms of economic fundamentals.
In particular, it seems useful to consider a North-South scenario where one country’s, i.e. North’s, market as well as the stock of human capital is larger than that of the other (i.e. South). Suppose $M_i > M_j$ and $K_i > K_j$. The non-linearity of first order conditions (FOCs) under NT (see (14)) makes it difficult to obtain analytical solutions under asymmetry. Nevertheless, we show below that the key driving forces behind NT being efficiency-reducing relative to discrimination in a North-South setting remain the same as those under symmetry. To start, we add up FOCs for both countries under NT. This yields

$$2C_c - (1 + \theta)C_m - \pi = \gamma \left[ \frac{\mu_i}{P_{NT}^i(\theta)}[(C_m - C_c)P_{NT}^i(\theta) + (M_i + \theta M_j)C_cT] - (1 - \theta)\theta M_j \Omega_j(\theta) \right] + \frac{\mu_j}{P_{NT}^j(\theta)}[(C_m - C_c)P_{NT}^j(\theta) + (M_j + \theta M_i)C_cT - (1 - \theta)\theta M_i \Omega_i(\theta)]$$

Similarly, adding the two FOCs under discrimination yields

$$2C_c - (1 + \theta)C_m - \pi = \gamma \left[ \frac{1}{2P_i(\theta)}(C_m - C_c)P_i(\theta) + (M_i + \theta M_j)C_cT - (1 - \theta)\theta M_j \Omega_j(\theta) \right] + \frac{1}{2P_j(\theta)}[(C_m - C_c)P_j(\theta) + (M_j + \theta M_i)C_cT - (1 - \theta)\theta M_i \Omega_i(\theta)]$$

Note that the left hand-side of both equations above can be interpreted as the global marginal cost of patent protection, as it is the sum of marginal costs of patent protection across countries. Analogously, the right hand-side of both equalities represents the global marginal benefit of patent protection. Observe that the global marginal cost of patent protection under the two regimes is the same (since the LHS of the two equations is the same). However, from the perspective of global marginal benefit of patent protection, NT yields a worse outcome than discrimination due to two reasons. First, when trade frictions exist, NT forces countries to overuse foreign protection, which other things being equal, tends to reduce the global marginal benefit of patent protection. This overuse of foreign protection under NT was the key driving force behind our analysis of the symmetric case. Of course, this mechanism continues to exist under asymmetry. Indeed, observe that the incentive-reducing effects of trade frictions under NT, captured by the terms $(1 - \theta)\theta M_i \Omega_i(\theta)$ and $(1 - \theta)\theta M_j \Omega_j(\theta)$ in (16), are larger than those under

$^{23}$One may also assume that the North has higher labor productivity (i.e. $a_i < a_j$), but this will not change our analysis in a substantive way.
discrimination, captured by the terms \((1 - \theta)\theta M_j \Omega_{ji}(\theta)\) and \((1 - \theta)\theta M_j \Omega_{ji}(\theta)\). This is because \(\Omega_{ij}(\theta) > \Omega_{ji}(\theta)\) and \(\Omega_{ij}(\theta) > \Omega_{ji}(\theta)\) in equilibrium.\(^{24}\) Intuitively, when countries consider raising domestic patent protection under NT, they are more conscious of the negative incentive effects of trade frictions since the level of foreign protection has to raised by the same amount.

The second reason that NT yields a worse outcome than discrimination is that it leads to unequal effective protection levels across countries. This is a new distortion specific to the North-South scenario, since under symmetry equal protection levels naturally arise. Recall that the analysis in section 4.2 shows that a necessary condition for global optimality is that countries should receive equal effective protection in the global economy, i.e. \(P_i^W(\theta) = P_j^W(\theta)\). This result is true regardless of symmetry. In a North-South setting with trade frictions, in Nash equilibrium the North ends up getting more total effective protection than the South. This international disparity, however, tends to be larger under NT relative to discrimination. To see this, observing that \(\mu_i\) in (16), which is the weight attached to the North, is greater than that in (17) which is \(\frac{1}{2}\). Hence, although the North (South) is over-protected (under-protected) under both regimes in the presence of trade frictions, the problem is more severe under NT.\(^{25}\)

It is also worth noting that, as shown in section 2, the above distortions generated by NT readily disappear when trade frictions vanish. On the one hand, when \(\theta = 1\) domestic and foreign protections are equally effective so that the incentive-reducing terms in both (16) and (17) drop out. On the other hand, under free trade both countries receive equal total effective protection under NT simply by definition (i.e. \(P_i = P_j = M_i \Omega_i + M_j \Omega_j\)), so that the problem of unequal protection also goes away.

We conducted numerical simulations to further study NT under asymmetry. We now briefly discuss the result of this analysis. For simplicity, consider a constant elasticity demand function \((x = p^{-\varepsilon}\) where \(\varepsilon = 1.5\)). With this specific demand function it can be shown that \(C_m = \pi \approx 0.2Cc\). Also, let the following values be assigned to the

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\(^{24}\)We have shown this is true under free trade, that is, \(\Omega_{ij}^{NT}(\theta) > \Omega_{ij}^{NT}(\theta)\) and \(\Omega_{ij}^{NT}(\theta) > \Omega_{ij}^{NT}(\theta)\) when \(\theta = 1\). As \(\theta\) falls, both \(\Omega_{ij}^{NT}(\theta)\) and \(\Omega_{ij}^{NT}(\theta)\) decrease. Indeed, the marginal benefit of extending patent protection to foreigners becomes infinitesimally small as \(\theta\) approaches zero (see the right hand-side of (13)). This is not true for \(\Omega_{ij}^{NT}(\theta)\) and \(\Omega_{ij}^{NT}(\theta)\) since the marginal benefit of patent protection under NT has a positive lower bound due to the fact that such protection also extends to domestic firms and part of their innovation incentive stems from domestic profits that remain unaffected by trade barriers (see the right hand-side of (14)). Therefore, \(\Omega_{ij}^{NT}(\theta)\) and \(\Omega_{ij}^{NT}(\theta)\) cannot be lower than \(\Omega_{ij}^{NT}(\theta)\) and \(\Omega_{ij}^{NT}(\theta)\).

\(^{25}\)Our numerical results below show that as the degree of asymmetry between countries increases, the negative effect of NT becomes smaller. This implies that while the two distortions move in opposite directions, the overuse of foreign protection may be a more serious problem than the unequal provision of total patent protection.
fundamental parameters of the model: \( \alpha = 0.67, \gamma = 3, C_c = 5 \) and \( T = 20 \). Let \( \rho = 1 \) without loss of generality. These parameter values ensure interior solutions under discrimination and NT and our results are robust to variations in their values. To normalize away any level effects, we fix the total world market size \( (M_i + M_f) \) and the stock of human capital \( (K_i + K_f) \).

![Figure 1: Discrimination versus NT when market size differs](image)

Figure 1 shows how the welfare difference between discrimination and NT, i.e. \( (WW^D - WW^{NT})/WW^{NT} \), varies with trade frictions \( \theta \), given \( M_i = 10, M_j = 5, K_i = 2 \) and \( K_j = 1 \). First note that so long as trade frictions exist (\( \theta < 1 \)), discrimination generates strictly higher welfare than NT regardless of the level of such frictions. This is consistent with our results regarding the negative effects of NT under the presence of trade frictions. Moreover, as trade frictions fall (i.e. \( \theta \) increases), the welfare differential between the two regimes converges to zero.

Table 1 shows the total effective patent protections across regimes and their relations. First note that the level of patent protection under NT lies in between the two discriminatory protections regardless of the level of trade frictions. This verifies the distortion of NT caused by excessive use of foreign protection. Moreover, we observe that \( P^N_{iNT} > P^D_{i} > P^D_{j} > P^N_{j} \) in the presence of trade frictions, indicating that NT indeed aggravates the over-protection (under-protection) problem for the North (South). Furthermore, Table 2 shows the welfare difference between the two patent regimes for individual countries. Notably, the North is worse-off under NT even if it receives more total effective protection than in the discriminatory regime. The reason is exactly because the South is under-innovating due to the lack of effective protection, so that this
generates a larger welfare loss for the North than its gains from higher effective protection under NT.

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| $\Omega_i^N$ | $\Omega_i^*$ | $\Omega_{ij}$ | $\Omega_j^N$ | $\Omega_j^*$ | $P_i^N$ | $P_i^D$ | $P_j^N$ | $P_j^D$ |
| $\theta = 0.8$ | 18.29 | 19.29 | 15.42 | 8.76 | 14.75 | 5.67 | 217.98 | 215.60 | 190.16 | 197.16 |
| $\theta = 0.9$ | 18.21 | 19.06 | 16.22 | 9.67 | 13.83 | 7.55 | 225.69 | 224.61 | 212.31 | 215.17 |
| $\theta = 1$ | 18.20 | 18.82 | 16.96 | 10.40 | 12.88 | 9.16 | 234.05 | 234.05 | 234.05 | 234.05 |

To see how the welfare gap is affected by the degree of asymmetry, we study the effects of variations in market size by assuming human capital stock to be equal across countries. In particular, we reduced the gap between $M_H$ and $M_F$ in the above experiment to 0, fixing their sum (at 20). Also we set $K_H = K_F = 1$ and $\theta = 0.75$. Figure 2 shows that the welfare loss from NT is smaller when countries are more asymmetric in terms of market size. To understand the intuition behind this result, recall from Proposition 2 that a country’s incentive for discrimination is inversely related to its market size. Since an increase in market size asymmetry reduces discrimination in the larger market while it raises it in the smaller market, the average degree of discrimination declines in our model as markets become more unequal in size. For analogous reasons, the degree of effective global protection increases with market size asymmetry. Thus, the global welfare loss generated by NT declines as markets become more unequal in size. This finding suggests that the NT discipline may be a smaller concern in a North-South setting.

Figure 2: Comparison when market size differs
Finally, we illustrate the effect of asymmetric human capital stocks. To this end, we equalize market size across countries by setting $M_H = M_F = 7.5$ and bring $K_H$ and $K_F$ closer to 1.5 from 2 and 1 respectively. Again, we see in Figure 3 that NT generates a smaller welfare loss when human capital stocks are more unequal. The intuition is different from that in the case of market asymmetry, however, as we have shown that relative capital stock does not affect a country’s tendency for discrimination. To see what drives our results, note that Home chooses stronger patent protection under NT (i.e. $\Omega_{HT}^N$) as its human capital stock increases, since it is able to capture a larger share of global profits that result from innovation. In the meantime, Home firms will receive more total protection as its major component is $\Omega_{HT}^N$ and the increase in $\Omega_{HT}^N$ is not discounted by trade frictions $\theta$. As a result, the country with more human capital has a stronger incentive for innovation under NT, a pattern that promotes innovation and welfare. This helps explain why welfare under NT is higher when the distribution of human capital stock is more unequal across countries (although welfare under NT is still lower than that under discrimination).

![Figure 3: Welfare difference with asymmetric human capital stocks](image)

5 Conclusion

The TRIPS agreement was controversial from the start. Developing countries fought hard against the inclusion of any multilateral rules on intellectual property, just as major developed countries put their considerable weight behind the opposite position. In addition to raising intellectual property protection in developing countries, TRIPS made
it illegal for WTO members to discriminate against as well as across foreign nationals via the NT and MFN principles respectively.

At first glance, the inclusion of these principles in TRIPS hardly seems worthy of comment. After all, the idea of non-discrimination is the very foundation of today's multilateral trading system. Yet, our analysis has shown that the desirable properties of NT in the context of policy instruments that affect trade in goods (or market access) do not extend automatically to the domain of policies that determine the protection of intellectual property.

The key driving force behind our results is that incentives for innovation depend upon the overall patent protection firms receive in the global economy and the composition of such protection matters only when international market access is hampered by trade frictions. Absent such frictions, NT is inconsequential since what firms lose abroad is fully compensated by what they gain at home. While we focus mostly on a two-country setting, the driving forces behind our analysis carry over to a multi-country scenario. Indeed, one can show the neutrality of NT under free trade holds for any number of countries as long as we restrict attention to interior solutions.

When access to foreign markets is imperfect, the case for non-discrimination in patent protection is even weaker. The intuition here is simple as it is undeniable: in the presence of trade frictions, substituting domestic patent protection for foreign protection affords firms a higher level of effective patent protection because exports are relatively less profitable than domestic sales. Furthermore, consumer welfare considerations reinforce this argument: trade frictions make foreign innovation relatively less valuable to domestic consumers in each country by making foreign goods costlier (or reducing the volume of trade). As a result, in our model, imposing a NT constraint on national governments actually reduces welfare in the presence of trade frictions.

Finally, it is important to recognize that our findings do not necessarily imply that NT should not have been included as a fundamental principle in TRIPS. Rather, we see our findings as highlighting one potential efficiency cost of NT that arises from the wedge that trade frictions create between the incentive effects of domestic and foreign patent protection. NT may yield various benefits that are not captured by our model, such as lower enforcement and implementation costs, greater consistency across international trade agreements, and potentially lower costs of international coordination across countries. Inclusion of these potential benefits of NT can make it more desirable than discrimination.
6 Appendix

6.1 Supporting calculations

Here we show that

\[ \frac{\partial \phi_i}{\partial \Omega_{ii}} = \frac{\gamma \phi_i M_i}{M_i \Omega_{ii} + M_j \Omega_{jj}} \]

Note that \( \frac{\partial \phi_i}{\partial \Omega_{ii}} = \frac{\partial \phi_i}{\partial v_i} \times \frac{\partial v_i}{\partial \Omega_{ii}} \). Hence, \( \frac{\partial \phi_i}{\partial \Omega_{ii}} = \frac{\partial \phi_i}{\partial \Omega_{ij}} \frac{\partial \Omega_{ij}}{\partial v_i} = F_i^L \times \frac{\partial L_{ii}}{\partial v_i} \). Differentiating the firm’s FOC \( v_i F_L = w_i \) w.r.t \( v_i \) we obtain \( F_i^L + v_i F_L^ii \frac{\partial L_{ii}}{\partial v_i} = 0 \). This implies \( \frac{\partial L_{ii}}{\partial v_i} = -\frac{F_i^L}{v_i F_L^ii} \).

Therefore, \( \frac{\partial \phi_i}{\partial \Omega_{ii}} = \frac{\gamma \phi_i}{M_i \pi} \times (M_i \pi + M_j \pi) \)

Note that \( \frac{\partial \phi_i}{\partial \Omega_{ii}} = \frac{\partial \phi_i}{\partial \Omega_{ij}} \frac{\partial \Omega_{ij}}{\partial v_i} \).

6.2 Proof of Proposition 1

We prove Proposition 1 under the more general CES research technology with \( \beta \leq 0 \). The generalization brings about the essential feature that responsiveness of innovation to patent protection may differ across countries, i.e. \( \gamma_H \neq \gamma_F \). Taking account of this feature, we can modify (9) and (10) as follows

\[ C_c - C_m - \pi = \frac{\gamma_i M_i}{M_i \Omega_{ii} + M_j \Omega_{jj}} [(C_m - C_c) \Omega_{ii} + C_c T] \] (A1)

\[ C_c - C_m = \frac{\gamma_j M_j}{M_i \Omega_{ij} + M_j \Omega_{jj}} [(C_m - C_c) \Omega_{ij} + C_c T] \] (A2)

where \( \gamma \) is no longer a constant. We may then add up (A1) for country \( i \) and (A2) for country \( j \) to get

\[ 2(C_c - C_m) - \pi = \frac{\gamma_i M_i}{M_i \Omega_{ii} + M_j \Omega_{jj}} [(C_m - C_c)(M_i \Omega_{ii} + M_j \Omega_{jj}) + (M_i + M_j)C_c T] \] (A3)

\[ 2(C_c - C_m) - \pi = \frac{\gamma_j M_j}{M_j \Omega_{jj} + M_i \Omega_{ij}} [(C_m - C_c)(M_j \Omega_{jj} + M_i \Omega_{ij}) + (M_i + M_j)C_c T] \] (A4)

It is easy to see that the right-hand sides of (A3) and (A4) are respectively monotonic functions of total protections \( M_i \Omega_{ii} + M_j \Omega_{jj} \) and \( M_j \Omega_{jj} + M_i \Omega_{ij} \). And they must also be equal to each other. It follows that we must have \( M_i \Omega_{ii} + M_j \Omega_{jj} = M_i \Omega_{jj} + M_j \Omega_{ij} \) and \( \gamma_i = \gamma_j = \gamma^* \). Hence (A1) and (A2) immediately imply that \( \Omega_{ii} > \Omega_{ij}^* \) for \( i, j = H, F \).
6.3 Proof of Proposition 3

We first show (ii). Adding up the first-order conditions for $\Omega_i$ and $\Omega_j$ under NT yields

$$2(C_c - C_m) - \pi = \frac{\gamma}{M_i\Omega_i + M_j\Omega_j}[(C_m - C_c)(M_i\Omega_i + M_j\Omega_j) + (M_i + M_j)C_cT]. \quad (A5)$$

Comparing (A5) with either (A3) or (A4) yields that $\gamma_i = \gamma_j = \gamma = \gamma^*$ and

$$P_{NT} = M_i\Omega_i^{NT} + M_j\Omega_j^{NT} = P^*, \, i, j = H, F$$

which establishes (ii).

Now notice that since $C_c - C_m - \mu_i\pi < C_c - C_m - \mu_j\pi < C_c - C_m$, we must have

$$\gamma^*\frac{M_i}{P_i}[(C_m - C_c)\Omega_i^* + C_cT] < \gamma^*\frac{M_j}{P_j}[(C_m - C_c)\Omega_j^* + C_cT] < \gamma^*\frac{M_i}{P_i}[(C_m - C_c)\Omega_{ij}^* + C_cT]$$

due to the first-order conditions for $\Omega_{ii}$, $\Omega_i$ and $\Omega_{ij}$. This implies

$$\Omega_{ii}^* > \Omega_{i}^{NT} > \Omega_{ij}^*, \, i, j = H, F$$

which is the desired result.

Finally, when countries are symmetric we may focus on the symmetric equilibria such that $\Omega_{ii}^* = \Omega_{jj}^*$, $\Omega_{ij}^* = \Omega_{ji}^*$ under discrimination and $\Omega_i^{NT} = \Omega_j^{NT}$ under NT. Then (A3) and (A5) together imply that

$$\frac{1}{(\Omega_{ii}^* + \Omega_{ij}^*)}[(C_m - C_c)(\Omega_{ii}^* + \Omega_{ij}^*) + 2C_cT] = \frac{1}{2\Omega_i^{NT}}[(C_m - C_c)2\Omega_i^{NT} + 2C_cT], \, i, j = H, F$$

Monotonicity of both sides ensures that $\Omega_{ii}^* + \Omega_{ij}^* = 2\Omega_i^{NT}$. ■

6.4 Proof of Proposition 4

We prove this claim under the Cobb-Douglas technology, noting that it is easy to generalize under the assumption of CES. Again one can obtain the first-order conditions for country $j$ by reversing $i$ and $j$ in (12) and (13). It is easy to show that

$$\Omega_{ii}^*(\theta) = \frac{C_cT}{(2 + \gamma)(C_c - C_m) - \pi} \left[ (1 + \gamma) - \frac{\eta\theta(C_c - C_m - \pi)}{(C_c - \theta C_m)} \right]$$

and

$$\Omega_{ij}^*(\theta) = \frac{C_cT}{(2 + \gamma)(C_c - C_m) - \pi} \left[ (1 + \gamma)(C_c - C_m) - \pi \frac{\eta}{\theta} \right]$$
We know that \( \eta = M_j/M_i \). It follows that \( \Omega^{*}_{ii}(\theta) \) decreases in \( \theta \) since
\[
\eta \frac{(C_c-C_m-\pi)}{(C_c-yC_m)}
\]
is an increasing function of \( \theta \).

Similarly, \( \Omega^{*}_{ij}(\theta) \) increases in \( \theta \) since
\[
\frac{(1+\gamma)(C_c-C_m-\pi)}{(C_c-yC_m)} - \frac{\eta}{\theta}
\]
is an increasing function of \( \theta \). Moreover, it can be shown that
\[
P^*_i(\theta) = M_i\Omega^{*}_{ii}(\theta) + \theta M_j\Omega^{*}_{ij}(\theta) = \frac{\gamma C_c\bar{T}}{(2+\gamma)(C_c-C_m)-\pi} \left[ M_i + M_j\frac{\theta(C_c-C_m)}{(C_c-\theta C_m)} \right]
\]
Clearly, since \( M_j\frac{\theta(C_c-C_m)}{(C_c-\theta C_m)} \) is an increasing function of \( \theta \), \( P^*_i(\theta) \) is increasing in \( \theta \). ■

\[\textbf{6.5 Proof of Proposition 5}\]

We know that \( \Omega^*(\theta) \) satisfies the following first-order condition:
\[
2C_c-(1+\theta)C_m-\pi = \frac{\gamma}{(1+\theta)\Omega^*(\theta)}[(C_m-C_c)(1+\theta)\Omega^*(\theta)+(1+\theta)C_c\bar{T}-(1-\theta)\theta C_m\Omega^*(\theta)]
\]
(A6)

Similarly, \( \Omega^*_d(\theta) \) and \( \Omega^*_f(\theta) \) respectively satisfy the following first order conditions:
\[
C_c-C_m-\pi = \frac{\gamma}{\Omega^*_d(\theta)+\theta\Omega^*_f(\theta)}[(C_m-C_c)\Omega^*_d(\theta)+C_c\bar{T}]
\]
and
\[
C_c-\theta C_m = \frac{\gamma\theta}{\Omega^*_d(\theta)+\theta\Omega^*_f(\theta)}[(\theta C_m-C_c)\Omega^*_f(\theta)+C_c\bar{T}]
\]
Adding up the last two equations we obtain
\[
2C_c-(1+\theta)C_m-\pi = \gamma \left[ \frac{1}{\Omega^*_d(\theta)+\theta\Omega^*_f(\theta)}[(C_m-C_c)(\Omega^*_d(\theta)+\theta\Omega^*_f(\theta))+(1+\theta)C_c\bar{T}-(1-\theta)\theta C_m\Omega^*_f(\theta)] \right]
\]
(A7)

Moreover, it can be shown that \( \Omega^*(\theta) > \Omega^*_d(\theta) \), which further implies that \((1-\theta)\theta C_m\Omega^*(\theta) > (1-\theta)\theta C_m\Omega^*_d(\theta) \).\(^{26}\) Since the right-hand sides of (A6) and (A7) must be equal, and since both are decreasing functions of \( \Omega_d(\theta)+\theta\Omega_f(\theta) \) and \((1+\theta)\Omega(\theta) \), we may conclude that
\[
\Omega^*_d(\theta) + \theta\Omega^*_f(\theta) > (1+\theta)\Omega^*(\theta)
\]
Multiplying both sides by the common market size \( M \), we get
\[
M(\Omega^*_d(\theta) + \theta\Omega^*_f(\theta)) > M(1+\theta)\Omega^*(\theta).
\]

\(^{26}\)Note that \( \Omega^*_d(\theta) > \Omega^*_f(\theta) \) in any interior equilibrium. Further, if \( \Omega^*_f(\theta) \geq \Omega^*(\theta) \), then \( \Omega^*_d(\theta) > \Omega^*_f(\theta) \) and this implies \( \Omega^*_d(\theta) + \theta\Omega^*_f(\theta) > (1+\theta)\Omega^*(\theta) \). One can use the latter inequality to show that (A6) and (A7) cannot hold simultaneously. As a result, we must have \( \Omega^*(\theta) > \Omega^*_f(\theta) \) in equilibrium.
6.6 Proof of Proposition 6

We first show that

\[
\frac{\partial WW^D(\theta)}{\partial \Omega_{ii}} - \frac{1}{\theta} \frac{\partial WW^D(\theta)}{\partial \Omega_{ji}} = \frac{\phi_i M_i}{\rho} \frac{(1-\theta) C_c}{\theta} > 0 \text{ for all } \theta < 1
\]

We have

\[
\frac{\partial WW^D(\theta)}{\partial \Omega_{ii}} = \frac{\phi_i M_i}{\rho} \left[ \frac{\gamma}{P_i(\theta)} \right] \left[ (C_m - C_c) P_i(\theta) + (M_i + M_j) C C_T - (1-\theta) M_j C_c \Omega_{ji} - (C_c - C_m - \pi) \right]
\]

and

\[
\frac{1}{\theta} \frac{\partial WW^D(\theta)}{\partial \Omega_{ji}} = \frac{\phi_i M_i}{\rho} \left[ \frac{\gamma}{P_i(\theta)} \right] \left[ (C_m - C_c) P_i(\theta) + (M_i + M_j) C C_T - (1-\theta) M_j C_c \Omega_{ji} \right]
-(C_c - C_m - \pi) - \frac{(1-\theta)}{\theta} C_c
\]

(A8)

Subtracting the second equation from the first yields the desired result.

First order conditions (A8) and (A9) simply say that for any country the net marginal benefit of domestic protection is higher than that of protection received from abroad. It follows that global efficiency requires each country to be protected through its domestic market whenever possible. Foreign protection may be needed (which depends on model parameters such as \( \gamma \)) when domestic protection has hit the boundary \( T \). Assuming foreign protection is always interior (i.e. \( \gamma \) cannot be too large), we have \( \Omega_{ji}^w < \Omega_{ii}^w \). In particular, \( \Omega_{ji}^w = 0 \) whenever \( \Omega_{ji}^w \) is an interior solution.

To show that each country necessarily practices discrimination (i.e. \( \Omega_{ij}^w < \Omega_{ii}^w \)), let us differentiate several cases. First, the conclusion is obvious if both \( \Omega_{ii}^w \) and \( \Omega_{ji}^w \) are interior solutions. Second, when \( \Omega_{ii}^w = \Omega_{jj}^w = T \) discrimination must exist as foreign protection is not at the same corner. Finally, suppose \( \Omega_{ii}^w = T \) and \( \Omega_{jj}^w < T \), so that \( \Omega_{ji}^w \geq 0 \). Suppose \( \Omega_{ji}^w > 0 \) (otherwise we are done). To show that \( \Omega_{jj}^w > \Omega_{ji}^w \), note that under CES technology with \( \beta \leq 0 \), we must have \( P_i^*(\theta) \leq P_j^*(\theta) \) because country \( i \) resorts to foreign protection that is more costly. This implies \( M_i \Omega_{ii}^w + M_j \Omega_{ji}^w \leq M_j \Omega_{jj}^w + M_i \Omega_{ij}^w \), which is reduced to \( M_i \Omega_{ii}^w + M_j \Omega_{ji}^w \leq M_j \Omega_{jj}^w \) (as \( \Omega_{ij}^w = 0 \)). It follows that we must have \( \Omega_{ji}^w < \Omega_{jj}^w \) for the inequality to hold.

\[\blacksquare\]
References


