International Review of Economics and Finance xxx (2015) xxx–xxx

Contents lists available at ScienceDirect

International Review of Economics and Finance

journal homepage: www.elsevier.com/locate/iref

Anti-dumping protection, price undertaking and product innovation

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ARTICLE INFO

Article history:
Received 20 January 2015
Received in revised form 30 September 2015
Accepted 30 September 2015
Available online xxxx

JEL classification:
F12
F13

Keywords:
Anti-dumping policy
Price undertaking
Product R&D

ABSTRACT

This paper examines how price undertaking policies affect the product investments of firms in an intra-industry trade model. We show that the dumping margin will decline if the products become more differentiated. Under bilateral anti-dumping actions, relative to those under free trade, the aggregate product R&D investment may either increase or decrease, depending on the tolerable dumping margin set by the governments. By contrast, the aggregate product R&D will definitely decline and the products will become less differentiated if only one government implements anti-dumping actions.

1. Introduction

In the real world, an anti-dumping policy is considered to be a mechanism that advances the interests of domestic producers. Konings and Vandenbussche (2005) use panel data for about 4000 European Union (EU) producers that have been involved in anti-dumping cases to estimate markups both before and after the filing of a case, and find that anti-dumping protection has both positive and significant effects on domestic markups. Anti-dumping policies also have potential impacts on the behaviors or strategies of both domestic and foreign industries. For example, Dinlersoz and Dogan (2009) compare the relative merits of tariffs and antidumping duties. Wu, Chang, and Chen (2014) investigate the welfare effects of anti-dumping duty and price undertaking policies. Anti-dumping policies may also encourage foreign firms to engage in FDI (Belderbos, 1997; Blonigen, 2002; Belderbos, Vandenbussche and Veugelers, 2004), change the cost-reducing R&D intensity of both domestic and foreign firms (Gao and Miyagiwa, 2005), or improve their product quality (Vandenbussche and Wauthy, 2001).

Understanding a firm's R&D behavior has been an important objective of industrial organization. A substantial literature has highlighted the welfare consequences of marginal-cost-reducing (process) R&D investment (see for example, Arrow, 1962; Brander and Spencer, 1983; D'Aspremont and Jacquemin, 1988; Chang, Hwang, and Peng, 2013, among others). More recently, the literature on R&D has started to center on product R&D and its link with process R&D (for example, Cohen and Klepper, 1996; Bonanno and Haworth, 1998; Lin and Saggi, 2002, Symeonidis, 2003). In particular, Miyagiwa and Ohno (1999) find that temporary safeguard protection can increase process R&D if the commitment to dismantle protection by policymakers is credible, but may reduce

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http://dx.doi.org/10.1016/j.iref.2015.09.006
1059-0560/

R&D if they believe policymakers will extend protection. Haaland and Kind (2008) examine the industrial process R&D investment and tariff competition between countries in an international setting. They show that trade liberalization generates more R&D and that the policy competition between countries critically depends on the competitiveness of the market.

The empirical evidence has shown that anti-dumping policies often target R&D-intensive industries such as the electronics, primary metals, chemical and mechanical engineering industries (Niels, 2000). Thus it is important to investigate the R&D behavior of such industries under anti-dumping policies. Gao and Miyagiwa (2005) is the first paper to investigate the impact of anti-dumping policies on the cost-reducing R&D incentives of the protected firm and the constrained firm. Given an ad valorem transport cost, they find that a unilateral anti-dumping policy decreases (increases) the cost-reducing R&D of the protected (constrained) firm.

However, approximately three-fourths of the R&D conducted by firms in the US is devoted to product R&D (Scherer and Ross, 1990). The current paper aims to fill this gap in the related literature and provide a theoretical rationale for the effects of price undertaking actions on firms' product R&D. The product R&D setup in this paper is borrowed from Lin and Saggi (2002), who compare the impact of the competition mode on firms' incentives to produce, whereas we investigate the effect of anti-dumping policies on the product R&D incentives of firms. This paper also contributes to the literature on price undertaking policies in that we assume that the governments can set a tolerable dumping margin against foreign firms. While existing studies on anti-dumping policies usually treat the AD policy as a binary variable, in which case, if price undertaking actions are imposed, the dumping margin will be completely eliminated and where the ex-factory prices are all the same. In our paper, we relax this assumption by assuming that governments may not eliminate the dumping completely and may instead implement a more amicable price undertaking action by imposing a tolerable dumping margin against the foreign firm. Thus, the foreign constrained firm can set its prices subject to this tolerable dumping margin. This is a more general setup since it not only can discuss the case where antidumping policy eliminates full dumping margin, but also can investigate the case where government aims to eliminate only the material injury.[1]

Although countries such as the US and Canada usually adopt anti-dumping duties as their instrument when dealing with the dumping country, most EU anti-dumping filings are finalized with the acceptance by the EU of a price undertaking.[2] The study by Zanardi (2004) also shows that countries such as Japan, Finland, Sweden and South Korea make frequent use of price undertakings.[3] Besides, the dumping firm usually chooses to accept the price set by the authority rather than pay duties (Gao and Miyagiwa, 2005). As a result, in this paper we mainly focus on the price undertaking policy.

We show that the dumping margin of each dumping firm declines as the products become more differentiated. Supposing that both governments engage in anti-dumping actions with no tolerable dumping margin, the two firms will increase their product R&D investments. However, this result will be reversed if the tolerable dumping margins are set at the free trade level. In other words, relative to that under free trade, the aggregate product R&D investment may either decrease or increase, depending on the tolerable dumping margins. By contrast, the aggregate product R&D will definitely decline and the products will become less differentiated if only one government implements an anti-dumping action.

The remainder of this paper is organized as follows. Section 2 introduces our basic (free trade) model. Section 3 investigates the effects of bilateral anti-dumping protection on firms' product R&D incentives. Section 4 examines the effects of unilateral anti-dumping protection on the optimal product R&D of firms. Section 5 concludes the paper.

2. The benchmark model

Assume that there are two countries, country H and country F, that host one firm each. The two firms, firm H and firm F, engage in intra-industry trade in the two markets. The utility functions of a representative consumer in each of country H and country F are assumed to be:

$$U = a(q+Q) - \frac{1}{2}\left(bq^2 + 2rqQ + bQ^2\right) + m,$$
$$U* = a(q*+Q*) - \frac{1}{2}\left(bq*^2 + 2rq*Q*+bQ*^2\right) + m,$$

where m is the consumption of numeraire goods, the variables in the lower (upper) case are the actions taken by firm H (F), and those with an asterisk are associated with country F. Moreover, the parameter $r(\equiv b-k-K)$ expresses the degree of product differentiation, ranging from zero when the goods are independent to b when the goods are perfect substitutes. Note that an increase in the degree of product differentiation (a decline in r) shifts the demand curves for both firms outward. We assume that the two firms carry out

[1] As the EU applies lesser-duty rule (EU regulation 384/96), injury is measured by the smaller of the dumping and injury margins. Therefore, dumping margin may not be fully eliminated if the injury margin is lower than the dumping margin (Vermulst and Waer, 1991; Vandenbussche, 1995). Vermulst and Waer (1991) show that in 44% of EU AD cases, the injury margin was lower than the dumping margin from 1980 to 1990. Finger (1993) also denote that five of the ten price undertakings accepted under Special Import Measure Act were intended to raise prices only enough to eliminate the material injury rather than to eliminate the full dumping margin in Canada during 1985 to 1989.

[2] As agreed at the Essen Summit in 1994, these Agreements grant a preferential role for price undertakings (see, e.g., Annex IV to the Conclusions of the Essen European Council 1994; Chapter IV, Article 34 of the European Agreement with Bulgaria).

[3] Zanardi (2004) shows that, for the period 1881–2001, Japan accepted more undertakings, i.e., in about 60% of the cases, as did Finland and Sweden before their EU membership (82% and 100%, respectively).

Please cite this article as: Kao, K.-F., & Peng, C.-H., Anti-dumping protection, price undertaking and product innovation, *International Review of Economics and Finance* (2015), http://dx.doi.org/10.1016/j.iref.2015.09.006

product R&D, i.e., $k, K \in [0, b/2]$, to make their products more differentiated based on the same cost function $f(\bullet)$ with $f(0) = 0, f' > 0,\ f'' > 0$, and $f''' = 0$. From the utility functions, we can derive the demand functions in the two different countries as follows:

$$q = \frac{a(b-r)-bp+rP}{b^2-r^2}, Q = \frac{a(b-r)-bP+rp}{b^2-r^2}; \tag{1}$$

$$q* = \frac{a(b-r)-bp*+rP*}{b^2-r^2}, Q* = \frac{a(b-r)-bP*+rp*}{b^2-r^2}. \tag{2}$$

From Eqs. (1) and (2), we can derive $q_p = q^*_{p*} = Q_P = Q^*_{P*} = -b/(b^2-r^2) < 0$, and $q_P = q^*_{P*} = Q_p = Q^*_{p*} = r/(b^2-r^2) > 0$, where the subscripts are used to denote partial differentiation. Given the above assumptions, the profit functions of firm H and firm F are specified as follows:

$$\pi = (p-c)q + (p*-c-t)q*-f(k), \tag{3}$$

$$\Pi = (P-c*-t)Q + (P*-c*)Q*-f(K), \tag{4}$$

where t is the per-unit transport cost, and c and c^* are the marginal production costs.

We proceed to investigate the R&D incentives of the two firms under free trade. The game in question encompasses two stages. In the first stage, firm H and firm F determine their product R&D investments simultaneously. In the second stage, given the R&D investments, both firms compete in price terms in both countries. We shall solve for the sub-game perfect Nash equilibrium via backward induction.

In the second stage, both firms determine their prices in country H and country F to maximize their profit. By differentiating Eq. (3) with respect to p and p^*, and Eq. (4) with respect to P and P^*, we can derive the first-order conditions for profit maximization for the two firms as follows:

$$\pi_p = q + (p-c)q_p = 0, \tag{5}$$

$$\pi_{p*} = q*+(p*-c-t)q^*_{p*} = 0, \tag{6}$$

$$\Pi_P = Q + (P-c*-t)Q_P = 0, \text{and} \tag{7}$$

$$\Pi_{P_*} = Q*+(P*-c*)Q^*_{P*} = 0 \tag{8}$$

Given the linear demands, constant marginal costs and trade cost, the second-order conditions and the stability conditions are satisfied. By solving Eqs. (5) and (7) ((6) and (8)) simultaneously, the domestic (foreign) equilibrium prices in the second-stage are respectively $\overline{p}$ and $\overline{P}$ ($\overline{p}*$ and $\overline{P}*$), where variables with a "bar" are the equilibrium associated with the free trade regime.[4] By subtracting Eq. (6) from Eq. (5) and Eq. (8) from Eq. (7) and then solving these two equations simultaneously, we obtain:

$$\overline{q}-\overline{q}* = \frac{bt}{(b-r)(2b+r)} \text{and} \overline{Q}-\overline{Q}* = \frac{-bt}{(b-r)(2b+r)} \tag{9}$$

It is apparent that the two firms have larger outputs in their home market than in their foreign market.

Moreover, by totally differentiating Eqs. (5) to (8), we obtain:

$$p_r = -\frac{2b^2Q+3brq+r^2Q}{4b^2-r^2} < 0, p^*_r = -\frac{2b^2Q*+3brq*+r^2Q*}{4b^2-r^2} < 0, \tag{10}$$

$$P_r = -\frac{2b^2q+3brQ+r^2q}{4b^2-r^2} < 0, P^*_r = -\frac{2b^2q*+3brQ*+r^2q*}{4b^2-r^2} < 0. \tag{11}$$

It follows that if the products are less differentiated, the competition between the two firms will become more intense and the equilibrium prices will be lower.

[4] These equilibrium prices under free trade are reported in Appendix A.

We assume that the dumping margin is measured by the difference between the ex-factory export and home price of the product.[5] Thus, under free trade, the dumping margins for firm H in country F and firm F in country H, δ^* and δ, may respectively be derived as follows:

$$\begin{aligned} \delta* &= \overline{p} - (\overline{p}* - t) = \frac{b^2 - r^2}{b}(\overline{q} - \overline{q}*) = \frac{(b+r)t}{2b+r} > 0, \\ \delta &= \overline{P}* - (\overline{P} - t) = \frac{b^2 - r^2}{b}\left(\overline{Q}* - \overline{Q}\right) = \frac{(b+r)t}{2b+r} > 0. \end{aligned} \tag{12}$$

From Eq. (12), it is obvious that reciprocal dumping occurs and increases with the trade cost, t. By differentiating Eq. (12) with respect to r, it is straightforward to show that $\partial\delta/\partial r > 0$ and $\partial\delta^*/\partial r > 0$, which implies that the dumping margins decrease when the two products become more differentiated. Besides, we can find that the dumping margins are not affected by the marginal product costs, c and c^*, which implies that the dumping margins are irrelevant to the process innovation of the two firms. Thus, we can construct the following proposition:

Proposition 1. *When two firms engage in intra-industry trade, the dumping margins will decrease if their products become more differentiated. However, the dumping margins are not affected by the process R&D of the two firms.*

The economic explanation for Proposition 1 is as follows. From Eqs. (1) and (2), it can be found that, other things being equal, the demand for each of the two firms shifts outwards when their products become more differentiated. This outward-shifting effect is stronger in relation to the firms' foreign demand than their domestic demand as each firm accounts for a smaller market share of its export market than of its domestic market (i.e., $q > q^*$ and $Q^* > Q$). Consequently, the gap related to the ex-factory prices for each firm in the two markets decreases.

In the first stage, the two firms can determine their product R&D investments to maximize their profits. By differentiating Eq. (3) with respect to k and Eq. (4) with respect to K, the first-order derivatives are as follows:

$$\frac{d\overline{\pi}}{dk} = \Bigg(\underset{=0}{\overline{\pi}_p p_r} + \underset{=0}{\overline{\pi}_{p*} p_r^*} + \underset{(-)}{\overline{\pi}_P P_r} + \underset{(-)}{\overline{\pi}_{P*} P_r^*} + \underset{(+/-)}{\overline{\pi}_r} \Bigg) \underset{(-)}{r_k} - \underset{(+)}{f'} = 0, \tag{13}$$

$$\frac{d\overline{\Pi}}{dK} = \Bigg[\underset{=0}{\overline{\Pi}_P P_r} + \underset{=0}{\underbrace{\overline{\Pi}_{P*} P_r^*}} + \underset{(-)}{\overline{\Pi}_p p_r} + \underset{(-)}{\underbrace{\overline{\Pi}_{p*} p_r^*}} + \underset{(+/-)}{\overline{\Pi}_r} \Bigg] \underset{(-)}{r_K} - \underset{(+)}{f'} = 0, \tag{14}$$

where $\overline{\pi}_p = \overline{\pi}_{p*} = \overline{\Pi}_P = \overline{\Pi}_{P*} = 0$ (by Eqs. (5) to (8)), $r_k = r_K = -1$, and $\overline{\pi}_P = (p - c)q_P > 0, \overline{\pi}_{P*} = (p* - c - t)q^*_{P*} > 0, \overline{\Pi}_p = (P - c* - t)Q_p > 0, \overline{\Pi}_{p*} = (P* - c*)Q^*_{p*} > 0, \overline{\pi}_r = (p - c)q_r + (p* - c - t)q^*_r$, and $\overline{\Pi}_r = (P - c* - t)Q_r + (P* - c*)Q^*_r$, where q_r, q^*_r, Q_r, and Q^*_r can be derived from Eqs. (1) and (2), and are as follows:

$$q_r = \frac{-bQ + rq}{b^2 - r^2}, Q_r = \frac{-bq + rQ}{b^2 - r^2}, q_r^* = \frac{-bQ* + rq*}{b^2 - r^2}, Q_r^* = \frac{-bq* + rQ*}{b^2 - r^2}.$$

The first and second terms on the RHS of both Eqs. (13) and (14) are vanished based on the envelope theorem. The third and fourth terms denote the positive competition effects in the domestic and foreign markets, respectively. If the products were more differentiated, the competition between the firms in both markets would become less intense, and both firms would raise their prices, resulting in higher profits. The fifth term stands for the product differentiation effect, which is ambiguous. The last term is the negative R&D cost effect. Those effects jointly determine the optimal R&D investments of the two firms. By solving Eqs. (13) and (14) simultaneously, we can derive the optimal product R&D investments for the two firms, $\overline{k}$ and $\overline{K}$. Accordingly, the level of product differentiation under free trade is $\overline{r} = b - \overline{k} - \overline{K}$, and the dumping margin for firm F (H) in country H (F) under free trade is $(b + \overline{r})t/(2b + \overline{r}) \equiv \overline{\delta}$ $(\overline{\delta}*)$. The second-order conditions and the stability condition are assumed to be satisfied, which requires that $d^2\overline{\pi}/dk^2 < 0$, $d^2\overline{\Pi}/dK^2 < 0$, and $(d^2\overline{\pi}/dk^2)(d^2\overline{\Pi}/dK^2) - (d^2\overline{\pi}/dkdK)(d^2\overline{\Pi}/dKdk) > 0$.

[5] According to Article VI of the GATT, dumping occurs when the price charged in the export market is below the 'normal' or 'fair' value of the good. This definition of dumping can also be found in the EU regulation 384/96. If the market-generated prices are available, the US Department of Commerce (USDOC) and the EU usually measure the dumping margin based on the difference between the *ex-factory* foreign export price and the home price of the good (Blonigen and Haynes, 2002; Gao and Miyagiwa, 2005, among others). However, the calculation of the dumping margin by USDOC is usually not straightforward and revolves around how the USDOC measures what should be the fair value of the product sold in the US (Blonigen and Park, 2004). In this context, price-based valuations of dumping margins are not the "normal" practice. In cases where home market prices are inadequate or not available, the government bases the fair value on the sale prices in third-country markets. If the third-country prices are inadequate, then cost-based valuation of dumping margin will be constructed by using the investigated firm's manufacturing, selling, general and administrative costs (Veugelers and Vandenbussche, 1999; Tivig & Walz, 2000; Vandenbussche, Veugelers, and Konings, 2001; Falvey and Wittayarungruangsri, 2006; and Wu, Chang, and Chen, 2014, among others). To facilitate our analysis, we assume that the market-generated prices of the products are available.

3. Bilateral anti-dumping protection

In this section, we suppose that both countries implement price undertaking actions against their foreign dumping firms. That is to say, both firm H and firm F are subject to the policy of price undertaking when exporting their products to the foreign market. We explore how the bilateral price undertaking actions affect the product R&D incentives of the two firms. All the model setups and game structures are similar to those in the previous section, except that now both firm H and firm F face price undertaking actions when determining their prices and their product R&D.

In the second stage, both firms determine their prices to maximize their profits subject to the bilateral price undertaking policies. Therefore, firm H (F) is subject to the constraint $p-(p^*-t)\leq v^*$ $(P^*-(P-t)\leq v)$ when determining its optimal pricing, where v^* (v) is the tolerable dumping margin set by country F (H). We assume that the tolerable dumping margins are effective, i.e., $0\leq v, v*\leq\overline{\delta}=\overline{\delta}*$. Accordingly, by utilizing the Lagrangian approach, the profit maximization problems of firm H and firm F can be rewritten as follows:

$$\underset{p,p*,\lambda}{\text{Max}}\, L\equiv \pi+\lambda[v*-p+(p*-t)],$$

$$\underset{P,P*,\lambda*}{\text{Max}}\, L*\equiv \Pi+\lambda*[v-P*+(P-t)],$$

where $\lambda\geq 0$ and $\lambda^*\geq 0$ are the Lagrange multipliers. The first-order conditions of firm H and firm F are as follows:

$$L_p=\pi_p-\lambda=q-\lambda+(p-c)q_p=0, \tag{15}$$

$$L_{p*}=\pi_{p*}+\lambda=q*+\lambda+(p*-c-t)q^*_{p*}=0, \tag{16}$$

$$L_\lambda=v*-p+(p*-t)=0 \tag{17}$$

$$L^*_P=\Pi_P+\lambda*=Q+\lambda*+(P-c*-t)Q_P=0, \tag{18}$$

$$L^*_{P*}=\Pi_{P*}-\lambda*=Q*-\lambda*+(P*-c*)Q^*_{P*}=0, \tag{19}$$

$$L^*_{\lambda*}=v-P*+(P-t)=0. \tag{20}$$

By solving Eqs. (15) to (20) simultaneously, we can derive the equilibrium prices as follows[6]:

$$\begin{aligned}
&p=\overline{p}-\frac{1}{2}\left[\frac{(b+r)t}{(2b+r)}-v*\right], p*=\overline{p}*+\frac{1}{2}\left[\frac{(b+r)t}{(2b+r)}-v*\right],\\
&P=\overline{P}+\frac{1}{2}\left[\frac{(b+r)t}{(2b+r)}-v\right], P*=\overline{P}*-\frac{1}{2}\left[\frac{(b+r)t}{(2b+r)}-v\right],\\
&\lambda=\frac{(b+r)t-(rv+2bv*)}{2(b-r)(b+r)}, \lambda*=\frac{(b+r)t-(2bv+rv*)}{2(b-r)(b+r)}.
\end{aligned}$$

From the above results, it is straightforward to show that the equilibrium prices for each firm are not affected by the tolerable dumping margin set by their respective governments. Nevertheless, each firm's domestic (export) price increases (decreases) in terms of the tolerable dumping margin with which it is faced.

[6] The detailed derivations of the equilibrium prices are presented in Appendix B.

Substituting p, p^*, P, P^*, λ and λ^* into Eqs. (1) and (2) yields:

$$q=\overline{q}+\frac{(b+r)^2t-(2b+r)(rv+bv*)}{2(b^2-r^2)(2b+r)},q*=\overline{q}*-\frac{(b+r)^2t-(2b+r)(rv+bv*)}{2(b^2-r^2)(2b+r)},$$
$$Q=\overline{Q}-\frac{(b+r)^2t-(2b+r)(bv+rv*)}{2(b^2-r^2)(2b+r)},Q*=\overline{Q}*+\frac{(b+r)^2t-(2b+r)(bv+rv*)}{2(b^2-r^2)(2b+r)}.$$

From the above equations, it is straightforward to show that $q+q*=\overline{q}+\overline{q}*$ and $Q+Q*=\overline{Q}+\overline{Q}*$, namely, the aggregate output of each firm is unaffected by the price undertaking policies. The intuition behind this result is obvious. Given the linear demand, the aggregate marginal revenue is also linear. In this context, the optimal total output is not affected by the pricing strategies. Although this result has been proposed by Robinson (1933), she assumes that the market is characterized by a monopoly. We obtain a similar result under oligopolistic competition. Given the above discussion, we can construct the following proposition:

Proposition 2. *Given a linear demand and constant marginal cost, a price-undertaking policy has no effect on the total outputs of the constrained and the protected firms.*

We proceed to analyze the first-stage game. In the first stage, both firms determine their optimal product R&D levels. By substituting the equilibrium prices and outputs in the second stage into Eqs. (3) and (4) and utilizing Eqs. (9) and (12), the objective functions of firm H and firm F can be rewritten as follows:

$$\pi=\overline{\pi}-\frac{b[(2b+r)v*+(b+r)t]}{2(b^2-r^2)(2b+r)}\left[\frac{(b+r)t}{(2b+r)}-v*\right]+\frac{v*[(b+r)t-(rv+2bv*)]}{2(b-r)(b+r)}, \tag{21}$$

$$\Pi=\overline{\Pi}-\frac{b[(2b+r)v+(b+r)t]}{2(b^2-r^2)(2b+r)}\left[\frac{(b+r)t}{(2b+r)}-v\right]+\frac{v[(b+r)t-(rv*+2bv)]}{2(b-r)(b+r)}. \tag{22}$$

Eqs. (21) and (22) show the profit linkages of the two firms under both the free trade and price undertaking regimes. If the governments set their tolerable dumping margin at $v=v*=\overline{\delta}$, then the last two terms on the RHS of Eqs. (21) and (22) will be zero and the profits will degenerate to the free trade level, i.e., $\pi=\overline{\pi}$ and $\Pi=\overline{\Pi}$. By contrast, the two firms will suffer profit losses if both countries implement price undertaking policies and aim to eliminate the dumping margins completely, i.e., $\pi(v=0,v*=0)<\overline{\pi}$ and $\Pi(v=0,v*=0)<\overline{\Pi}$. The intuition is straightforward. When both firms are subject to the regulation of price undertaking policies, they can no longer carry out discriminatory pricing in the two markets, resulting in a lower profit level than under the free trade regime.

By differentiating Eq. (21) with respect to k and Eq. (22) with respect to K, respectively, the first-order conditions for the two firms are as follows:

$$\frac{d\pi}{dk}=\frac{d\overline{\pi}}{dk}+\frac{b(b+r)^3t^2-(2b+r)^2v*\left[b(b+r)v+r^2(v*-v)\right]}{2(b-r)^2(b+r)^2(2b+r)^2}-\frac{v*\left[(b+r)^2t-(2b+r)(bv+rv*)\right]}{2(b-r)^2(b+r)^2}-\frac{brt^2}{2(b-r)(2b+r)^3}$$
$$=0, \tag{23}$$

$$\frac{d\Pi}{dK}=\frac{d\overline{\Pi}}{dK}+\frac{b(b+r)^3t^2-(2b+r)^2v\left[b(b+r)v*+r^2(v-v*)\right]}{2(b-r)^2(b+r)^2(2b+r)^2}-\frac{v\left[(b+r)^2t-(2b+r)(bv*+rv)\right]}{2(b-r)^2(b+r)^2}-\frac{brt^2}{2(b-r)(2b+r)^3}$$
$$=0. \tag{24}$$

The second-order and the stability conditions are assumed to be satisfied. By solving Eqs. (23) and (24) simultaneously, we derive the optimal product R&D investments, k and K, under price undertaking actions.

Please cite this article as: Kao, K.-F., & Peng, C.-H., Anti-dumping protection, price undertaking and product innovation, *International Review of Economics and Finance* (2015), http://dx.doi.org/10.1016/j.iref.2015.09.006

By totally differentiating Eqs. (23) and (24), we obtain[7]:

$$\frac{dk}{dv}>0, \frac{dK}{dv}<0, \frac{dk}{dv*}<0, \text{and } \frac{dK}{dv*}>0. \tag{25}$$

The above comparative static effects imply that, other things being equal, a stricter price undertaking policy on the part of a country weakens its domestic firm's R&D incentive but encourages its foreign firm to engage in more R&D.

We proceed to investigate the case where the foreign firm also implements an anti-dumping protection policy against the domestic firm. Supposing that both governments set the dumping margin equal to zero (i.e., $v = v^* = 0$), by evaluating Eqs. (23) and (24) at the R&D level under free trade ($k = \overline{k}, K = \overline{K}$), we obtain:

$$\left.\frac{d\pi}{dk}\right|_{v=v*=0,k=\overline{k},K=\overline{K}} = \frac{d\overline{\pi}}{dk} + \frac{b\left(b^2 + b\overline{r} + \overline{r}^2\right)t^2}{(b-\overline{r})^2(2b+\overline{r})^3}>0, \text{and} \tag{26}$$

$$\left.\frac{d\Pi}{dK}\right|_{v=v*=0,k=\overline{k},K=\overline{K}} = \frac{d\overline{\Pi}}{dK} + \frac{b\left(b^2 + b\overline{r} + \overline{r}^2\right)t^2}{(b-\overline{r})^2(2b+\overline{r})^3}>0. \tag{27}$$

From Eqs. (13) and (14), the first terms on the RHS of Eqs. (26) and (27) are zero given $k = \overline{k}, K = \overline{K}$. Therefore, Eqs. (26) and (27) are definitely positive. This result implies that both firms will increase their product R&D investment if the two governments carry out price undertaking policies and set the tolerable dumping margin at zero. Thus, we can construct the following proposition:

Proposition 3. *If both governments implement price undertaking policies to eliminate the dumping margins completely, then both firms will engage in more product R&D. Therefore, relative to free trade, the two products become more differentiated under bilateral anti-dumping protection.*

By contrast, if the two firms set the dumping margin at the free trade level, i.e., $v = v* = \overline{\delta}$, from Eqs. (23) and (24) at $k = \overline{k}, K = \overline{K}$, we obtain:

$$\left.\frac{d\pi}{dk}\right|_{v=v*=\overline{\delta},k=\overline{k},K=\overline{K}} = -\frac{b\overline{r}t^2}{2(b-\overline{r})(2b+\overline{r})^3}<0, \text{and}$$
$$\left.\frac{d\Pi}{dK}\right|_{v=v*=\overline{\delta},k=\overline{k},K=\overline{K}} = -\frac{b\overline{r}t^2}{2(b-\overline{r})(2b+\overline{r})^3}<0$$

This result implies that if both governments set the tolerable dumping margin at the free trade level, both firms will engage in less R&D than they would under free trade. This is because anti-dumping actions commit less intensive competition in the two markets, thereby stifling the incentive of the firms to engage in R&D. According to this result, we can find that if the tolerable dumping margin is large, AD policies may discourage firms' R&D which is in contrast to Proposition 3.[8] Thus, we can establish the following lemma:

Lemma 1. *If both governments set the tolerable dumping margin at the free trade level, then both firms will decrease their R&D investments.*

Given the results in Proposition 3 and Lemma 1 and making use of intermediate value theorem, there exists a critical tolerable dumping margin, $\overline{v} \in (0, \overline{\delta})$, at (above, below) which the total R&D investment under the bilateral price undertaking protection is identical to (lower, higher than) that under free trade. This result differs from that in Gao and Miyagiwa (2005), in which the total process R&D will definitely increase, and has not been documented in the literature. In sum, we can construct the proposition as follows:

Proposition 4. *Bilateral anti-dumping protection may increase or decrease the total product R&D by an amount that is contingent upon the tolerable dumping margin set by the governments.*

4. Unilateral anti-dumping protection

In this section, we suppose that country H implements price undertaking actions against firm F, while country F does not implement an anti-dumping policy against firm H. We investigate the effects of such unilateral price undertaking actions on the product R&D incentives of the two firms. All the model setups and the game structure are similar to those in the previous section, except that now firm F faces a price undertaking action when determining its prices and product R&D.

[7] Please refer to Appendix C for the detailed derivation.
[8] We thank a referee for suggesting this discussion.

In the second stage, firm F is subject to $P^* - (P - t) \leq v$ while determining its optimal pricing. The profit maximization problems of firms H and F are as follows:

$$\underset{p,p*}{\text{Max}}\ \pi = (p - c)q + (p * - c - t)q * - f(k),$$

$$\underset{P,P*,\lambda*}{\text{Max}}\ L * \equiv \Pi + \lambda * [v - P * + (P - t)],$$

where $\lambda^* \geq 0$ is again the Lagrange multiplier. Following the same process as that shown above, we are able to derive[9]:

$$p = \overline{p} + \frac{r}{4b}\left[\frac{(b+r)t}{(2b+r)} - v\right], p* = \overline{p} * - \frac{r}{4b}\left[\frac{(b+r)t}{(2b+r)} - v\right],$$
$$P = \overline{P} + \frac{1}{2}\left[\frac{(b+r)t}{(2b+r)} - v\right], P* = \overline{P} * - \frac{1}{2}\left[\frac{(b+r)t}{(2b+r)} - v\right],$$
$$\lambda* = \frac{(2b-r)[(b+r)t - (2b+r)v]}{4b(b-r)(b+r)}.$$

In the first stage, both firms determine their optimal product R&D levels. By substituting the equilibrium prices in the second stage into Eqs. (3) and (4), the objective functions of firm H and firm F can be rewritten as follows:

$$\pi = \overline{\pi} + r\left[v - \frac{(b+r)t}{(2b+r)}\right]\left[\frac{r(2b+r)v - (b+r)(4b+r)t}{8b(b^2-r^2)(2b+r)}\right], \tag{28}$$

$$\Pi = \overline{\Pi} - \left[v - \frac{(b+r)t}{(2b+r)}\right]\left[\frac{(2b+r)\left(2b^2-r^2\right)v - 2b^2(b+r)t}{4b(b^2-r^2)(2b+r)}\right]. \tag{29}$$

Eqs. (28) and (29) show the profit linkages of the two firms under the free trade and unilateral price undertaking regimes. If government H sets its tolerable dumping margin at $v = \overline{\delta}$, then the last two terms on the RHS of Eqs. (28) and (29) will disappear and the profits will be restored to their free trade levels, i.e., $\pi = \overline{\pi}$ and $\Pi = \overline{\Pi}$. From Eq. (28) and (29), it can be derived that $\partial\pi/\partial v < 0$ and $\partial\Pi/\partial v > 0$, which implies that firm H gains while firm F loses if country H implements a price undertaking policy.

By differentiating Eq. (28) with respect to k and Eq. (29) with respect to K, respectively, the first-order conditions for the two firms are as follows:

$$\frac{d\pi}{dk} = \frac{d\overline{\pi}}{dk} + \frac{v\left[(b+r)^2t - brv\right]}{4\left(b^2-r^2\right)^2} - \frac{\left(4b^3 + 8b^2r + 2br^2 + r^3\right)t^2}{4(b-r)^2(2b+r)^3} = 0, \tag{30}$$

$$\frac{d\Pi}{dK} = \frac{d\overline{\Pi}}{dK} + \frac{v\left[2brv - (b+r)^2t\right]}{4\left(b^2-r^2\right)^2} + \frac{b\left(b^2 + br + r^2\right)t^2}{(b-r)^2(2b+r)^3} = 0. \tag{31}$$

The second-order and the stability conditions are assumed to be satisfied. By solving Eqs. (30) and (31) simultaneously, we derive the optimal product R&D investments, k and K, under unilateral price undertaking actions. By evaluating Eqs. (30) and (31) at the R&D level under free trade ($k = \overline{k}, K = \overline{K}$), we can derive that if $0 < v \leq \overline{\delta}$,

$$\left.\frac{d\pi}{dk}\right|_{k=\overline{k},K=\overline{K}} = \frac{v\left[(b+\overline{r})^2t - b\overline{r}v\right]}{4\left(b^2-\overline{r}^2\right)^2} - \frac{\left(4b^3 + 8b^2\overline{r} + 2b\overline{r}^2 + \overline{r}^3\right)t^2}{4(b-\overline{r})^2(2b+\overline{r})^3} < 0, \tag{32}$$

$$\left.\frac{d\Pi}{dK}\right|_{k=\overline{k},K=\overline{K}} = \frac{v\left[2b\overline{r}v - (b+\overline{r})^2t\right]}{4\left(b^2-\overline{r}^2\right)^2} + \frac{b\left(b^2 + b\overline{r} + \overline{r}^2\right)t^2}{(b-\overline{r})^2(2b+\overline{r})^3} > 0. \tag{33}$$

It follows that firm H will invest less, while firm F will invest more, in product R&D under a unilateral price undertaking policy than under free trade. While this result is similar to that in Gao and Miyagiwa (2005), the causes are, however, very different. In their process R&D model, the ad valorem trade cost plays a very important role and the R&D incentives of the firms are mainly affected by the

[9] The detailed derivations of the equilibrium prices are presented in Appendix D.

nonlinear cost saving effect. Price undertaking policies have no effect in their model if the trade cost is a specific one. In this paper, we show that price undertaking policies are effective in terms of affecting the two firms even with a constant trade cost. This is because the dumping margin changes with product differentiation, and thus price undertaking policies alter the two firms' incentives in choosing their optimal product R&D levels. It is also worth noting that Miyagiwa and Ohno (1999) show that temporary safeguard protection can increase protected firm's R&D if the commitment to dismantle protection by policymakers is credible, but may reduce protected firm's R&D if they believe policymakers will extend protection. Namely, our result is in contrast to (line with) Miyagiwa and Ohno (1999) if the price undertaking policy is viewed by petitioners as temporary (a form of protection that can be extended for many years through sunset reviews).[10]

In addition, by making use of Eqs. (32) and (33), we obtain

$$\left(\frac{d\pi}{dk}+\frac{d\Pi}{dK}\right)\Big|_{k=\overline{k},K=\overline{K}}=-\frac{\overline{r}\left[-b(2b+\overline{r})^3v^2+(b+\overline{r})^2\left(4b^2-2b\overline{r}+\overline{r}^2\right)t^2\right]}{4\left(b^2-\overline{r}^2\right)^2(2b+\overline{r})^3}<0,$$

which implies that $k+K<\overline{k}+\overline{K}$ for any $v\in[0,\overline{\delta}]$. That is to say, the total product R&D under a unilateral price undertaking policy is definitely lower than that under free trade. This result is interesting and has never been documented in the literature. We present this result in the form of the following proposition:

Proposition 5. *Suppose that the domestic government unilaterally implements anti-dumping protection against the foreign firm. The foreign firm will engage in more product R&D but the domestic firm will engage in less. Moreover, the total product R&D investment will be less than that under free trade.*

The intuition behind Proposition 5 is as follows. From Proposition 1, the dumping margin decreases as the products become more differentiated. Thus, the foreign (home) firm has more (less) of an incentive to engage in product R&D to decrease (increase) the dumping margin. The R&D-stimulating effect of the foreign firm is dominated by the R&D-stifling effect of the home firm owing to the quadratic R&D cost function, resulting in lower overall R&D.

5. Conclusion

This paper aims to explore the effects of price undertaking policies on firms' product R&D investments. A duopolistic intra-industry model with differentiated products is employed. We show that the dumping margin is negatively related to product differentiation. Thus, the firms do have different incentives to invest in product R&D with and without price undertaking policies. Under bilateral anti-dumping actions, the firms will increase or decrease their total product R&D, depending on the tolerable dumping margin set by the governments. This finding is different from that in Gao and Miyagiwa (2005) in which the total cost-reducing R&D is increased by bilateral anti-dumping actions. By contrast, if only one government implements a price undertaking policy, the firm subject to the anti-dumping action will engage in more product R&D, but the protected firm will engage in less. This finding is similar to that in Gao and Miyagiwa (2005), although the causes are very different. Their findings are sensitive to the setup of the trade cost, whereas ours are not. Besides, we have also found that the aggregate R&D definitely decreases under unilateral anti-dumping actions, a finding which has never been corroborated in the literature.

In this paper, we have assumed that there is only one firm in each country, and that the firms can only carry out product R&D while the governments implement price undertaking actions. For future studies, one could consider cases in which anti-dumping duties are imposed or in which the firms are able to undertake both product and process R&D. This paper can also be extended to the case with an endogenous market structure. It is hoped that this paper can shed light on this line of research and stimulate further studies.

Acknowledgments

The authors thank an anonymous referee, the Editor, Hong Hwang, Chin-Sheng Chen, Pei-Cyuan Shih, Ray-Yun Chang, and the participants at the international trade workshop of National Taiwan University and the 89th Western Economic Association International Annual Conference for their helpful comments and insightful suggestions. They also gratefully acknowledge the financial support from the Ministry of Science and Technology of Taiwan. The usual disclaimer applies.

[10] We are indebted to a referee for suggesting this comparison.

Appendix A

This appendix is provided to show the equilibrium prices under a free trade regime. Given the linear demand functions, by solving Eqs. (5) and (7) ((6) and (8)) simultaneously, we can derive the equilibrium prices in country H (F) under free trade as follows:

$$\overline{p} = \frac{a(b-r)}{2b-r} + \frac{b[2bc + r(c*+t)]}{4b^2-r^2}, \overline{P} = \frac{a(b-r)}{2b-r} + \frac{b[rc + 2b(c*+t)]}{4b^2-r^2};$$
$$\overline{p}* = \frac{a(b-r)}{2b-r} + \frac{b[rc*+2b(c+t)]}{4b^2-r^2}, \overline{P}* = \frac{a(b-r)}{2b-r} + \frac{b[2bc*+r(c+t)]}{4b^2-r^2}.$$

Appendix B

This appendix shows the equilibrium prices under a bilateral anti-dumping policy regime and their relationship with the respective prices under free trade.

Given the linear demand functions, by routine calculus, we can derive the equilibrium prices in the second-stage game under the bilateral price undertaking policy as follows:

$$p = \frac{a(b-r)}{2b-r} + \frac{b(2bc + rc*)}{4b^2-r^2} - \frac{(b-r)t}{2(2b-r)} + \frac{v*}{2},$$
$$p* = \frac{a(b-r)}{2b-r} + \frac{b(2bc + rc*)}{4b^2-r^2} + \frac{(3b-r)t}{2(2b-r)} - \frac{v*}{2},$$
$$P = \frac{a(b-r)}{2b-r} + \frac{b(rc + 2bc*)}{4b^2-r^2} + \frac{(3b-r)t}{2(2b-r)} - \frac{v}{2},$$
$$P* = \frac{a(b-r)}{2b-r} + \frac{b(rc + 2bc*)}{4b^2-r^2} - \frac{(b-r)t}{2(2b-r)} + \frac{v}{2},$$
$$\lambda = \frac{(b+r)t-(rv + 2bv*)}{2(b-r)(b+r)}, \lambda* = \frac{(b+r)t-(2bv + rv*)}{2(b-r)(b+r)}.$$

By comparing the equilibrium prices with those in Appendix A, it is straightforward to show that:

$$p = \overline{p} - \frac{1}{2}\left[\frac{(b+r)t}{(2b+r)} - v*\right], p* = \overline{p}* + \frac{1}{2}\left[\frac{(b+r)t}{(2b+r)} - v*\right],$$
$$P = \overline{P} + \frac{1}{2}\left[\frac{(b+r)t}{(2b+r)} - v\right], P* = \overline{P}* - \frac{1}{2}\left[\frac{(b+r)t}{(2b+r)} - v\right].$$

Appendix C

This appendix shows the comparative statics of v and v^* on k and K.

Totally differentiating Eqs. (23) and (24) yields:

$$\frac{dk}{dv} = \frac{1}{D}\left[-\frac{d^2\pi}{dkdv}\frac{d^2\Pi}{dK^2} + \frac{d^2\Pi}{dKdv}\frac{d^2\pi}{dkdK}\right] > 0,$$
$$\frac{dK}{dv} = \frac{1}{D}\left[-\frac{d^2\Pi}{dKdv}\frac{d^2\pi}{dk^2} + \frac{d^2\pi}{dkdv}\frac{d^2\Pi}{dKdk}\right] < 0,$$
$$\frac{dk}{dv*} = \frac{1}{D}\left[-\frac{d^2\pi}{dkdv*}\frac{d^2\Pi}{dK^2} + \frac{d^2\Pi}{dKdv*}\frac{d^2\pi}{dkdK}\right] < 0,$$
$$\frac{dK}{dv*} = \frac{1}{D}\left[-\frac{d^2\Pi}{dKdv*}\frac{d^2\pi}{dk^2} + \frac{d^2\pi}{dkdv*}\frac{d^2\Pi}{dKdk}\right] > 0,$$

where

$$D \equiv \frac{d^2\pi}{dk^2}\frac{d^2\Pi}{dK^2} - \frac{d^2\pi}{dkdK}\frac{d^2\Pi}{dKdk} > 0,$$
$$\frac{d^2\pi}{dkdv} = \frac{\left(b^2+r^2\right)v*}{2\left(b^2-r^2\right)^2} \geq 0,$$
$$\frac{d^2\pi}{dkdv*} = \frac{-(b+r)^2t+\left(b^2+r^2\right)v+4brv*}{2\left(b^2-r^2\right)^2} < 0,$$
$$\frac{d^2\Pi}{dKdv} = \frac{-(b+r)^2t+4brv+\left(b^2+r^2\right)v*}{2\left(b^2-r^2\right)^2} < 0,$$
$$\frac{d^2\Pi}{dKdv*} = \frac{\left(b^2+r^2\right)v}{2\left(b^2-r^2\right)^2} \geq 0.$$

Moreover, from the above comparative statics, it is derivable that:

$$\frac{d(k+K)}{dv} = \frac{1}{D}\left[\frac{d^2\pi}{dkdv}f''(K) + \frac{d^2\Pi}{dKdv}f''(k)\right] = \frac{f''}{D}\left[\frac{-(b+r)^2t+4brv+2\left(b^2+r^2\right)v*}{2\left(b^2-r^2\right)^2}\right],$$
$$\frac{d(k+K)}{dv*} = \frac{1}{D}\left[\frac{d^2\pi}{dkdv*}f'(K) + \frac{d^2\Pi}{dKdv*}f'(k)\right] = \frac{f''}{D}\left[\frac{-(b+r)^2t+4brv*+2\left(b^2+r^2\right)v}{2\left(b^2-r^2\right)^2}\right].$$

Appendix D

This appendix derives the equilibrium prices under the regime characterized by a unilateral anti-dumping policy.

Under the linear demand functions, by routine calculus, we can derive the equilibrium prices in the second-stage game under the unilateral price undertaking policy as follows:

$$p = \frac{a(b-r)}{2b-r} + \frac{b(2bc+rc*)}{4b^2-r^2} - \frac{(3b-r)rt}{4b(2b-r)} - \frac{rv}{4b},$$
$$p* = \frac{a(b-r)}{2b-r} + \frac{b(2bc+rc*)}{4b^2-r^2} + \frac{\left(4b^2-3br+r^2\right)t}{4b(2b-r)} + \frac{rv}{4b},$$
$$P = \frac{a(b-r)}{2b-r} + \frac{b(rc+2bc*)}{4b^2-r^2} + \frac{(3b-r)t}{2(2b-r)} - \frac{v}{2},$$
$$P* = \frac{a(b-r)}{2b-r} + \frac{b(rc+2bc*)}{4b^2-r^2} - \frac{(b-r)t}{2(2b-r)} + \frac{v}{2},$$
$$\lambda* = \frac{(2b-r)[(b+r)t-(2b+r)v)]}{4b(b-r)(b+r)}.$$

By comparing the equilibrium prices to those in Appendix A, it is straightforward to show that:

$$p = \overline{p} - \frac{r}{4b}\left[v - \frac{(b+r)t}{(2b+r)}\right], p* = \overline{p}* + \frac{r}{4b}\left[v - \frac{(b+r)t}{(2b+r)}\right],$$
$$P = \overline{P} + \frac{1}{2}\left[\frac{(b+r)t}{(2b+r)} - v\right], P* = \overline{P}* - \frac{1}{2}\left[\frac{(b+r)t}{(2b+r)} - v\right].$$

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Please cite this article as: Kao, K.-F., & Peng, C.-H., Anti-dumping protection, price undertaking and product innovation, *International Review of Economics and Finance* (2015), http://dx.doi.org/10.1016/j.iref.2015.09.006

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Please cite this article as: Kao, K.-F., & Peng, C.-H., Anti-dumping protection, price undertaking and product innovation, *International Review of Economics and Finance* (2015), http://dx.doi.org/10.1016/j.iref.2015.09.006