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Technology Adoption under Price Undertakings*

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Abstract

Economists most often analyse the effects of protectionist or antidumping policies in the context of tariffs or voluntary export restraints - the latter are very similar to quotas in fact. Antidumping policies in the European Union however make frequent use of price undertakings. Whereas the effects of tariff and quota protection on technology adoption have been demonstrated by Miyagiwa and Ohno (1995), no such analysis has been carried out for price undertakings. In contrast to previous analysis, this article shows that adoption of new technologies is always delayed under a regime of price undertakings, as compared to the case of free trade, and that this doesn't depend on whether protection is temporary or permanent. Thus, our results challenge some of the conclusions of Miyagiwa and Ohno (1995) and put further doubt on the infant-industry argument for protection. We further analyse the sensitivity of the timing of technology adoption to the instrument of protection and formulate policy recommendations on the basis of this analysis.

- **JEL-Classification:** F10, F13, O33
- **Key Words:** Trade protection, Antidumping, Technology adoption, Price Undertaking
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1 Introduction

Antidumping policies have frequently been accused of being outright protectionist (Stegemann, 1991; Blonigen and Prusa, 2001; Hoekman and Kostecki, 2001). Even though such safeguard clauses - usually part of free trade agreements e.g. General Agreements on Tariffs and Trade (GATT) - could in a limited number of cases be justified to account for *unfair* trade practices e.g. predatory pricing, ‘beggar-thy-neighbour’ or ‘strategic’ trade policies¹ (Niels, 2000), antidumping clauses have most frequently been used as an excuse for protection.

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 can consist of the price in the domestic market, the price charged in other export markets or else an estimate of the total average cost of the good. However, such a situation of international price discrimination might arise for many reasons, and not as much for unfair trade practices (like predation) as put forward in the argumentation above². Higher prices in the domestic market might for instance be due to a lack of competition in the domestic market or to a lower demand elasticity. Alternatively, a domestic market might be completely non-existing e.g. when production facilities are entirely confined to exporting production. Using total average costs as a benchmark for determining the normal value might also be inappropriate, e.g. in a case of increasing returns to scale³. Clearly, a simple comparison between domestic and export prices cannot make a convincing case for predatory dumping. Consequently, antidumping measures that have been adopted in response to such price differentials might not be justified on the basis of unfair trade practices - and hence, they might not be justified altogether.

Given the problems with distinguishing dumping that arises from unfair trade practices from low-price imports that are due to genuine competitive advantage and given the arbitrariness of the antidumping law itself (Niels, 2000) antidumping legislation has become an escape clause to call for protection whenever import competing industries are suddenly injured by cheap

¹Strategic trade policies are often paralleled by active industrial policies or lax competition policies which cannot (yet) be regulated through WTO.

²As an illustration, the US Antidumping Act of 1916 stipulates predation as the only standard for allowing antidumping protection, but is rarely invoked. Import competing sectors usually refer to other statutes, such as the Tariff Act of 1930, to call for protection (Hoekman and Kostecki, 2001).

³In a case of constant returns to scale, total average and marginal costs are equal and constant. However, with increasing returns, total average costs are higher than marginal costs and therefore, it is more likely to find the constructed price for the domestic market to exceed the price charged in the export market.

imports and loss of market share⁴. In effect, European Union legislation is explicit in recognising the factor ‘injury’, i.e. it only accepts a dumping complaint provided dumping also inflicts injury to the European industry⁵. Case-study evidence in the EU has shown that the Commission’s decision on the presence of injury is importantly related to the level of price-undercutting (Vandenbussche 1995,1996), even though injury might be much less than the price differential suggests e.g. due to other product characteristics. This, of course, only enlarges the scope for protectionism.

Even though antidumping filings are now widely recognised as being a tool for protecting industries that are injured by low-cost imports or for protecting industries that are struggling to restructure, they nevertheless have surged in recent years (Blonigen and Prusa, 2001; Zanardi, 2004), as is shown in Figure (1). From Figure (1) one can clearly see the upward trend in the total number of initiated antidumping investigations, reflecting the increasing importance of antidumping action⁶. Some authors argue that antidumping has in fact become the most important instrument of trade policy in many countries (Niels, 2000). Remarkably, most of the increase comes from a surge in the amount of cases initiated by developing countries. The so-called ‘traditional’ users of antidumping - the EU, Canada, Australia, New Zealand, the US and also South Africa - report a stable to decreasing number of antidumping investigations over time. These countries make up the difference between the total number of investigations and those initiated by developing countries in Figure (1). The increasing antidumping activity of less-developed countries is striking, because it challenges the traditional view that it is mainly rich countries that protect their markets against cheap labour-intensive imports. On the other hand, this increase parallels the increasing number of countries joining the WTO and liberalising trade. In this respect, antidumping regula-

⁴Within the rules of the WTO, there is also the option to invoke safeguard tariffs as opposed to antidumping duties. Safeguard protection however requires the affected exporters to be compensated or else, they reserve the right to retaliate if no agreement on compensation is reached. The relatively stringent conditions for obtaining safeguard protection (Article XIX) reflect the fact that such protection is seen to violate earlier tariff commitments, whereas this is not the case for cases under antidumping (Hoekman and Kostecki, 2001, p.311). Consequently, safeguard tariffs have not frequently been used in the past.

⁵Next to the presence of dumping and injury, EU legislation also stipulates that the antidumping measure should only be taken if it were in the interest of the entire Community (EU regulation 384/96). For a discussion of EU anti-dumping legislation, see Vandenbussche (1995,1996). In US legislation, ‘injury’ is only very vaguely defined (Hoekman and Kostecki, 2001).

⁶One has to note also that the number of cases should be weighted by the according trade volumes of the countries involved to get a more accurate picture of the seriousness of antidumping action (Zanardi, 2004).

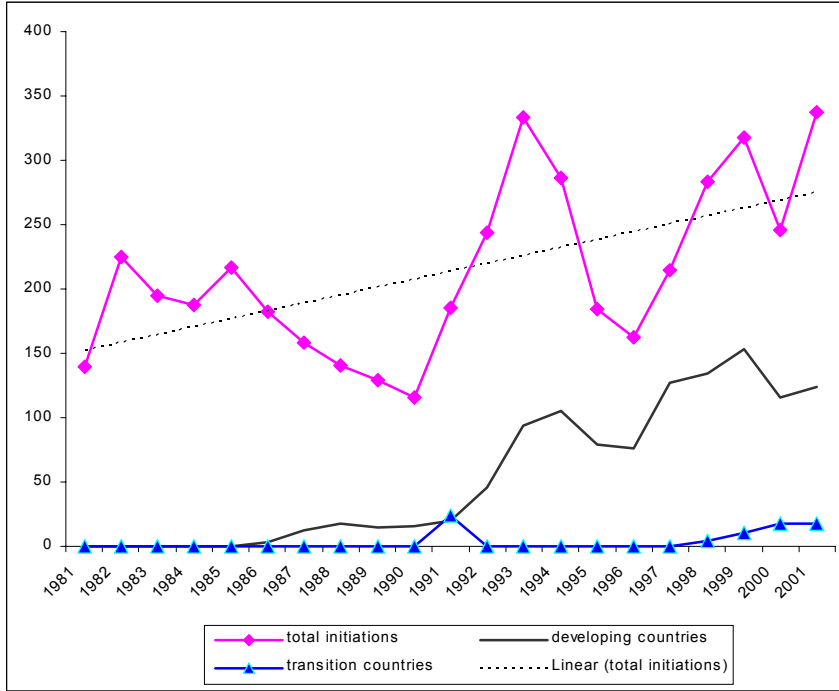


Figure 1: Antidumping initiations, 1981-2001 (Source: Zanardi, 2004)

tions are sometimes regarded as the necessary counterpart to free trade, since they help to achieve continued trade liberalisation. I.e. in the absence of antidumping clauses, many countries would not be willing to commit to free trade agreements. Protectionism would then be totally left at the discretion of politicians, which - it can be argued - is an even worse outcome. Hence, the increasing use of antidumping practice should perhaps not be considered that alarming after all.

In any case, this sharp increase of antidumping filings and use of antidumping law points to the inherent difficulty for countries to commit to free trade and to resist protectionist pressures when its domestic industries are not all on the winning side of the exchange⁷. Then, the argument goes, temporary protection in the form of antidumping measures could give an ailing industry the necessary time to invest in order to restore its competitiveness. Once competitiveness is restored, it is argued, both countries could resume to free trade.

The validity of this popular argument has been fiercely contested in the

⁷Given that free trade might benefit other industries, the inherent difficulty is actually one of redistribution. For a discussion, Acemoglu and Robinson (2001).

literature and in some respects goes back to the infant-industry argument (Corden, 1974). First and foremost however, there is a problem with the credibility of temporary protection, as has been argued by Matsuyama (1990). Once protection is in place, it is rational for an industry to under-invest in cost-reducing technology - even when investment-contingent subsidies are in place (Tornell, 1991). Along the same line, Miyagiwa and Ohno (1995) show that temporary protection delays the adoption of new technologies and cannot empower domestic industries in (re)gaining competitiveness quicker⁸. Finally, we have learnt from political economy analysis that the presence of opportunities for protection might induce rent-seeking behaviour or it may serve as a tool for preserving political support. In other words, there is plenty of government failure as well (Krueger, 1996).

In this article we show that the adoption of new technologies is also delayed under a different tool of protection, namely price undertakings. In contrast to Miyagiwa and Ohno (1995) who study the effects of tariffs and quotas, we look at the case of price undertakings. Whereas duties are like tariffs, price undertakings are different protectionist tools. They are in fact voluntary price increases whereby the foreign exporter agrees to charge a price that is at least as high as the domestic producers' price.

We analyse the case of price undertakings because, to an important extent, European antidumping decisions finalise with accepting price undertakings from foreign producers, as opposed to levying duties. This holds especially for antidumping filings against Central and Eastern European Countries with whom the EU has signed Europe Agreements. As agreed on the Essen Summit in 1994, these Agreements grant a preferential role for price undertakings in the case a trade dispute between the EU and its future member states should arise (see e.g. Annex IV to the Conclusions of the Essen European Council 1994; Chapter IV, Article 34 of the European Agreement with Bulgaria). However, accepting price undertakings from foreign exporters is also a more general practice in the EU. Evidence by Zanardi (2004) shows that, for the period 1981-2001, in 40.6% of the antidumping cases initiated by the EU price undertakings were accepted for at least some producers; only Japan accepted more undertakings, i.e. in about 60% of the cases, as well as Finland and Sweden before their EU membership (82% and 100% respectively).

Apart from their importance as instruments of temporary protection, it must also be stressed that price undertakings are different in nature, compared with duties. Whereas duties tend to 'punish' the dumping exporters by levying a tax on their exports, price undertakings are perceived to have a

⁸However, this result does not necessarily hold for permanent protection.

more ‘amicable’ character, since they allow the exporting firms to raise their prices and *ceteris paribus* collect higher profits on exported production⁹. The more friendly character of price undertakings hence explains also why they have become preferred when the EU settles trade disputes with its future member states.

Little is known however what the effects of price undertakings are on the protected firms. This paper tries to fill this gap by analysing the effectiveness of price undertakings in speeding up the adoption of new technologies in protected firms. As far as we know, this paper is the first to address this issue and can hence be seen as a novel contribution to the literature.

Our results suggest that technology adoption is always delayed when protection takes on the form of price undertakings. What is more, whether or not such price agreements are removed after the adoption of new technologies does not affect the timing of technology adoption in our model. In other words, permanent and temporary protection have identical effects under the case of price undertakings. Thus, our results go against the findings of Miyagiwa and Ohno (1995) who find a positive impact of permanent tariff protection on technology adoption. Hence, we demonstrate the fallacy of the argument that (antidumping) protection might buy time for domestic industries to update their technology and to help them in regaining competitiveness. We further compare the effects of price undertakings with those of tariffs and find that duties withhold the adoption of new technologies less than price undertakings do. For policy-makers, this implies that, from an efficiency-enhancing perspective, duties or free trade arrangements should bear preference over price undertakings.

This paper makes several contributions and is most directly related to the literature on protection and antidumping. Firstly, we extend the work of Miyagiwa and Ohno (1995) who use Fudenberg and Tirole’s (1985) representation of technology adoption in a dynamic context. Our work differs from that of Miyagiwa and Ohno in that we look at the effects of a different protectionist tool, namely price undertakings. To our knowledge, this is the first paper to address this issue. Crowley (2002) also looks at closing technology gaps, but her work compares safeguard tariffs with antidumping duties. Rodrik (1992) looks at a more general question whether trade liberalisation helps to close productivity gaps, but in his model he does not include any explicit instrument of protection. The latter is a central feature in our analysis.

⁹To the extent that firms operate under increasing returns to scale, however, lower production due to higher prices that now have to be met in the export market, can also raise average costs and reduce profit margins.

Secondly, since protection is often called for in the context of developing countries (see also Figure (1)), the paper is directly related to the debate on infant-industry protection. Recent contributions in this long tradition of debate include papers by Leahy and Neary (1999) and Miravete (2003) who stress the importance of commitment and time-consistency. However, also developed countries frequently call for temporary protection under the form of antidumping filings. Consequently, the current paper is also related to a growing body of literature that analyses the effects of antidumping protection.

An excellent survey on antidumping has been conducted by Blonigen and Prusa (1999). However, this strand of literature continues to analyse the effects of antidumping protection mostly in terms of antidumping duties (which are like tariffs), even though most of EU antidumping filings finalise with the acceptance by the EU of a price undertaking. Little work has been done to assess the different effects of price undertakings versus antidumping duties¹⁰. Some notable exceptions are Veugelers and Vandebussche (1999) who look at market structure and collusive behaviour of firms in the presence of tariffs and undertakings. Vandebussche and Wauthy (2001) show that price undertakings lead to low product quality in the protected industries. Vandebussche et al. (2001) distinguish between duties and undertakings when analysing the impact of unions on antidumping protection. Finally, Veugelers et al. (2003) present evidence of divestment following the expiry of price undertakings against Japanese firms. In this paper, we look at another issue, namely technology adoption under price undertakings. The relative neglect of more analysis might be explained by the fact that price undertakings are officially only applied by the European Union (EU) (EEC Regulation no. 2423/88) and Australia. Case study evidence for the US however shows that in practice similar deals are struck between US producers and importers on an informal basis (Hoekman and Kostecki, 2001). Informal price arrangements might in fact explain why so many petitions are withdrawn after an initial investigation is launched (Hoekman and Kostecki, 2001). The study by Zanardi (2004) also shows that countries like Japan and South Korea make frequent use of undertakings. This paper explicitly acknowledges the importance of price undertakings and their potentially different impact on technology adoption, as compared to duties or tariffs.

Another contribution we make is that we analyse the effects of antidumping protection in a dynamic framework. Existing work mostly studies the effects of antidumping protection in a static framework. We examine the

¹⁰This is in sharp contrast to the extensive body of literature that analyses the different impacts of tariffs versus quotas (Bhagwati, 1969).

adoption of technology in continuous time.

Finally, our work is related to the literature on the credibility of temporary protection. Matsuyama (1990) focuses on the process by which temporary protection might become permanent. Tornell (1991) demonstrates that the time-consistency problem with temporary protection persists even when investment-contingent subsidies are introduced. Brainard and Verdier (1994, 1997) attribute the persistence of protection in declining industries to powerful lobbies. By lobbying for protection, declining industries fail to adjust sufficiently. Therefore, subsequent protection levels are also high. In other words, once policy makers have given in to initial protection, protection will persist. Acemoglu and Robinson (2001) explicitly relate group size to political influence. By lobbying, industries not only receive protection, but also preserve their group size which will ensure them of future political influence. These papers all deal with the time-consistency problem that politicians face and how this might result in inefficient policies¹¹. In this paper, rather than focusing on the time-consistency problem of protection, we simply compare cases of temporary and permanent protection without explicitly modelling the relation between the two.

The paper is structured as follows. Section II presents the model and its solutions. In Section III we discuss the results. A final Section concludes.

2 The Model

2.1 Set-up

The model we use is a modified version of Miyagiwa and Ohno (1995). We consider time, t , as a continuous variable $t \in [0; +\infty[$ and a cost-reducing technology, Θ , that has become available sometime in the past, because of ongoing research and development. This innovative technology is commonly known, but its cost of adoption - a one-time fixed sum $k(t)$ - decreases over time, i.e. $k'(t) < 0$ ¹². We assume that the rate of decline of the adoption cost decreases over time, i.e. $k''(t) > 0$. The adoption cost is thus a downward sloping, convex function. We further assume that by $t = 0$ the firm in the foreign country has adopted this new technology Θ and hence enjoys a lower marginal cost of production c_Θ . The firm in the home country still uses an old technology ϑ which results in a higher marginal cost $c_\vartheta > c_\Theta$. The home

¹¹A similar story could be told for subsidies. In fact, then a situation of soft budget constraints arises (Kornai, 1980).

¹²E.g. because of growing experience with implementing the new technology or because of other innovating technologies that become available over time.

firm thus has an incentive to adopt the new technology as soon as possible to be able to produce at lower marginal costs. However, there is a trade-off, since postponing the technology adoption makes its adoption less costly. So the firm will balance the gains from early adoption against higher costs of early adoption and will choose the timing accordingly.

Now, given that protection will affect profits, the profitability of early technology adoption might be altered and hence the timing, as compared to the case of free trade. This comparison will be our central concern in what follows.

Now, assume that both firms produce a differentiated good and compete in the home market. Competition is thus characterised by a non-cooperative price-setting Bertrand game in every period¹³.

Demand for the home and foreign product, q^h and q^f respectively, are given by

$$\begin{aligned} q^h &= 1 - p^h + \gamma p^f \\ q^f &= 1 - p^f + \gamma p^h \end{aligned}$$

where p^h and p^f are the price of the home and foreign product respectively. The parameter γ indicates the degree of substitutability between the two goods and is assumed to be $0 \leq \gamma < 1$.

Denote the time at which the new technology is adopted with t^j . Then, before the new technology is adopted, the home firm earns the following profit in every period $t < t^j$

$$\pi_{\vartheta}^h = (p^h - c_{\vartheta})q^h$$

where the subscript refers to the adopted technology. As laid out above, at the time of adoption of new technology t^j , a one-time fixed cost $k(t^j)$ is incurred. After that, i.e. $t > t^j$, period t -profits equal

$$\pi_{\Theta}^h = (p^h - c_{\Theta})q_t^h$$

The foreign firm's profits at any time t equal

$$\pi_{\Theta}^f = (p^f - c_{\Theta})q^f$$

Without loss of generality, we can normalise

$$c_{\Theta} = 0$$

¹³Since with price undertakings, firms have to mimic their competitor's price, a Bertrand game is more intuitive than a Cournot game. Choosing for the more general specification of differentiated products also has the advantage of avoiding discontinuities in the demand expressions.

and simplify notation by writing c_ϑ now as $c > 0$.

We now turn to the solution under free trade and then compare this with the case of protection.

2.2 Free trade

Under free trade, the outcome of the Bertrand game at $t < t^{FT}$, i.e. before the adoption date under free trade, is characterised by the solution to the following problem

$$\begin{aligned}\max_{p^h} \pi_{FT,\vartheta}^h &= (p^h - c)q^h \\ \max_{p^f} \pi_{FT,\Theta}^f &= p^f q^f\end{aligned}\tag{1}$$

which yields the following reaction functions

$$p^h(p^f) = \frac{1 + \gamma p^f + c}{2}\tag{2}$$

$$p^f(p^h) = \frac{1 + \gamma p^h}{2}\tag{3}$$

and equilibrium prices

$$\begin{aligned}p_{FT,\vartheta}^h &= \frac{2 + 2c + \gamma}{4 - \gamma^2} \\ p_{FT,\Theta}^f &= \frac{2 + \gamma + c\gamma}{4 - \gamma^2}\end{aligned}$$

It is easy to see that in equilibrium

$$p_{FT,\vartheta}^h > p_{FT,\Theta}^f$$

since this holds $\forall \gamma < 2$, which is satisfied by assumption that $0 \leq \gamma < 1$. Similarly, one can easily show that with equilibrium profits

$$\begin{aligned}\pi_{FT,\vartheta}^h &= \frac{(2 + \gamma - 2c + \gamma^2 c)^2}{(4 - \gamma^2)^2} \\ \pi_{FT,\Theta}^f &= \frac{(2 + \gamma + \gamma c)^2}{(4 - \gamma^2)^2}\end{aligned}$$

and $0 \leq \gamma < 2$ the following holds

$$\pi_{FT,\vartheta}^h < \pi_{FT,\Theta}^f$$

since $\gamma^2 - \gamma - 2 < 0 \iff \gamma \in]-1; 2[$.

The characterisation of the equilibrium at $t > t^{FT}$ is easily derived by noticing that at $t > t^{FT}$ the marginal costs of both firms are equal as both have adopted the new technology. Therefore, the equilibrium is perfectly symmetric with equilibrium prices

$$p_{FT,\Theta}^h = p_{FT,\Theta}^f = \frac{1}{2 - \gamma}$$

and equilibrium profits

$$\pi_{FT,\Theta}^h = \pi_{FT,\Theta}^f = \frac{1}{(4 - \gamma^2)^2}$$

Now, the optimal timing of technology adoption under the case of free trade, t^{FT} , is chosen by maximising the following inter-temporal profit function

$$\max_t \Gamma = \int_0^{t^{FT}} e^{-rt} \pi_{FT,\vartheta}^h dt + \int_{t^{FT}}^{+\infty} e^{-rt} \pi_{FT,\Theta}^h dt - e^{-rt^{FT}} k(t^{FT}) \quad (4)$$

where r is the interest rate. As shown in the Appendix, a solution t^{FT} is given by t that satisfies¹⁴

$$rk(t) - k'(t) = \pi_{FT,\Theta}^h - \pi_{FT,\vartheta}^h \quad (5)$$

which equates marginal costs to marginal benefits of technology adoption at time t . This equation is easy to interpret. The left hand side represents the marginal benefit of waiting one period: the home firm benefits from investing the money in an alternative use and earns $rk(t)$ and saves on the cost of the technology adoption by waiting one more period $k'(t)$. The right hand side of the equation gives the marginal benefit of adopting the new technology now: profits increase with the difference $\pi_{FT,\Theta}^h - \pi_{FT,\vartheta}^h$. In other words, equation (5) equates the marginal value of technology adoption with the marginal (opportunity) cost of technology adoption.

The optimal time of technology adoption t^{FT} is found at the intersection of costs and benefits and is illustrated in Figure (2). Given that we assume $k'(t) < 0$ and $k''(t) > 0$, the marginal cost of adopting technology at time t , as derived from Equation (4) is also decreasing over time, i.e.

$$\frac{d}{dt}(rk(t) - k'(t)) < 0$$

¹⁴Miyagiwa and Ohno (1995) also show that the assumptions $k'(t) < 0$ and $k''(t) \geq 0$ also guarantee that the second-order condition for a maximum is satisfied and that the solution is an interior solution.

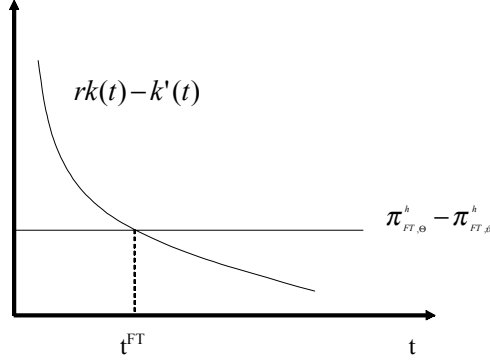


Figure 2: Technology Adoption

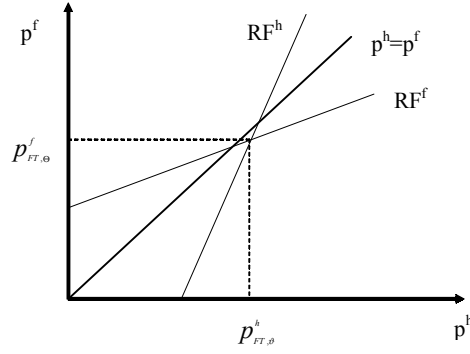


Figure 3: Price Undertakings compared to Free Trade

The benefit of adopting technology is independent of time and can be represented by a horizontal line. If the marginal benefit of adoption increases, the horizontal curve in Figure (2) will shift upwards and this results in earlier technology adoption.

To see whether price undertakings change the timing of technology adoption, we have to compare the marginal benefit of technology adoption with and without protection. This is what we will do in the following Section.

2.3 Price undertakings

We start by looking at the effect of a temporary price undertaking. The temporary character of protection is reflected in the fact that we assume that the undertaking is removed after new technology has been adopted.

We recognise that, from a legal point of view, antidumping measures are usually removed after a fixed period of time (e.g. 5 years in the EU) which is independent of whether the new technology has been introduced or not. However, we argue that the economic incentives to initiate new investigations or to ask for ‘expiry’ reviews remain present as long as the protected industry has failed to update its infrastructure. Therefore, we think that our approach to temporary protection is more representative of economic reality.

The effect of a price undertaking on competition can easily be demonstrated by looking at Figure (3). The reaction curve of the home firm remains as in Equation (2), whereas that of the foreign firm now coincides with the 45 degree line, since this firm has to equalise its price to that of the domestic producer. This way of modelling price undertakings is akin to the work of Veugelers and Vandenbussche (1999). I.e.

$$p^f(p^h) = p^h$$

Notice that the above reaction curve corresponds in fact to following a path of collusive pricing.

In the price undertaking equilibrium before technology adoption, prices are now

$$p_{U,\vartheta}^h = p_{U,\Theta}^f = \frac{1+c}{2-\gamma}$$

It is easy to see that this price is greater than the prices from the free trade equilibrium, i.e

$$\begin{aligned} p_{U,\vartheta}^h &> p_{FT,\vartheta}^h \\ p_{U,\Theta}^f &> p_{FT,\Theta}^f \end{aligned}$$

This can also be graphically verified by looking at Figure (3). The intersection of the 45 degree line with the reaction curve of the home firm increases equilibrium prices of both firms. Equilibrium profits are now

$$\begin{aligned} \pi_{U,\vartheta}^h &= \frac{(1-c+\gamma c)^2}{(2-\gamma)^2} \\ \pi_{U,\Theta}^f &= \frac{(1+c)(1-c+\gamma c)}{(2-\gamma)^2} \end{aligned}$$

After some calculations and rearranging, it can be shown that, before technology adoption takes place

$$\pi_{U,\vartheta}^h > \pi_{FT,\vartheta}^h$$

$$\pi_{U,\Theta}^f \begin{cases} > \pi_{FT,\Theta}^f & c \in]0; \frac{-\gamma^2(\gamma+2)}{\gamma^3+2\gamma^2-4}[\\ = \pi_{FT,\Theta}^f & c \in \{0, \frac{-\gamma^2(\gamma+2)}{\gamma^3+2\gamma^2-4}\} \\ < \pi_{FT,\Theta}^f & otherwise \end{cases}$$

Now after some time, it becomes optimal for the firm to adopt the new technology, because of the decreasing marginal adoption cost¹⁵. Whether this takes place earlier or later, compared to the case of free trade, is analysed below. First note that once the new technology has been introduced, the price undertaking is removed. Consequently, both firms produce at zero marginal costs, without any protective barriers, i.e. we are back to the free trade equilibrium after technology adoption:

$$\begin{aligned} p_{FT,\Theta}^h &= p_{FT,\Theta}^f = \frac{1}{2-\gamma} \\ \pi_{FT,\Theta}^h &= \pi_{FT,\Theta}^f = \frac{1}{(2-\gamma)^2} \end{aligned}$$

To see whether temporary protection alters the timing of technology adoption compared with the case of free trade, we compare

$$\pi_{FT,\Theta}^h - \pi_{FT,\vartheta}^h \stackrel{?}{>} \pi_{FT,\Theta}^h - \pi_{U,\vartheta}^h \quad (6)$$

If Equation (6) holds, the technology adoption is delayed under the price undertaking. Rewriting (6)

$$\pi_{U,\vartheta}^h \stackrel{?}{>} \pi_{FT,\vartheta}^h \iff \frac{(1-c+\gamma c)^2}{(2-\gamma)^2} > \frac{(2+\gamma-2c+\gamma^2 c)^2}{(4-\gamma^2)^2}$$

which holds for $0 \leq \gamma < 2$. This implies that temporary protection in the form of price-undertakings delays the adoption of new technologies, as compared to the situation of free trade. This is our first proposition.

Proposition 1 *Under temporary price undertakings, new technologies are adopted later as compared to a situation of free trade.*

The intuition behind the result of Proposition 1 is as follows. Since temporary protection increases the home firm's profits relative to those under

¹⁵In this respect, our model differs from the time-inconsistency literature of protection where it is never optimal for the firm to adopt new technologies or restructure such that protection will always continue infinitely.

free trade ($\pi_{U,\vartheta}^h > \pi_{FT,\vartheta}^h$), the relative gain from adopting new technology Θ and subsequently producing under free trade, remains limited. In a way, the protectionist option is ‘too’ attractive. On the other hand, the profit increase that can be realised under free trade by switching to newer technologies is much higher. Therefore, firms are willing to invest in such technologies when their marginal cost is still much higher. Consequently, free trade encourages earlier adoption as compared with the case of temporary price undertakings.

We now turn to a situation where the price undertaking remains in place even after new technologies have been adopted. This corresponds to a case of a ‘permanent’ price undertaking. A few remarks are in place. On the one hand, there is little economic rationale for having a permanent undertaking in place, since, with equal marginal costs, prices will be symmetric after the adoption of the technology. Therefore, no injury will be inflicted upon the domestic industry and hence there is no need for a price undertaking to be imposed. Moreover, from a purely legal point of view, antidumping protection has a limited duration (e.g. 5 years in the EU), as noted above. On the other hand, a ‘permanent’ price undertaking can also be interpreted as a situation where, after the technology is adopted by the home producer, the foreign firm continues to mimic the home producer’s price. I.e., its reaction curve remains the same as during the period of the price undertaking, i.e. $p^f(p^h) = p^h$ ¹⁶. Price undertakings might indeed be powerful tools to sustain collusive pricing nationally or internationally (Messerlin, 1990; Stegemann, 1991; Veugelers and Vandenbussche, 1999). Also, there remains a possibility to renew an antidumping investigation even after cost-reducing restructuring has taken place such that antidumping measures might become semi-permanent¹⁷. Hence, we rather refer to the analysis of a permanent price undertaking as a case where the foreign firm continues to meet its competitor’s price.

To infer conclusions about the timing of technology adoption, we now compare

$$\pi_{FT,\Theta}^h - \pi_{FT,\vartheta}^h \stackrel{?}{>} \pi_{U,\Theta}^h - \pi_{U,\vartheta}^h$$

The difference with (6), is that now, profits after technology adoption might still be affected by the fact that a certain price has to be met. However, with completely symmetric firms - i.e. if both firms have introduced the new

¹⁶During the period of the price undertaking, the foreign firm is already behaving collusively by mimicing the price of the home producer.

¹⁷However, it would become less obvious in this case to find injury in the domestic industry. However, antidumping regulations remain often arbitrary.

technology - the reaction curve of the home firm shifts to the left exactly to the point where the 45-degree line intersects with the free trade reaction curve of the foreign firm. Hence, $\pi_{U,\Theta}^h = \pi_{FT,\Theta}^h$ and the effect on the timing of technology adoption is analogous to the case of temporary protection. Proposition 2 summarises.

Proposition 2 *When foreign firms continue to mimic the price of their competitors after technology has been adopted by the latter, as would be the case with permanent price undertakings, the adoption of new technologies is delayed in exactly the same way as with temporary price undertakings.*

The intuition behind this result is analogous as before. Given that off-equilibrium prices cannot be sustained once both firms operate under the new technology, i.e. we exclude cooperative collusive behaviour, prices and profits are identical with a permanent price undertaking as they are under the case of free trade. Therefore, the relative profitability of shifting to the new technology is limited, and therefore, firms are only willing to undertake such investments when the cost of technology adoption has become sufficiently low. This results in later adoption as compared to the case of free trade.

This result differs from Miyagiwa and Ohno (1995) who find that, for tariffs and sufficiently restrictive quotas, permanent protection speeds up technology adoption, whereas temporary protection delays it.

2.4 Duties

In this section we compare the timing of technology adoption under price undertakings with that under tariffs. We first look at the case of temporary protection and analyse how the instrument of protection affects the timing of technology adoption.

Since both duties and undertakings are aimed at eliminating injury (Vandenbussche et al., 2001), the duty level is set equal to the pre-filing price difference (Vandenbussche, 1996)

$$\begin{aligned} t &= p_{FT,\vartheta}^h - p_{FT,\Theta}^h \\ &= c(2 - \gamma) \end{aligned}$$

With a duty, the expression for profits of the home firm remains unchanged as in (1). The foreign firm's profit is now written as

$$\pi_{D,\Theta}^f = (p^f - t)q^f$$

Firms' profits and prices in equilibrium are given below

$$\begin{aligned}
p_{D,\vartheta}^h &= \frac{2 + 2c + \gamma + t\gamma}{4 - \gamma^2} \\
p_{D,\Theta}^f &= \frac{2 + 2t + \gamma + c\gamma}{4 - \gamma^2} \\
\pi_{D,\vartheta}^h &= \frac{(2 + \gamma + t\gamma - 2c + \gamma^2 c)^2}{(4 - \gamma^2)^2} \\
\pi_{D,\vartheta}^f &= \frac{(2 + \gamma - 2t + \gamma c + \gamma^2 t)^2}{(4 - \gamma^2)^2}
\end{aligned}$$

Comparing the adoption dates when there is temporary protection in the form of duties and undertakings comes down to comparing

$$\begin{aligned}
\pi_{FT,\Theta}^h - \pi_{D,\vartheta}^h &\stackrel{?}{>} \pi_{FT,\Theta}^h - \pi_{U,\vartheta}^h \\
\pi_{U,\vartheta}^h &\stackrel{?}{>} \pi_{D,\vartheta}^h \\
\frac{(1 - c + c\gamma)^2}{(2 - \gamma)^2} &\stackrel{?}{>} \frac{(2 + \gamma + t\gamma - 2c + \gamma^2 c)^2}{(4 - \gamma^2)^2} \\
c &\stackrel{?}{>} t
\end{aligned}$$

Since the tariff is chosen $t \leq c(2 - \gamma)$ and $0 \leq \gamma < 1$ it immediately follows that $t < c$ is satisfied. This means that technology adoption occurs sooner under temporary tariff protection, as compared to the case of temporary price undertakings. This result is stated below in Proposition 3.

Proposition 3 *Under temporary protection, tariffs hinder the adoption of new technology less than price undertakings do.*

Again, the intuition behind the result is understood by noting that the home firm's profits are less protected by duties than by undertakings. Therefore, the profit increase that can be realised by switching technologies with duties is higher and domestic firms are willing to pay a higher marginal cost for this implementation. Consequently, adoption occurs earlier under temporary tariff protection, compared with price undertakings.

For the case of permanent protection, we derive by transitivity of the argument that adoption of technology occurs earlier under tariffs than under price agreements, since permanent tariff protection speeds up adoption (Miyagiwa and Ohno, 1995), whereas it is delayed compared to the case of free trade, under permanent price agreements, as can be seen from the analysis above.

A formal derivation can easily be carried out by checking that the following inequality holds for $0 < \gamma \leq 2$.

$$\pi_{D,\Theta}^h - \pi_{D,\vartheta}^h > \pi_{U,\Theta}^h - \pi_{U,\vartheta}^h$$

We summarise this in the following proposition.

Proposition 4 *Permanent tariff protection speeds up technology adoption, whereas permanent price agreements delay such investment.*

The intuition here is that permanent tariff protection secures higher market shares and profits for the domestic industry, before as well as after the new technology is introduced. This speeds up technology adoption instead of delaying it. Since we ignore possibilities of off-equilibrium collusive behaviour in this paper, no such gains can be realised under price undertakings. Therefore, the latter delay new investment.

3 Discussion

The above results not only put into question the validity of temporary protection as a means to speed up the technological catching-up process, they also point to the inefficiency of using price undertakings as a means of protection, as is frequently done in the European Union. If European bureaucrats were aiming at maximising efficiency and speeding up technology adoption in protected sectors, they should give clear preference to ‘less friendly’ tools like duties (or introduce free trade conditions). Since European antidumping law does not oblige policy-makers to accept price undertakings that are offered by exporters to the EU, it should be easy to realise such a shift in policy and to make more frequent use of duties instead of undertakings.

However, European antidumping law is far from designed as to maximise efficiency or the competitiveness of the domestic industry (as competition policy does). Currently, the only thing that antidumping law aims at is to achieve protection. In this respect, price undertakings are in fact even more effective in achieving protection than duties are. Price undertakings are not only ‘friendly’ measures for the exporters, also protected firms enjoy longer protection with undertakings. In other words, antidumping law, far from being a safeguard for predatory pricing, seems a very ‘efficient’ tool for achieving protection. Hence, one should seriously question the frequent practice of antidumping.

Some authors therefore argue to make antidumping law more ‘competition friendly’ and less arbitrary or to substitute antidumping law in free trade

agreements for common (supranational) competition practices. So far, the debate around this issue has not resided yet (see Niels (2000) for a good discussion). To date, only the members of the EU and Australia and New Zealand have exchanged their antidumping for a common competition law in their mutual trade relations (Hoekman, 1998). Also Chili and Canada have exchanged promises not to use their antidumping against each other (Niels, 2000). It remains a question however whether other countries will follow these examples. The crucial problem seems to lie with the fact that “competition law is not concerned with the fate of the *individual competitors*, but with *competition*. In the international trade context, however the fate of the individual, i.e. national competitors *does* matter” (Niels, 2000, p.478).

On the other side, since many price undertaking agreements were made especially with exporters from Central and Eastern Europe, the prospect of the abolition of such rules upon EU accession in 2004 could be an incentive for European industries to restructure and restore their price competitiveness with these countries¹⁸.

4 Conclusion

Price undertakings are important tools when considering antidumping protection, but very little theoretical analysis has been done to distinguish between effects from price undertakings and duties. This paper tries to fill up this gap by looking whether firms that are protected by price undertakings succeed in adopting cost-reducing technologies. This is indeed one of the most popular rationales for allowing temporary protection. We compare our results with earlier results for duties or tariffs by Miyagiwa and Ohno (1995). Whereas the picture for permanent protection is somewhat ambivalent and depends on the instrument of protection, we find that for the case of temporary protection price undertakings delay new technology adoption even more than duties do. Both cases of temporary protection are strictly dominated by the outcome under free trade however. Hence, this paper casts further doubt on the validity of the infant-industry argument and questions the frequent use of price undertakings in the European context.

This paper is only a first step in analysing the effects of price undertakings. Currently, we have addressed the aspect of the timing of technology adoption. However, a large research agenda is left to analyse the differential impact of duties and price undertakings. Some extensions of this work will

¹⁸It might be argued, however, that in this respect, it is most likely not firms in CEECs that produce with more advanced technologies.

consist of introducing collusion (in this model, firms interact many times!), unions, technology or R&D races ...

We further want to compare the adoption of technology by a monopolist with the case of an international duopoly to mimic the effect of trade liberalisation and import penetration (Rodrik, 1992). To account for the possibilities that liberalisation gives on the export side, we also want to analyse the effects of technology adoption in a reciprocal dumping model where liberalisation gives rise to both import penetration and export promotion (Krugman, 1984). Other options are introducing competition in the home country where firms race for technology adoption.

We further think of conducting a more comprehensive welfare analysis, instead of simply calculating the timing of technology adoption.

On the empirical side, very few (or no) authors that we know of have distinguished between duties and price undertakings. Consequently, a second step in this work consists of combining firm-level data with information on dumping outcomes and testing the above hypotheses. One possibility is to construct a counterfactual by a matching procedure, as is frequently done in the labour literature.

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Appendix:

To solve for

$$\max_t \Gamma = \int_0^{t^{FT}} e^{-rt} \pi_{FT,\vartheta}^h dt + \int_{t^{FT}}^{+\infty} e^{-rt} \pi_{FT,\Theta}^h dt - e^{-rt^{FT}} k(t^{FT})$$

we note that $\pi_{FT,\vartheta}^h$ and $\pi_{FT,\Theta}^h$ are independent from t . Therefore, we rewrite the integrals and the above expression as

$$\begin{aligned} \Gamma &= \pi_{FT,\vartheta}^h \left[\frac{e^{-rt}}{-r} \right]_0^{t^{FT}} + \pi_{FT,\Theta}^h \left[\frac{e^{-rt}}{-r} \right]_{t^{FT}}^{+\infty} - e^{-rt^{FT}} k(t^{FT}) \\ &= \pi_{FT,\vartheta}^h \left[\frac{e^{-rt^{FT}}}{-r} - \frac{1}{-r} \right] + \pi_{FT,\Theta}^h \left[0 - \frac{e^{-rt^{FT}}}{-r} \right] - e^{-rt^{FT}} k(t^{FT}) \end{aligned}$$

Regrouping the expressing yields

$$\Gamma = \frac{e^{-rt^{FT}}}{-r} [\pi_{FT,\vartheta}^h - \pi_{FT,\Theta}^h] + \pi_{FT,\vartheta}^h \frac{1}{r} - e^{-rt^{FT}} k(t^{FT})$$

Now, taking the first derivative of Γ with respect to t^{FT} yields

$$\Gamma' = e^{-rt^{FT}} [\pi_{FT,\vartheta}^h - \pi_{FT,\Theta}^h] - \left[e^{-rt^{FT}} k'(t^{FT}) + k(t) e^{-rt^{FT}} (-r) \right]$$

Extrema are found for t^{FT} that satisfy

$$\begin{aligned} \Gamma' &= 0 \\ \iff e^{-rt^{FT}} [\pi_{FT,\vartheta}^h - \pi_{FT,\Theta}^h] - e^{-rt^{FT}} [k'(t^{FT}) - rk(t^{FT})] &= 0 \\ \iff \pi_{FT,\vartheta}^h - \pi_{FT,\Theta}^h &= k'(t^{FT}) - rk(t^{FT}) \end{aligned}$$