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Kaz Miyagiwa, Huasheng Song, Hylke Vandenbussche

Institutions: Florida International University, Zhejiang University, Katholieke Universiteit Leuven

Published on: 01 Feb 2016 - The World Economy (John Wiley & Sons, Ltd)

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The World Economy

The World Economy (2016)
doi: 10.1111/twec.12371

Accounting for Stylised Facts about Recent Anti-dumping: Retaliation and Innovation

Kaz Miyagiwa[1], *Huasheng Song*[2] *and Hylke Vandenbussche*[3]
[1]*Economics, Florida International University, Miami, FL, USA,* [2]*CRPE and School of Economics, Zhejiang University, Hangzhou, Zhejiang, China, and* [3]*Department of Economics and LICOS, University of Leuven, Belgium*

1. INTRODUCTION

TODAY, thanks to GATT/WTO-led tariff-cutting agreements, international trade appears freer than ever. However, use of anti-dumping (AD) poses a serious threat to free trade. In fact, during the past quarter century, use of AD has spread from a few traditional users such as the US, the EU to over 100 countries, most of which are developing or semi-industrialised economies.[1] At the bottom of the problem is the fact that the GATT/WTO anti-dumping framework legally sanctions the pursuit of strategic trade policy disguised as ‘fair’ trade policy (Matschke and Schottner, 2013).[2]

As Stiglitz (1997) puts it, AD policy today has nothing to do with the notion of ‘unfair trade’, let alone, welfare maximisation; it is simply a convenient instrument for governments to improve the competitiveness of domestic firms against imports.[3] This change in the nature of AD is attributable to frequent amendments to AD law that made it easier to grant protection at the requests of domestic complainants. In the US, for example, the frequent use of ‘facts available’ methods to estimate the costs and prices of exports has made dumping margin determination completely arbitrary. As a result, the US. Department of Commerce, which is responsible for margin determination, almost always rules that dumping has occurred even against firms making handsome profits from every sale of exports to the US. For instance, from 1980 to 1992 Commerce ruled that dumping had occurred in 93 per cent of all cases (Irwin, 2002).

Empirical research has uncovered several important stylised facts about recent AD actions, of which we highlight three. First, industrial countries rarely use AD against each other despite high volumes of trade among them. Instead, rich countries direct their AD actions towards developing countries (Bown et al., 2004). Second, developing countries in turn use AD to retaliate against those industrial countries that have targeted them in their AD actions,

We thank Paul Belleflamme, Daniel Bernhofen, Bruce Blonigen, Meredith Crowley, Claude d’Aspremont, Jim Hartigan, Florian Mayneris, Ray Riezman, Jacques Thisse, Anthony Venables, Ruqu Wang, Zhihong Yu, Maurizio Zanardi and participants of various seminars and conferences for useful comments. Miyagiwa and Song (corresponding author) thank CORE (Universite catholique de Louvain) and LICOS (Katholieke Universiteit Leuven) for the hospitality and financial support during their visits. Vandenbussche is grateful for financial support of Leuven under PF/10/003 “Governments and Market” and under METH/15/004. Song is grateful to Chinese Ministry of Education (10JJD790030), National Science Fund of China (71573230), Hengyi Foundation, and CSC for financial support.

[1] For example, Mexico, China, India, Turkey, Egypt, and Brazil (Prusa, 2001; Zanardi, 2004).
[2] AD use may accelerate in the event of adverse shocks such as seen in the wake of the recent financial crisis (Baldwin and Evenett, 2009).
[3] More on this view and evidence, see the survey by Blonigen and Prusa (2001).

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resulting in reciprocal AD.[4] Third, AD actions occur relatively more often in R&D-intensive industries than in industries with no or little R&D activity (Niels, 2000).[5]

The primary objective of this study was to present a framework that can account for these three empirical findings. To do so, we extend the Brander and Krugman (1983) model of reciprocal dumping to a multicountry setting, where countries are heterogeneous in market size.[6] In such a setting, each firm has a unilateral incentive to file for an AD action against all foreign firms. However, when the target retaliates with its AD action, reciprocal AD actions harm both initiator and retaliator if they have similar-sized home markets. In such cases, since firms interact repeatedly over time, the desire to avoid AD war restrains use of AD measures. However, that is not the case between countries having home markets of dissimilar sizes. In such cases, a large country has the incentive to take AD actions against a smaller country, leaving the latter no recourse but retaliation with its AD filings. Thus, our model is consistent with the empirical finding that AD activity is mostly between the North and the South, where market size differences can be substantial. A country with a smaller domestic market prefers to avoid an AD war with a country with a larger domestic market but has the incentive to use AD when the latter does not honour free trade. Thus, our model is also consistent with the finding that retaliation underlies AD actions in the South.

Having shown that the difference in market size can account for the first two stylised facts, we turn to the question why AD actions tend to occur more frequently in R&D-intensive industries. To that end, we introduce R&D opportunities into our analysis and examine how the presence of opportunities to invest in R&D can affect the inventive to initiate AD actions. In doing so, we focus on a two-country (North–South) version of our model, but introduce the two additional features that capture the real-world asymmetries between the North and the South: (i) the North's supremacy in R&D efficiency and (ii) the South's laxity in enforcement of intellectual property rights (IPRs). Thus, our North–South model exhibits three intercountry asymmetries; countries differ in market size, R&D capability and IPR protection. Assuming that the South is smaller in market size than the North, we find that reciprocal AD reduces the southern firm's investment in R&D and its profit while the effect in the North depends on the market size differences. If the two markets are sufficiently similar in size, reciprocal AD also reduces the northern firm's R&D investment. If the difference in market size is substantial, however, reciprocal AD increases the northern firm's R&D investment and its profit. More importantly, comparing the results with and without R&D opportunities, we find that AD war is more likely to occur with R&D opportunities. This result is consonant with the third stylised fact, that is AD actions are observed relatively more often in R&D-intensive industries than in industries with little R&D activity.

Another finding of note is that AD is less likely if the South closes its gap with North in R&D capability. Since AD is nothing but a protectionist tool today, our analysis implies that

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[4] Most studies identify retaliation as the main determinant of AD filings; see, for example, Feinberg and Reynolds (2006), Prusa and Skeath (2002), Martin and Vergote (2008), Vandenbussche and Zanardi (2008) and Moore and Zanardi (2009). By contrast, Bown and Tovar (2011) show that trade liberalisation is responsible for anti-dumping filings in India and argue against the retaliation motive for the case of India.

[5] Theoretical works, for example, Miyagiwa and Ohno (1999) and Bouet (2001), suggest that tariff protection can stimulate firm investment in R&D. Liebman and Reynolds (2013) use US firm-level data between 1975 and 2005 to test the theoretical prediction of Miyagiwa and Ohno (1999) and find support for it.

[6] This model is applied widely to investigate various AD issues; see, for example, Anderson et al. (1995), Bian and Gaudet (1997), Veugelers and Vandenbussche (1999) and Gao and Miyagiwa (2005).

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developing countries can avert industrial countries' AD actions against them by expanding its domestic markets – which may come through economic growth or market opening policies – or by catching up to the North in R&D technology.

The remainder of the study is organised in four sections. The next section presents the multicountry model without R&D. Section 3 considers the effect of R&D opportunities on AD war in a North–South setting, where the North has a larger home market and is more efficient in R&D than the South. The main finding of this section is that the presence of R&D opportunities increases the likelihood of AD war. The final section concludes.

2. BASIC MODEL

a. Environment

Consider an industry spanning M ($\geq$ 2) national markets. Assume linear market demands and write country m's inverse demand as $p_m = 1 - Q_m/b_m$, where the demand intercepts are identical across countries and normalised to unity, Q_m denotes total sales in country m, and $b_m \in(0, 1)$ measures the size of market m. Markets are enumerated in a descending order, with the size of country 1's market normalised to unity:

$$b_1 = 1 > b_2 > \ldots > b_M.$$

On the production side of the model, assume that each country has a single firm that produces a homogeneous good at marginal cost fixed at the common value c. Let t_{mj} denotes a specific AD duty country m imposes on imports from country j, and let:

$$T_m = t_{m1} + t_{m2} + \cdots + t_{m(m-1)} + t_{m(m+1)} + \cdots + t_{mM},$$

be the sum of duties country m imposes on imports from all other countries.

Firms consider all national markets segmented and play a Cournot game in each market. It is straightforward to show that firm m's equilibrium profit from domestic sales equals:

$$\pi_{mm} = b_m(1 - c + T_m)^2/(1 + M)^2, \tag{1}$$

and its profit from exporting to country e ($\neq m$) equals

$$\pi_{me} = b_e(1 - c - (M + 1)t_{em} + T_e)^2/(1 + M)^2. \tag{2}$$

The total profit to firm m is the sum of the profits from all the national markets:

$$\pi_{m1} + \pi_{m2} + \ldots + \pi_{mM}.$$

In the analysis to follow, assume that there are no tariffs initially. Then, firm m's profits (1) and (2) differ only in market size:

$$\pi_{mm} = b_m(1 - c)^2/(1 + M)^2$$
$$\pi_{me} = b_e(1 - c)^2/(1 + M)^2.$$

b. AD and retaliation

As noted in the introduction, recent studies highlight the fact that AD duty determination is completely arbitrary and divorced from the notion of welfare maximisation. To capture

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such arbitrariness in AD determination, we depart from the standard assumption of welfare maximising governments. Instead, we assume that governments set AD duties just to raise their home firm's total profits and focus on each firm's incentive to file for AD protection. To keep the analysis simple, we consider only small and symmetric departures from free trade, that is, each country imposes an AD duty:

$$t_{me} = \mathrm{d}t > 0,$$

for all m and all e ($\neq m$), although we may keep the country subscripts to avoid possible confusions.

Firm m clearly benefits from its own government's AD action against any foreign firm e, as can be shown by differentiating (1) with respect to t_{me} and evaluating the result at $t_{me} = 0$:

$$\partial\pi_{mm}/\partial t_{me} = 2b_m(1-c)/(1+M)^2 > 0.$$

However, when country e takes an AD action against firm m in retaliation, firm m's profit in country e falls as in:

$$\partial\pi_{me}/\partial t_{em} = -2Mb_e(1-c)/(1+M)^2 < 0.$$

Therefore, reciprocal AD between firm m and firm e changes firm m's total profit by:

$$\partial\pi_{m,m}/\partial t_{m,e} + \partial\pi_{m,e}/\partial t_{e,m} = 2(b_m - Mb_e)(1-c)/(1+M)^2.$$

Thus, the change in firm m's profit from reciprocal AD depends on the sign of ($b_m - Mb_e$). Given b_e and b_m, the above condition is more likely to be met with more firms (M).

Proposition 1: *If there is free trade initially, firm m has the unilateral incentive to file for AD protection against any foreign firm. If foreign country e retaliates, however, firm m is harmed by reciprocal AD if and only if* $b_e > b_m/M$.

The inequality automatically holds if $b_e > b_m$. Thus, firm m wants to avoid reciprocal AD against any firm e having the large home market than its own.

c. Bilateral AD Actions and Retaliation in Repeated Game Settings

Game theory tells us that reciprocal AD can be avoided if firms interact repeatedly over time. To explore this possibility, take any two firms m and e, with $b_m > b_e$. Thus, by proposition 1 firm e never wants to engage in reciprocal AD, so we focus on firm m's incentive. If both firms agree to avoid reciprocal AD, firm m earns the total profit from two markets m and e:

$$\pi_m = b_m(1-c)^2/(1+M)^2 + b_e(1-c)^2/(1+M)^2.$$

This could be the equilibrium profit under grim trigger strategies. When firm m deviates by imposing an AD duty t in one period, its profit from its home market during that period increases to:

$$b_m(1-c+\mathrm{d}t)^2/(1+M)^2.$$

However, from the next period on both firms engage in reciprocal AD forever, so firm m's profit per period from market e falls to:

$$b_e(1-c-M\mathrm{d}t)^2/(1+M)^2.$$

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Therefore, firm m has no incentive to deviate from free trade if:

$$b_m(1-c)^2 + b_e(1-c)^2$$
$$\geq (1-\delta)\{b_m(1-c+\mathrm{d}t)^2 + b_e(1-c)^2\} + \delta\{b_m(1-c+\mathrm{d}t)^2 + b_e(1-c-M\mathrm{d}t)^2\},$$

where δ is the discount factor. This condition simplifies to:

$$\delta b_e[(1-c)^2 - (1-c-M\mathrm{d}t)^2] \geq b_m[(1-c+\mathrm{d}t)^2 - (1-c)^2].$$

Dividing both sides by dt, and letting d$t \to 0$, we can rewrite the above condition as:

$$\delta b_e \geq b_m/M. \qquad (3)$$

If (3) holds, firm m does not file for AD protection against firm e. A comparison with the condition in proposition 1 shows that in a repeated game firm e must have an even larger home market to avoid reciprocal AD.

To sum up, all firms have the unilateral incentives to file for AD protection, but only those in large countries face winnable AD wars; those in small countries file for AD only in retaliation against large countries.

3. INNOVATION AND ANTI-DUMPING

The preceding section shows that market sizes matter in AD activity, that is, a country can benefit from reciprocal AD only with a country that has a substantially smaller market than its own. These are consistent with the two stylised facts: (i) the main rationale for developing countries' AD use is retaliation against the traditional AD users and (ii) AD activities are mostly between industrial countries (the North) and developing countries (the South).

In this section, we turn to the third stylised fact, namely AD actions tends to be in R&D-intensive industries. To that end, we modify the preceding model as follows. First, given that AD actions are mostly between the North and South, we focus on a two-country (North–South) setting. Second, we introduce into our analysis three familiar asymmetries that allegedly exist between the North and the South. A first is the market size asymmetry. We normalise the North's market size to one and let b (< 1) be the South's relative market size. By Proposition 1 there is reciprocal AD if b < ½. The two other asymmetries are with respect to R&D capability and intellectual property rights (IPRs) protection. We assume that the South lags behind in R&D capability and also does not protect IPRs as strongly as the North.

a. The Two-stage Game

Firm N and firm S play a two-stage game. They first invest in cost-reducing R&D and then competing in product markets. Marginal production costs are assumed constant with respect to output but can be reduced as a result of investment in R&D. The cost of investment k in R&D is $\gamma_i k^2/2$ ($i = n, s$). Firm S is less efficient in R&D in that $\gamma_s > \gamma_n$.

As regards IPRs, we assume that IPRs are well protected in the North but not in the South. We express this asymmetry in IPR protection as follows. In the North, firm N's *ex post* marginal cost c_n depends only on its own investment level in R&D, k_n, so:

$$c_n = c - k_n,$$

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where c denotes the *ex ante* marginal cost. In the South, IPR protection is so lax that firm S can appropriate firm N's innovation with impunity. Letting $\alpha \in (0, 1]$ denote the extent of appropriability, we write firm S's *ex post* marginal cost as follows:[7]

$$c_s = c - k_s - \alpha k_n.$$

The greater the α, the less protected are the North's IPRs in the South.

b. Equilibrium Profits

We consider the subgame-perfect Nash equilibrium. Given linear demands, and the marginal costs c_n and c_s, the second-stage game equilibrium profits are straightforward to calculate. In market N, firm N faces the unit cost c_n while firm S incurs the unit cost $c_s + t_n$, where t_n is an AD duty by country N. Thus, firm N's equilibrium profit from domestic sales equals:

$$\begin{aligned}&[(1 - 2(c - k_n) + (c - k_s - \alpha k_n) + t_n]^2/9\\&= [w + (2 - \alpha)k_n - k_s + t_n]^2/9,\end{aligned}$$

where $w \equiv 1 - c$. In market S, the firms' positions are reversed as firm N now incurs AD duty t_s in country S. Thus, firm N's equilibrium profit from exporting to the South is:

$$\begin{aligned}&b[1 - 2(c - k_n) + (c - k_s - \alpha k_n) - 2t_s]^2/9\\&= b[w + (2 - \alpha)k_n - k_s - 2t_s]^2/9.\end{aligned}$$

Assume that there is an interior solution to the Cournot game; that is, each firm always produces strictly positive output for all relevant parameter values. Collecting terms and subtracting the cost of R&D yields each firm's first-stage profit:

$$\begin{aligned}\pi_n &= [w + (2 - \alpha)k_n - k_s + t_n]^2/9 + b[w + (2 - \alpha)k_n - k_s - 2t_s]^2/9 - (\gamma_n/2)k_n^2,\\\pi_s &= [w + 2k_s - (1 - 2\alpha)k_n - 2t_n]^2/9 + b[w + 2k_s - (1 - 2\alpha)k_n + t_s]^2/9 - (\gamma_s/2)k_s^2.\end{aligned} \quad (4)$$

c. Optimal R&D Investments

We now move back to the first stage of the game, where firms simultaneously choose R&D investments. Maximising π_n in (4) with respect to k_n yields the first-order condition for firm N:

$$2(2 - \alpha)\{(1 + b)[w + (2 - \alpha)k_n - k_s] + (t_n - 2bt_s)\} - 9\gamma_n k_n = 0. \quad (5)$$

The second-order condition is satisfied if:

$$Z_n \equiv 9\gamma_n - 2(2 - \alpha)^2(1 + b) > 0. \quad (6)$$

The first-order condition (5) can be written, after arranging terms, as follows:

$$A_n + 2(2 - \alpha)^2(1 + b)k_n - 2(2 - \alpha)(1 + b)k_s - 9\gamma_n k_n = 0, \quad (7)$$

[7] This part of the model builds on d'Aspremont and Jacquemin's (1988) analysis of R&D competition with technology spillovers.

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where

$$A_n \equiv 2(2-\alpha)[(1+b)w+(t_n-2bt_s)]>0. \tag{8}$$

The inequality in (8) follows from the assumption of positive equilibrium output in both markets.

Similarly, the first-order condition for firm S is written as follows:

$$4[w+2k_s-(1-2\alpha)k_n-2t_n]+4b[1-c_o+2k_s-(1-2\alpha)k_n+t_s]-9\gamma_s k_s=0,$$

which simplifies to

$$A_s+8(1+\beta)k_s-4(1-2\alpha)(1+b)k_n-9\gamma_s k_s=0. \tag{9}$$

The positive equilibrium output in both markets implies:

$$A_s \equiv 4[(1+b)w+(bt_s-2t_n)]>0.$$

The second-order condition requires that:

$$Z_s \equiv 9\gamma_s-8(1+b)>0. \tag{10}$$

Assume that γ_n and γ_s are sufficiently large so $Z_n > 0$ and $Z_s > 0$.[8]

The first-order conditions (7) and (9) are arranged to yield the first-stage game best-response functions:

$$k_n=[A_n-2(2-\alpha)(1+b)k_s]/Z_n, \tag{7'}$$

$$k_s=[A_s-4(1-2\alpha)(1+b)k_n]/Z_s. \tag{9'}$$

(see Appendix A for the derivations). Differentiating (7′) yields:

$$\mathrm{d}k_n/\mathrm{d}k_s=-2(2-\alpha)(1+b)/Z_n<0,$$

so k_n is a strategic substitute to k_s. Differentiating (9′) yields:

$$\mathrm{d}k_s/\mathrm{d}k_n=-4(1-2\alpha)(1+b)/Z_s. \tag{11}$$

Thus, $\mathrm{d}k_s/\mathrm{d}k_n$ is negative if and only if $\alpha < ½$; that is, k_s is a strategic substitute to k_n only if $\alpha < ½$, that is, IPR protection is sufficiently strong in the South. If $\alpha > ½$, k_s is a strategic complement to k_n, while if $\alpha = ½$, k_s does not depend on k_n. Intuitively, if $\alpha < ½$ and firm N increases investment in R&D, firm S's profits fall in both markets, prompting firm S to reduce investment in R&D. By contrast, if $\alpha > 1/2$, the South's appropriability is so strong that an increase in R&D investment by firm N increases firm S's profits, which in turn induces firm S to invest more in R&D. Thus, for $\alpha > 1/2$, k_s is a strategic complement to k_n.

The Nash equilibrium (k_n*, k_s*) is given by:

$$k_n^*=\{A_nZ_s-2(2-\alpha)(1+b)A_s\}/\Delta, \tag{12}$$

$$k_s^*=\{A_sZ_n-4(1-2\alpha)(1+b)A_n\}/\Delta. \tag{13}$$

Invoking the Hahn stability condition, we assume:

$$\Delta \equiv Z_nZ_s-8(2-\alpha)(1-2\alpha)(1+b)^2>0.$$

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[8] If the second-order fails, R&D is so cheap that firm S invests until marginal production cost drops to zero.

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With $\Delta > 0$, the interior solution implies that the numerator in (12) and (13) must be positive. In the absence of AD duties, we have that:

$$A_n = 2w(2-\alpha)(1+b) > 0,$$
$$A_s = 4w(1+b) > 0.$$

Substituting these values into (12) and (13) yields the necessary and sufficient conditions for $k_n^* > 0$:

$$w(1+b)[Z_s - 4(1+b)] > 0. \tag{14}$$

The bracketed expression in (14) is written:

$$Z_s - 4(1+b) = 9\gamma_s - 12(1+b) > 0.$$

We thus assume:

$$\frac{\gamma_s > 4(1+b)}{3.} \tag{15}$$

Similarly, for $k_s^* > 0$ we have:

$$w(1+b)[Z_n - 2(1-2\alpha)(2-\alpha)(1+b)] > 0.$$

Substituting for Z from (6), we can rewrite the bracketed expression as:

$$9\gamma_n - 2(2-\alpha)(3-2\alpha)(1+b).$$

Thus, $k_s^* > 0$ requires that:

$$\gamma_n > (2/9)(2-\alpha)(3-2\alpha)(1+b). \tag{16}$$

We assume both (15) and (16) hold for the remainder of the analysis.

d. AD Actions and Retaliation

In this subsection, we examine the effect of AD actions and retaliation. We first study how reciprocal AD affects firms' investment in R&D. Differentiating (12) and (13) with respect to $\mathrm{d}t_n = \mathrm{d}t_s = \mathrm{d}t$ yields:

$$\mathrm{d}k_n^*/\mathrm{d}t = \{Z_s dA_n/\mathrm{d}t - 2(2-\alpha)(1+b)\mathrm{d}A_s/\mathrm{d}t\}/\Delta, \tag{17}$$

$$\mathrm{d}k_s^*/\mathrm{d}t = \{Z_n dA_s/\mathrm{d}t - 4(1-2\alpha)(1+b)\mathrm{d}A_n/\mathrm{d}t\}/\Delta. \tag{18}$$

To evaluate these derivatives, differentiate A_n and A_s in (8) and (9):

$$\mathrm{d}A_n/\mathrm{d}t = 2(2-\alpha)(1-2b),$$
$$dA_s/\mathrm{d}t \equiv 4(b-2) < 0.$$

Substituting these expressions into (17) and (18) yields:

$$\mathrm{d}k_n^*/\mathrm{d}t = 2(2-\alpha)\{(1-2b)Z_s + 4(1+b)(2-b)\}/\Delta, \tag{19}$$

$$\mathrm{d}k_s^*/\mathrm{d}t = 4\{(b-2)Z_n - 2(2-\alpha)(1-2\alpha)(1+b)(1-2b)\}/\Delta. \tag{20}$$

The expression in braces on the right-hand side of (19) simplifies to:

$$3[4b^2 - 2(3\gamma_s - 2)b + 3\gamma_s]. \tag{21}$$

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Equation (21) is positive at $b = 0$, and negative at $b = 1$, given the condition (15): $\gamma_s > 4(1 + b)/3$. Thus, there is a unique $\tilde{b} \in (0, 1)$, at which the expression in (21) vanishes. A calculation yields

$$\tilde{b} = \frac{3\gamma_s - 2 - \sqrt{(3\gamma_s - 2)^2 - 12\gamma_s}}{4}. \tag{22}$$

Hence, $dk^*_n/dt > 0$ if and only if $b \in (0, \tilde{b})$. A calculation shows that $\tilde{b} > ½$.

Turning to (20), we show, in Appendix B, that $dk_s^*/dt < 0$ for all relevant values of α and b. The next proposition summarises the effect of reciprocal AD on investment in R&D.

Proposition 2:
(A) If $b < \tilde{b}$, $dk^*_n/dt > 0$, and if $b > \tilde{b}$, $dk^*_n/dt < 0$.
(B) $dk_s^*/dt < 0$ for all values of α and b.

Proposition 2 states that, with reciprocal AD firm S always invests less in R&D, whereas firm N invests less in R&D if and only if market S is larger than $\tilde{b}$. The intuition can be understood in light of the first-stage game best-response functions. Reciprocal AD always reduces firm S's profit, thereby shifting its best-response function down. If the market sizes are similar, firm N's best-response function also shifts down by a similar distance, and hence, both firms invest less in R&D. If the southern market is sufficiently smaller, however, export profits are relatively less important for firm N while they are more important for firm S. That is, firm N's best-response function does not shift as much as firm S's under reciprocal AD. If there is a substantial size difference, firm N's best-response function can even shift out as a result of reciprocal AD. In either case, firm N's equilibrium R&D level increases and that of firm S decreases.

Note that the above intuition holds regardless of the value of α. This explains why the signs of derivatives in (19) and (20) are independent of α. Regardless of the level of IPR protection in the South, reciprocal AD always discourages firm S from investing in R&D, whereas the effect of reciprocal AD on firm N's investment in R&D depends on the South's market size.

Although it has no qualitative effect on R&D, α affects the magnitudes of changes in R&D investment under reciprocal AD. Calculations show that $\partial^2 k^*_n/\partial t\partial\alpha < 0$ and $\partial^2 k_s^*/\partial t\partial\alpha > 0$. In the light of proposition 2, these results imply that reciprocal AD causes R&D investment to fall more in the South. By contrast, reciprocal AD causes R&D investment to increase less if $b < \tilde{b}$, and to decrease less if $b > \tilde{b}$ in the North.

Proposition 3: *$\partial^2 k^*_n/\partial t\partial\alpha < 0$ and $\partial^2 k_s^*/\partial t\partial\alpha > 0$; an increase in IP protection in the South magnifies the effect of reciprocal AD on R&D in the South and lessens the effect in the North.*

Proposition 3 has the following intuitive explanation. An increase in IPR protection (a reduction in α) raises firm S's marginal cost at given R&D investment levels, thereby increasing firm N's profits in both markets. Since firm N sells a greater quantity at home, however, there is a greater increase in profit at home than abroad. Thus, with stricter IP protection in the South, reciprocal AD raises firm N's profit even more. The same logic applies to firm S but yields a contrasting result. An increase in IPR protection reduces firm S's profits but the decrease is greater in the

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larger market in the North. Hence, reciprocal AD is relatively more harmful to firm S when the South increases its IP protection. It follows that increased IP protection in the South causes firm N's best-response function to shift out more while causing firm S's best-response function to shift down less. Proposition 3 follows from a comparing the equilibriums at two values of α.

Now we turn to the effect on the profits from reciprocal AD actions. By the envelope theorem, the total effect for firm N is expressed as follows:

$$\mathrm{d}\pi_n/\mathrm{d}t = \partial\pi_n/\partial t + (\partial\pi_n/\partial k_s^*)(\partial k_s^*/\partial t).$$

The first term on the right-hand side captures the direct effect from reciprocal AD, while the second term reflects the indirect effect on the profits through induced changes in R&D investment of firm S. For the direct effect, a straightforward calculation yields:

$$\partial\pi_n/\partial t = 2[W + (2-\alpha)k_n - k_s + t_n] - 4b[w + (2-\alpha)k_n - k_s - 2t_s].$$

For the indirect effect, we write:

$$\partial\pi_n/\partial k_s = -2[W + (2-\alpha)k_n - k_s + t_n] - 2b[w + (2-\alpha)k_n - k_s - 2t_s].$$

These derivatives simplify to:

$$\partial\pi_n/\partial t = 2(1-2b)[w + (2-\alpha)k_n - k_s],$$
$$\partial\pi_n/\partial k_s = -2(1+b)[w + (2-\alpha)k_n - k_s].$$

Substituting these derivatives, we can write the total effect as:

$$\mathrm{d}\pi_n/\mathrm{d}t = 2[w + (2-\alpha)k_n - k_s]\{(1-2b) - (1+b)\partial k_s^*/\partial t\}.$$

The bracketed term on the right-hand side of the equality is positive since outputs are positive. Thus, the sign of $\mathrm{d}\pi_n/\mathrm{d}t$ depends on the sign of the term in braces on the right, which is written, after substituting from (20), as:

$$(1-2b) - (1+b)\partial k_s^*/\partial t = (1-2b)\{Z_nZ_s - 8(2-\alpha)(1-2\alpha)(1+b)^2\}/\Delta$$
$$-\,4(1+b)\{Z_n(b-2) - 2(1-2\alpha)(1+b)(2-\alpha)(1-2b)\}/\Delta.$$

This expression simplifies, after some manipulation, to:

$$Z_n\{(1-2b)Z_s + 4(1+b)(2-b)\}/\Delta. \qquad (23)$$

A comparison with (19) shows that (23) is positive if and only if $\mathrm{d}k_n^*/\mathrm{d}t > 0$, that is, sgn $\{\mathrm{d}\pi_n/\mathrm{d}t\}$ = sgn $\{\mathrm{d}k_n^*/\mathrm{d}t\}$. Similarly, we can show in the appendix that sgn$\{\mathrm{d}\pi_s/\mathrm{d}t\}$ = sgn $\{\mathrm{d}k_s^*/\mathrm{d}t\}$. These results and Proposition 3 combine to yield the next result.

Proposition 4:
(A) $\mathrm{d}\pi_n/\mathrm{d}t > 0$ *if* and only if $b < \tilde{b}$.
(B) $\mathrm{d}\pi_s/\mathrm{d}t < 0$.

Proposition 4 states that firm S never wins AD war whereas firm N wins AD war if (and only if) the South's market is small enough such that $b \in (0, \tilde{b})$. As mentioned before, these results are independent of South's IPR enforcement policy.

More importantly, note that this proposition is similar to Proposition 1. In the two-country setting ($M = 2$), Proposition 1 states that firm N can win AD war if and only if $b \in (0, ½)$ when there are no R&D opportunities. Proposition 4 says that firm N can win AD war if and

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only if $b \in (0, \tilde{b})$ when there are R&D opportunities. Since ½ < $\tilde{b}$, AD war is more likely when there are R&D opportunities; that is, AD is more frequently observed in R&D-intensive industries than in industries with no R&D activities. A similar conclusion follows in the repeated game setting. The next result summarises these findings.

Proposition 5: *The opportunity to invest in R&D increases the likelihood of AD war between the North and the South.*

Proposition 5 is consistent with the empirical evidence that AD actions are concentrated in R&D-intensive industries. To understand the intuition behind this proposition, recall that the effect of reciprocal AD is decomposed into two parts as in $d\pi_n^*/dt = \partial\pi_n/\partial t + (\partial\pi_n/\partial k_s^*)(\partial k_s^*/\partial t)$. First, suppose that there are no R&D opportunities. Then, $k_s \equiv 0$ and hence $d\pi_n^*/dt = \partial\pi_n/\partial t$. Assume further that b = ½. Then, firm N neither gains nor loses from AD war, that is $d\pi_n^*/dt = \partial\pi_n/\partial t = 0$. Consider next the case in which firms can invest in R&D. Then, $(\partial\pi_n/\partial k_s^*)(\partial k_s^*/\partial t)$ is positive and hence $d\pi_n/dt > 0$ at $b = 1/2$. Thus, at b = ½, firm N faces a winnable AD war in the presence of R&D opportunities while it does not without R&D opportunities.

Finally, we examine the effect of closing the gap in R&D capability between the North and the South. We measure the South's improvement in R&D capability by a decrease in the value of its R&D cost parameter γ_s. Differentiating the right-hand side of (19) totally and evaluating the result at $\tilde{b}$, we obtain:

$$d\tilde{b}/d\gamma_s = [8\tilde{b} - 2(3\gamma_s - 2)]/[3(1 - 2\tilde{b})].$$

Given that $\tilde{b}$ > ½, the denominator on the right-hand side is negative. The numerator is also negative because of the requirement (15) on γ_s. Thus, $d\tilde{b}/d\gamma_s > 0$. This means that a decrease in in γ_s lowers the critical value $\tilde{b}$, implying that the North is less likely to take AD actions against firm S when the South improves its R&D capability. This result is intuitive. When R&D cost falls in the South and firm S invests more in R&D, firm N's profits fall in both markets, but relatively more in its home market because it is bigger. Thus, this is akin to the effect obtained when the South expands its domestic market, thereby giving the North less of the incentive to take AD actions against the South.

Proposition 6: *The South's improvement in R&D technology makes AD war between the North and the South less likely.*

4. CONCLUDING REMARKS

In this study, we present a model that explains the three stylised facts about recent AD activities: (i) AD actions are observed mostly between the North and the South; (ii) empirical economists find retaliation as developing countries' primary motive to AD against developed countries and (iii) AD actions are more frequently observed in R&D-intensive industries than in industries with little or no R&D activities.

Our analysis has a number of policy implications. First, the North often defends its AD use against the South by saying that its decision is induced by the South's violation of its IPRs. However, we find that the North's incentive to initiate an AD action against the South

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has little to do with the latter's IPR protection. Thus, our analysis debunks the North's defence.

Second, our analysis suggests two ways for countries in the South to avert AD war with the North: expand its home market or improve its R&D capability. This is consistent with the fact that shares of AD actions by the US and the EU have declined against countries such as China and India, whose economies have grown substantially in recent years.

Third, free trade is basically a cooperative equilibrium outcome – there is always a bad equilibrium plagued by AD wars even between countries with similar market sizes. This poses a particularly difficult problem for developing countries. Even if their domestic markets grow, they may remain stuck in the bad equilibrium because of years of reciprocal AD with industrial countries. In this sense, history matters, and there may be a new role for the WTO to move countries to a better (AD-free) equilibrium.

Fourth, our model is based on the assumption that free trade prevails initially. However, protectionist policy remains in force in some countries. The presence of initial tariffs in the South shrinks the export market for firms in the North, making reciprocal AD more winnable for them. Thus, protectionist policy could make a developing country a more likely target of an AD action by the North.

We conclude our discussion with some remarks about our model specification. First, we use linear demand to obtain the closed-form solution. The main advantage of linear demand is that one can unambiguously sign certain cross partial derivatives. For example, $\partial^2\pi/\partial t\partial c$ is negative under linear demand but cannot be signed unambiguously under general demand. If we assume that such partials preserve the signs from linear case, which is standard in the literature (e.g. McAfee and Schwartz, 1994), many of our results are likely to hold under more general demand specifications. For example, a firm with the large home market still wins the AD war with a firm with the substantially smaller home market.

Second, in this study, we focus on reciprocal AD between two countries in a multicountry setting. It is worthwhile extending the analysis to the case in which all firms consider AD actions against each other simultaneously. Such an extension may yield results not obvious in a two-country analysis of reciprocal AD. For example, a firm may be more aggressive when filing for AD protections against a multiple of countries simultaneously. However, the main insight of this study – that reciprocal AD occurs between countries having markets of dissimilar sizes – is likely to hold in such an extension.

Our final remark concerns one of the key features of the North–South model of Section 3 – the assumption that the South has a smaller domestic market than the North.[9] This reflects the common practice in economics to represent a country's domestic market size in terms of its GDP. Indeed, our calculations show that the average GDP of developed countries is 6.33 times greater than that of developing countries.[10] Thus, our assumption seems natural. However, it is easy to find counter examples against it in a multicountry setting. For example, India has a much larger GDP than Switzerland, and yet the former is a developing country while the latter is a developed country. However, such exceptions do not invalidate our findings. Rather, in such exceptional cases, our analysis predicts that Switzerland is less likely to

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9 We thank the referee for pointing out this issue.

10 $1,223 billions as opposed to $193 billions (we follow The United Nations Development Programme to determine which countries are developed and which are developing.)

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take AD actions against India compared with larger developed countries such as the US and the EU.

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APPENDIX A

To compute the Nash equilibrium, substitute (9′) for k_s into (7′) to obtain:

$$k_n Z_n = A_n - 2(2-\alpha)(1+b)[A_s - 4(1-2\alpha)(1+b)k_n]/Z_s.$$

Multiplying through by Z_s yields:

$$k_n Z_n Z_s = A_n Z_s - 2(2-\alpha)(1+b)[A_s - 4(1-2\alpha)(1+b)k_n].$$

Collecting terms, we obtain:

$$k_n^* = \{A_n Z_s - 2(2-\alpha)(1+b)A_s\}/\Delta.$$

Similar operations yields:

$$k_s^* = \{A_s Z_n - 4(1-2\alpha)(1+b)A_n\}/\Delta.$$

APPENDIX B

$$\text{Proof that } \mathrm{d}k_s^*/\mathrm{d}t = 4\{(b-2)Z_n - 2(2-\alpha)(1-2\alpha)(1+b)(1-2b)\}/\Delta. \qquad \text{(B1)}$$

Given:

$$Z_n - 2(2-\alpha)(1-2\alpha)(1+b) > 0,$$

by the second-order condition, we have, for $1 - 2b \le 0$, that

$$-(1-2b)Z_n + 2(2-\alpha)(1-2\alpha)(1+b)(1-2b) > 0.$$

Adding this to the expression in braces in (B.1) yields $3(b - 1)Z_n < 0$. Therefore, for $b \ge 1/2$, the expression in braces in (B.1) is negative and hence $\mathrm{d}k_s{}^*/\mathrm{d}t < 0$. For $b < 1/2$, the sign of $\mathrm{d}k_s{}^*/\mathrm{d}t$ depends on α. Differentiating the numerator in (B.1) with respect to α yields:

$$\begin{aligned} &4\{4(b-2)(2-\alpha)(1+b) - 2(-5+4\alpha)(1+b)(1-2b)\} \\ &= 8(1+b)\{2(b-2)(2-\alpha) - (-5+4\alpha)(1-2b)\} = -24(1+b)[1+2b(1-\alpha)] < 0, \end{aligned}$$

while differentiating the denominator yields

$$\mathrm{d}\Delta/d\alpha \equiv 4(2-\alpha)(1+b)Z_s - 8(-5+4\alpha)(1+b)^2 > 0.$$

Thus, $\mathrm{d}k_s{}^*/\mathrm{d}t$ is decreasing in α and hence takes the maximum value at $\alpha = 0$. Substitution shows that at $\alpha = 0$:

$$\mathrm{d}k_s^*/\mathrm{d}t = 4\{(b-2)Z_n - 4(1+b)(1-2b)\}/\Delta < 0.$$

Thus, for any $b < 1/2$, $\mathrm{d}k_s{}^*/\mathrm{d}t < 0$ for any α. We have shown that for any value of b and α, $\mathrm{d}k_s{}^*/\mathrm{d}t < 0$.

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APPENDIX C

The total profit to firm S is:

$$\pi_s = [w + 2k_s - (1 - 2\alpha)k_n - 2t_n]^2/9$$
$$+ b[w + 2k_s - (1 - 2\alpha)k_n + t_s]^2/9 - (\gamma_s/2)k_s^2,$$

where k_n and k_s are evaluated at the Nash equilibrium values. By the envelope theorem, $d\pi_s/dt = \partial\pi_s/\partial t + (\partial\pi_s/\partial k_n)(\partial k_n/\partial t)$. The direct effect is:

$$\partial\pi_s/\partial t = -4[w + 2k_s - (1 - 2\alpha)k_n - 2t_n] + 2b[w + 2k_s - (1 - 2\alpha)k_n + t_s]/9.$$

We also have:

$$\partial\pi_s/\partial k_n = -2(1 - 2\alpha)[w + 2k_s - (1 - 2\alpha)k_n - 2t_n]/9$$
$$- 2b(1 - 2\alpha)[w + 2k_s - (1 - 2\alpha)k_n + t_s]/9.$$

If there is free trade initially, these are written as follows:

$$\partial\pi_s/\partial t = (b - 2)H,$$
$$\partial\pi_s/\partial k_n = -(1 - 2\alpha)(1 - b)H,$$

where

$$H \equiv 2[w + 2k_s - (1 - 2\alpha)k_n]/9 > 0.$$

Therefore,

$$d\pi_s/dt = \{(b - 2) - (1 - 2\alpha)(1 + b)(\partial k_n/\partial t)\}H.$$

The term in braces is written as follows:

$$(b - 2) - (1 - 2\alpha)(1 + b)dk_n/dt$$
$$= (b - 2) - (1 - 2\alpha)(1 + b)2(2 - \alpha)\{(1 - 2b)Z_s + 4(1 + b)(2 - b)\}/\Delta$$
$$= (b - 2)\{Z_nZ_s + 8(2 - \alpha)(1 - 2\alpha)(1 + b)^2\}/\Delta$$
$$- 2(1 - 2\alpha)(1 + b)(2 - \alpha)\{(1 - 2b)Z_s + 4(1 + b)(2 - b)\}/\Delta$$
$$= Z_s\{(b - 2)Z_n - 2(1 - 2\alpha)(2 - \alpha)(1 + b)(1 - 2b)\}/\Delta,$$

which has the sign of $\{dk_s^*/dt\}$ as in the text. Therefore,

$$\text{sgn}\{d\pi_s/dt\} = \text{sgn}\{dk_s^*/dt\}.$$

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