

## How should “protection” be evaluated in Art. III GATT disputes ?

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### Abstract

This paper considers the economic analysis protection in Art. III GATT disputes. We first observe that the appropriate measure of protection and the level of protection that is acceptable have hardly been discussed in the case law and that panels tend to presume that a strong substitution between domestic and foreign products always lead to substantial protection. Next, we consider a stylised model of trade and find that the ability to raise price is a robust measure of protection and that protection falls significantly (for a given barrier) with the degree of product differentiation but also with the degree of rivalry. We also observe that the effects of non-tariff barriers on import values in ambiguous so that imports are not a robust measure of protection. Our findings suggest that the distinction drawn in the case law between “like” and “directly competitive and substitutable” products is not helpful. Finally, we suggest a method to evaluate protection in trade disputes which is inspired by the definition of the relevant market in antitrust.

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## 1. Introduction

The multilateral system, as well as a number of regional trading arrangements, have established legal norms with respect to non-tariff barriers to trade. Most of the economic literature dealing with non-tariff barriers (like standards and technical barriers) in international trade analyse the effects of these barriers ex ante on the equilibrium pattern of output and welfare across countries (see Baldwin and Venables (1995) for a survey). But, the consequences of the liberalisation associated with the observance of these norms can also be evaluated ex post. Despite obvious methodological difficulties<sup>1</sup>, a few studies have indeed attempted to undertake such exercise, notably in the context of the European internal market.

This paper considers the implementation of the legal norm rather than its aggregate consequences. As expected with any legal framework, norms give rise to disputes and litigation. Whether a particular technical standard or non-tariff barrier should be viewed as lawful is presumably not a matter that can be assessed purely on the basis of legal reasoning. To the extent that a legal norm is not solely based on formalistic requirements and relies on an assessment of the effects of disputed measures, economic analysis will be instrumental in its implementation. Hence, like antitrust, trade is presumably an area where legal reasoning and economic analysis should interact.

The first part of the paper considers the legal framework towards non-tariff barriers in the multilateral system. We focus on Art. III of the GATT which establishes the principle of National Treatment which requires WTO Members not to introduce internal measures that discriminate in favour of domestic products. This provision is the main legal norm against which non-tariff barriers have to be assessed. We review both the legal norm itself and some of the most influential case law. We first observe that if the language of Art. III would seem to call for an evaluation of the effects of disputed measures, the case law has sometimes consciously not relied on an assessment of effects and has thus neglected or avoided an economic evaluation. In other cases,

however, the usefulness of an economic approach is recognised. For those cases, the economic analysis which is proposed is still remarkably unstructured. This is partly because Art. III does not clarify how effects should be assessed. Art. III expresses concern about protection of domestic firms but it is not clear how protection should be measured and in particular whether the effects of a disputed instrument should be measured in terms of price, trade flows or rents for the domestic firms.

Some structure in the investigation still arises from the need to find a market as a reference. Indeed, the investigation has to determine which domestic products are "like" or "directly competitive and substitutable" with the imported item which is allegedly discriminated against.

The case law that we review still does not follow a systematic approach in the delineation of these products and the approach that is followed often suffers from important shortcomings. This case law also reveals that Panels have avoided making reference to a benchmark for the evaluation of protection. Yet, protection is a matter of degree and one cannot escape from the definition of what should be considered as an acceptable degree of protection.

Overall, this state of affairs is in stark contrast with antitrust investigations where objectives are reasonably clear and where experienced agencies follow a structured set of principles in their analysis. In particular, antitrust investigations often proceed by first delineating the relevant market according to explicit principles and few would dispute that a rigorous market definition greatly contributes to the clarity and quality of antitrust decisions.

The remainder of the paper then seeks to develop a framework to evaluate the effects of disputed measures. Section 3 develops a simple model of trade with differentiated products and considers alternative variables which can be used to measure the effects of barriers which raise the (marginal) cost of foreign firms. We conclude that the ability to raise price for domestic firms is a robust (unambiguous) measure of

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<sup>1</sup> It is necessary to establish a reasonable counterfactual describing what would have happened without

protection and that the extent to which foreign firms are forced to raise price is a robust measure of the harm imposed on foreign firms. In addition, these two measures are consistent with one another (to the extent that protection always implies harm to foreign firms and *vice-versa*). By contrast, the value of trade which could proxy both for protection and for the harm imposed on foreign firms does not appear to be a robust indicator. We also observe that the extent of protection, as measured by the ability to raise price for the domestic firms (for a given barrier), is determined both by the degree of substitution between domestic and foreign products *and* by the degree of competition between them. A strong similarity between domestic and foreign products will thus not be a sufficient condition for the former to obtain protection from a differential treatment. When competition is intense, domestic firms might simply not benefit from a differential treatment imposed on foreign firms.

In light of these findings, section 4 proposes a two step procedure to evaluate the effects of disputed measures. In the first step, a set of products will be found such that a hypothetical monopolist controlling the *domestic* market would be able to raise price by x % above the competitive level given the existence of the disputed measure. If it is found that no such market exists (because for instance demand substitution is large or foreign competition is strong despite the barrier), the complaint should be dismissed. If such a market can be found, the second step of the evaluation would be to consider competition in this (relevant) market. If it is found that competition is intense, the complaint should again be dismissed, as no significant effect will be expected. If competition is not intense (for instance when concentration and barriers to entry are high), the investigation should consider to what extent domestic prices would fall if the additional cost imposed on foreign firms by the disputed barriers would be removed.

## **2. Economic analysis in Art. III of GATT**

Art. III of the GATT is concerned with situations where domestic regulations including taxes are applied in such a way as to discriminate in favour of domestic firms. This is a general provision, which apply in a wide range of circumstances. We will first

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the legal norm against which actual observations can be assessed.

briefly discuss (section 2.1) its scope and in particular whether technical standards or health related standards could be assessed against the norm of Art. III. We will then (section 2.2) examine whether Art. III contains a test in terms of the effects of disputed barriers and how the case law has defined the set of products that are "like" or "directly competitive and substitutable" with the foreign product subject to the disputed measures. A few conclusions are offered in section 2.3.

### *2.1. Some remarks on the scope of Art. III*

Art. III expresses a clear norm against discrimination in favour of domestic firms that in principle covers all internal measures. Discrimination can still be justified by appealing to the provisions of Art. XX. The Technical Barriers to Trade (TBT) and Sanitary and Phyto-sanitary (SPS) Agreements also introduce additional commitments with respect to technical standards and sanitary (or Phyto-sanitary) standards. In essence, the TBT Agreement commits the WTO members to use international standards when possible and not to introduce national standards that favour domestic production. The agreement on Sanitary and Phyto-Sanitary products establishes the principles that WTO members need to produce scientific evidence when they appeal to the protection of health in order to justify a trade restrictive measure. These two agreements thus provide specific arguments (in lieu of those contained in Art. XX) that can justify discriminatory measures. Legal actions against technical barriers falling within the scope of these agreements will then typically question the validity of the justification behind the barriers (as in the *Hormones* and *Australian Salmon* cases in the SPS context for instance). However, technical barriers falling within the scope of the TBT agreement can be (and have been) also challenged under Art. III (see for instance the Appellate Body decision on *US Gasoline* in 1996 or the Panel decision on the *Automotive sector in Indonesia* in 1997). Even though this is so far untested, the same could in principle happen with health related measures.

### *2.2. "Like", "directly competitive and substitutable products" and protection*

As indicated above, Art. III.1 is concerned with internal measures which treat foreign and national products differently. Art. III.1 informs the domestic regulation with respect to both the treatment of charge elements (III.2) and non-charge elements (III.4). Its concern is expressed in the following terms: it requires that taxes or internal measures “should not be applied to imported or domestic products so as to afford protection to domestic production” (see appendix 1 for the full text). Hence, the article emphasises the *protection* that is granted to domestic firms and makes *no reference to the cost imposed on foreign firms*. Accordingly, the investigation of a possible violation of Art. III should normally focus on domestic firms. Still, the fact that harm to foreign firms does not appear to be the focus of the analysis may seem somewhat at odds with the general spirit of the WTO contract, which arguably is equally concerned about export opportunities (see for instance, Krugman, 1991). Of course, to the extent that domestic protection is well correlated with harm to foreign firms, the distinction may not matter. This issue is further investigated in the stylised model presented below.

What is meant by “protection” and how it should be measured is not clarified in the Article. It is not clear either whether the form (the object) of a measure is a sufficient ground to conclude that it is unlawful.

With respect to Art III.2 (charge elements), some further insight is provided by the Panel decision on *Japanese Alcoholic Beverages* (confirmed by the Appellate Body decision on this point). According to this decision, Art. III is not concerned with intent and what matters is not whether Member governments designed their domestic regulation in order to favour domestic firms but only whether domestic regulation does actually grant protection.

Art. III still provides some structure for the investigation of domestic protection. It draws a distinction between domestic products that can be qualified as “like” products relative to those imported (first sentence of para 2) and domestic products that are “directly competitive and substitutable” for imported ones (second sentence of para 2). These two sets of products are subject to different legal standards<sup>2</sup>. If the standard

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<sup>2</sup> See Bronckers and McNelis (2000), or Mavroidis (2000), for a discussion of this issue.

which applies to like products appears to be unambiguous, the standards that applies to directly competitive and substitutable products as well as the distinction between like and directly competitive and substitutable products are much less clear.

Some insight with respect to like products is provided by the Panel decision in *Superfund*. In this case, the US government had provided evidence that the disputed measure had no significant effect on trade. The panel did not question the evidence but dismissed the argument altogether. The panel concluded, interpreting literally Art. III.2, that with respect to “like” products, even the slightest deviation is enough to establish discrimination against foreign products. Hence, it would seem that with respect to *charge elements* and with respect to *like* products, there must be absolute identity with respect to the treatment reserved for domestic and foreign product.

The argument of the Panel is worth discussing: the panel argued that evidence on trade effects was not relevant because one could not determine the appropriate counterfactual against which changes in trade flows should be measured. The panel noted that several solutions could be adopted to bring the disputed tax in conformity with Art. III, including an increase in the tax imposed on US products to bring it in line with the tax imposed on foreign products and a reduction in the tax imposed on foreign products to bring it into line with the US internal level. According to the Panel, “each of these solutions would have different trade results and it is therefore logically not possible to determine the difference in trade impact between the present tax and one consistent with Art III.2”. This argument is odd for at least two reasons. First, it is very likely that the net trade impact associated with the differential treatment that one would measure in the alternative scenarios mentioned by the Panel would be very similar. Second, and more fundamentally, it seems odd to dismiss evidence simply because it is subject to some strictly positive (but possibly small) measurement error.

The Panel concluded that Art. III “cannot be interpreted to protect expectations on exports volume; it protects expectations on the competitive relationship between imported and domestic products”. This statement is also hard to understand. Indeed, one wonders how the competitive relationship which is supposedly protected by Art. III

will be assessed if trade effects are not relevant because they cannot be measured precisely. Surely, whether the competitive relationship is affected cannot be inferred “logically” (unless of course the competitive relationship is defined very formally - in terms of the difference in regulation). It will have to be evaluated in terms of effects and those will presumably not be evaluated with more precision than trade effects.

Hence, it appears when with respect to like products and charge elements, Art. III does not require an evaluation of effects. The legal standard for the treatment of imported and like products (for charge element) is thus particularly strict as it admits no difference of treatment across products. This standard has also been affirmed without ambiguity by the Appellate Body in the case of *Japanese Alcoholic Beverages*; according to the Appellate Body, “even the smallest amount of excess is too much... The prohibition under Art. III.2, first sentence, is not conditional on a trade effects test nor is it qualified by a *de minimis* standard”.

This begs the question of how “like” products are determined and in particular how “like” products are distinguished from “directly competitive and substitutable ones”.

As clarified by various Panel decisions, “like” products form a subset of “directly competitive and substitutable” ones. Imported and like domestic products are supposed to share most physical characteristics and should normally be subject to the same HS tariff heading<sup>3</sup>.

With respect to “competitive and substitutable products”, the legal standard is less clear-cut. First, it appears that differences in the treatment of domestic and foreign products is subject to a *de minimis* standard. Hence, in order to find a prohibition, it will be necessary to show that the treatment of domestic and foreign products is not similar. Second, since the second sentence of Art. III.2 makes explicit reference to the first paragraph of the same article<sup>4</sup>, it appears that in order to find a prohibition, it will

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<sup>3</sup> See Horn and Mavroidis, (2000) on this issue.

<sup>4</sup> See appendix 1.



also be necessary to show that differences in the treatment of foreign and domestic products do effectively grant protection to the latter.

The distinction between “like” and “directly competitive and substitutable” products and the very strict standard applied to the former relative to the latter seems to be associated with the presumption that if two products are very similar, any difference in the treatment applied to them will translate into a significant protection for the product which benefit from more favourable conditions. In such case, it can simply be presumed that the protective effect exists and is significant. By contrast, when products are more differentiated, the significance of the protective effect has to be established. As discussed below, this presumption is not necessarily correct. If increased substitution enhances the degree of protection, it is however not a sufficient condition to generate a significant protection.

The practical significance of the distinction between different legal standards applied to “like” and “directly competitive and substitutable” products could be questioned. First, the distinction between the two types of products is in practice not easily drawn. According to various panel decisions, the distinction has to be made on a case by case basis and there is no single criterion that should be used in all cases. As indicated above, there is an apparent consensus that “like” products should share most physical characteristics. With respect to the assessment of whether products are directly competitive and substitutable, there is repeated suggestion in Panels that it should be determined in the market place and that similarity in end-use (as measured possibly by the elasticity of substitution across products or the cross-price elasticity of demand) is an important factor to take into account. Beyond this, little systematic guidance is offered by the panel decisions. The (unusually lyrical) comment by the Appellate Body on *Japanese Alcoholic Beverages* (p 23) that the “concept of likeness is one that evokes the image of an accordion... (which) stretches and squeezes in different places as different provisions of the WTO agreements are applied” also offers little comfort that the distinction between the two types of products can be established on a sound and systematic basis.

Second, the distinction between the legal standards applied to the two types of products seems (at least so far) largely immaterial. The case of *Japanese Alcoholic Beverages* is particularly telling in this respect: the panel decided (p 120) that “for it to conclude that dissimilar taxation afforded protection, it would be sufficient for it to find that the dissimilarity is not *de minimis*”. In other words, if the difference of treatment is large enough, the protective effect can simply be presumed (as in the case of “like” products). Hence, the only difference between the standard applied to “like” and “directly competitive and substitutable” products relates to the importance of the dissimilarity in treatment. Admittedly, the Appellate Body disagreed with this approach and insisted that the issue of whether protection was granted should be handled separately from the issue of whether the treatment was dissimilar. Unfortunately, however, the Appellate Body only provide vague guidance on how to assess protection. It merely referred to the fact that beyond the importance of the dissimilarity in treatment, there will be “other factors to be considered”. What these factors should be has unfortunately not been clarified by the Appellate Body<sup>5</sup>.

### 2.3. *Some conclusions*

A few conclusions can be drawn from this brief overview<sup>6</sup>. First, it is striking that while no evaluation of effects is required for “like” products, some evaluation is required for “directly competitive and substitutable products”. At the same time, the distinction between the two is far from clear. The mere fact that Art. III introduces a distinction between two levels of substitution (on the one hand, “like products” and on the other hand, “directly competitive and substitutable products”) would also seem to

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<sup>5</sup> Mattoo and Subramanian (1998) emphasise the need to distinguish between discriminatory measures and those which incidentally happen to have discriminatory effects while being supported by sound public policy justifications which however fall outside the scope of Art. XX. They observe that a broad definition of “like” products will enhance the set of measures that are inconsistent with Art. III (given the very strict standard applied to like products). Such an approach is biased against sound public policy measures which have unintended incidental effects. They argue (like us) in favour of a systematic effects test. They also favour an additional test regarding the “public policy justifications” put forward as a justification for measures which have protective effects. In order to distinguish between protective measures and those that happen to be protective, they propose to evaluate whether the disputed measures are the most efficient instruments to meet the stated public policy concern.

<sup>6</sup> Our discussion has focused exclusively on charge elements (Art. III.2). The case law with respect to non-charge elements is very scarce. According to Mavroidis (2000), an effects test should be read in the provision (Art. III.4) dealing with non-charge elements.

imply that it contains an effects test. Furthermore, it is striking that how protection should be measured has not been seriously discussed so far.

Second, the overall approach being followed by the Panels is odd, as revealed by our discussion of the distinction between “like” and “directly competitive and substitutable products”. It is striking that panels avoid quantitative benchmarks. Even though the extent to which products are substitutes for one another is obviously a matter of degree, there is no benchmark to decide when this substitution is low enough to consider that products are not directly competitive. By the same token, Panels have not considered any benchmark to evaluate the dissimilarity in products. Panels have also tried to identify the products that are “like” or “directly competitive and substitutable” separately from their evaluation of the importance of the barriers which are raised towards foreign firms (the importance of the dissimilarity in treatment). Still, one should recognise that protection is indeed *a matter of degree* and not a matter of principles. In addition, the extent to which domestic firms will be protected by a non-tariff barrier to trade will be determined (among other things) by the degree of substitution between domestic and foreign products and by the importance of the barrier which is raised. In other words, if Art. III expresses a standard with respect to the degree of protection, one cannot escape from the expression of some benchmark for what is considered an admissible degree of protection. In addition, the evaluation of actual protection against this benchmark should consider jointly the importance of the barrier and the degree of substitution between domestic and foreign products.

In the next section, we further clarify the link between the degree of protection that is granted to domestic firms and the harm imposed on foreign firm as a function of the importance of the barrier imposed on foreign firms, the substitution between foreign and domestic products and the degree of competition in the domestic market. We also experiment with several measures.

### **3. Determinants of protection – A stylised model**

The objective of this section is to compare alternative ways of measuring the effects of non-tariff barriers and to analyse the interplay between the different factors which determine the magnitude of these effects. We build a stylised model of competition to investigate this issue. In line with most of literature, we model non-tariff barriers as an increase in the marginal cost of foreign firms. This is certainly appropriate for some barriers like national quality standards or national product specification which require a change in the production methods of foreign firms. It is clear however that some technical barriers (like national certification procedures) do involve a fixed cost and not necessarily affect marginal cost.

Accordingly, we seek to evaluate the effects of an increase in the marginal cost of foreign firms. This question is actually closely related to the analysis of anti-competitive strategies aiming at raising rivals' cost which has been considered in the IO and antitrust literature (see Salop and Scheffman (1987), Scheffman (1992) or Krattenmaker and Salop (1986)). The issue there is whether and to what extent a group of firms could increase rents and profits by raising the cost of their rivals. For instance, Salop and Scheffman (1987) consider a Cournot model of competition and analyse the extent to which a change in cost which is asymmetric (i.e. which affects some firms more than others) can actually benefit the firms which are less affected by the cost increase. One difference between the question raised here and that analysed in this literature is of course that incumbents firms in our framework do not bear any cost in order to raise barriers for their rivals. The cost increase of rivals is handed to them free of charge by their domestic government.

As discussed above, given the concern of Art. III for protection, one should in principle focus on the effects for domestic firms. However, we also consider effects on foreign rivals to see whether the two concerns are consistent.

The first question which arises is then how to measure effects. As discussed above, the legal framework offers little guidance in this respect. Possibly the most natural candidate would be the profits accruing to domestic and foreign firms (relative

to what they would earn in the absence of a measure raising the marginal cost of the foreign firms).

If profits are a good indicator in principle, they are notoriously difficult to measure, because of accounting conventions which blur economic profits, but more fundamentally because much of the rent accruing to firms is likely to translate into higher cost rather than higher profit. To evaluate changes in profits relative to a counterfactual which is not observed is of course even harder and this can only be undertaken at great cost – and with a substantial degree of imprecision. Profits and rents are thus hardly used even in antitrust investigations and it would be equally difficult to use them in trade investigations.

Hence, it may be useful to experiment with alternative measures. The magnitude of the price distortion associated with non-tariff barriers is a possibility. Counterfactuals over prices are indeed routinely used in antitrust investigations which suggests that a test based on prices could be implemented from a practical point of view. The price that domestic firms are able to charge relative to the level that would prevail without the increase of the marginal cost of foreign firms is then a proxy for the protection enjoyed by domestic firms. The price that foreign firms have to charge relative to what they would charge in the absence of the barrier is then a proxy for the harm (loss of profits) imposed on them. The value of imports (relative to what would be observed without the increase in the marginal cost of foreign firms) could also be considered, both as a measure of protection as a measure of the harm imposed on foreign firms. As mentioned above, this measure was used in the *Superfund* case. We experiment with these measures in the following stylised model of international competition<sup>7</sup>.

### *3.1. The model*

Consider a market where products are differentiated and where each firm is selling a different variety. There are  $n$  firms, with  $k = (n-1)$  firms in the domestic

market and one foreign firm<sup>8</sup>, i.e.  $m = 1$ . Domestic firms operate with a marginal cost of  $c$  whereas the foreign firm is subject to a differential treatment and its marginal cost, is denoted  $c_F$ .

Demand for the differentiated products is given by the following system (see Shubik and Levitan (1980)) which allows for a fairly general pattern of symmetric substitution across products :

$$q_i = \frac{1}{n} \left[ v - P_i(1 + \mathbf{g}) + \frac{\mathbf{g}}{n} \sum P_j \right]$$

where  $q_i$  and  $P_i$  denote respectively the quantity sold and price charged by firm  $i$  and where  $\mathbf{g}$  is a measure of the substitution across products ( $\mathbf{g} = 0$  describes independent products and the degree of substitution increases with the parameter – for  $\mathbf{g} = \infty$ , products are homogenous).

In order to trace the effect of differential treatment, we derive the change in the price charged by domestic firm, the change in the price charged by the foreign firm and the value of imports as a function of the marginal cost of the foreign firm. We consider both the case of strategic substitutes and the case of strategic complements. Let us first consider price competition, assuming that prices are strategic complements.

### 3.2. Price competition

The profit function of firm  $i$  is written :

$$\Pi_i = \frac{P_i - c_i}{n} \left[ v - P_i(1 + \mathbf{g}) + \frac{\mathbf{g}}{n} \sum_{j=1}^n P_j \right]$$

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<sup>7</sup> The analysis presented here can be seen as an extension of Salop and Scheffman (1987), in which we allow for product differentiation.

<sup>8</sup> The assumption that there is a single foreign is unimportant for most of the analysis. It matters however for the evaluation of limit cases and it will be relaxed later when necessary.

The maximisation of profit with respect to price yields the following FOC for each firm:

$$v - P_i(1 + \mathbf{g}) + \frac{\mathbf{g}}{n} \sum_{j=1}^n P_j - (P_i - c_i)(1 + \mathbf{g} - \frac{\mathbf{g}}{n}) = 0 \quad i=1, \dots, n$$

All domestic firms are symmetric and we focus on the symmetric equilibrium where all domestic firms charge the same price. The system of FOCs then reduces to a couple of FOCs, one for the price charged by any domestic firm and one for price charged by the foreign firm, which jointly determine the price of domestic firms  $P$  and the price of the foreign firm  $P_F$ :

$$v - P(1 + \mathbf{g}) + \frac{\mathbf{g}}{n}(n-1)P + \frac{\mathbf{g}}{n}P_F - (P - c)(1 + \mathbf{g} - \frac{\mathbf{g}}{n}) = 0$$

$$v - P_F(1 + \mathbf{g}) + \frac{\mathbf{g}}{n}(n-1)P + \frac{\mathbf{g}}{n}P_F - (P_F - c_F)(1 + \mathbf{g} - \frac{\mathbf{g}}{n}) = 0$$

Solving this system for the equilibrium prices  $P^*$  and  $P_F^*$ , one obtains:

$$P^* = \frac{(c_F \mathbf{g}^2 + 2n^2 v(1 + \mathbf{g}) + n\mathbf{g}(c_F + v + c_F \mathbf{g}) + 2cn(1 + \mathbf{g})(n + \mathbf{g} + n\mathbf{g}))}{(\mathbf{g}^2 + n\mathbf{g}(4 + 3\mathbf{g}) + 2n^2(2 + 3\mathbf{g} + \mathbf{g}^2))}$$

$$P_F^* = \frac{(n(-c + v)\mathbf{g} - c\mathbf{g}^2 + n^2(1 + \mathbf{g})(2v + c\mathbf{g}) + c_F(2\mathbf{g}^2 + n\mathbf{g}(4 + 3\mathbf{g}) + n^2(2 + 3\mathbf{g} + \mathbf{g}^2)))}{(\mathbf{g}^2 + n\mathbf{g}(4 + 3\mathbf{g}) + 2n^2(2 + 3\mathbf{g} + \mathbf{g}^2))}$$

It is then easy to show (see appendix 2) that

$$\begin{aligned} \frac{\partial P^*}{\partial c_F} &> 0, \frac{\partial P_F^*}{\partial c_F} > 0, \frac{\partial P_D^*}{\partial c_F} < \frac{\partial P_F^*}{\partial c}, \\ \frac{\partial^2 P_F^*}{\partial c_F \partial n} &< 0, \frac{\partial^2 P_D^*}{\partial c_F \partial n} < 0, \\ \frac{\partial^2 P_F^*}{\partial c_F \partial g} &> 0, \frac{\partial^2 P_D^*}{\partial c_F \partial g} > 0, \end{aligned}$$

Hence, when a differential treatment is applied to the foreign firm, so that its marginal cost increases, its price increases. The price of domestic firms also increases but by less. The increase in both domestic and foreign price is also larger, the smaller is the number of domestic firms and the larger is the degree of substitution across products (the lower is product differentiation). As intuition would suggest, the profit of the domestic firms also increase and the profit of the foreign firm decreases with the level of cost incurred by the foreign firm.

Looking at the value of imports ( $I$ ), one can show that the value of imports does not always fall (as one might expect) when the cost of the foreign firm increases (see appendix 2). We will return to this observation later.

### 3.3. Cournot competition

As mentioned above, in order to check the robustness of alternative measures of protection, we also considered the possibility of Cournot competition when outputs are strategic substitutes. The demand system given above can be inverted and the inverse demand is then written as follows:

$$p_0 = v - \frac{1}{(1+g)} [nq + g \sum q_j]$$

Using lower case letters to denote prices and quantities in the Cournot game, one obtains the following first order conditions for respectively each of the domestic firm and the foreign firm:



$$v - c - \frac{(qn(2+g) + gq_F)}{(1+g)} = 0$$

$$v - c_F - \frac{(qg(n-1) + q_F 2(n+g))}{(1+g)} = 0$$

Solving this system of equations for equilibrium quantities and computing the resulting equilibrium prices, one obtains :

$$p^* = \frac{(n+g)(2nv + (c_F + v)g) + c(-g^2 + ng^2 + 2n^2(1+g))}{(2n+g)(g+n(2+g))}$$

$$p_F^* = \frac{(n+g)(2nv - cg + cng + vg) + c_F(2ng + g^2 + n^2(2+g))}{(2n+g)(g+n(2+g))}$$

The comparative statics of equilibrium prices with respect to the cost of the foreign firm can be summarised as follows (see appendix 2 for details).

$$\begin{aligned} \frac{\mathbb{1} p^*}{\mathbb{1} c_F} &> 0, \frac{\mathbb{1} p_F^*}{\mathbb{1} c_F} > 0, \frac{\mathbb{1} p_D^*}{\mathbb{1} c_F} < \frac{\mathbb{1} p_F^*}{\mathbb{1} c}, \\ \frac{\mathbb{1}^2 p_F^*}{\mathbb{1} c_F \mathbb{1} n} &< 0, \frac{\mathbb{1}^2 p_D^*}{\mathbb{1} c_F \mathbb{1} n} < 0, \\ \frac{\mathbb{1}^2 p_F^*}{\mathbb{1} c_F \mathbb{1} g} &> 0, \frac{\mathbb{1}^2 p_D^*}{\mathbb{1} c_F \mathbb{1} g} > 0, \end{aligned}$$

As in the case of price competition, both domestic and foreign prices increase with the level of cost incurred by the foreign firm. The increase in price is higher, the lower is the number of firms and the larger is the degree of substitution across products. As before, the profit of the foreign firm falls and the profit of the domestic firms increases with the level of cost incurred by the foreign firm. With respect to import values, however, the effect is now without ambiguity. The value of imports always falls when barriers are increased.

### 3.4. Interpretation and conclusion

A number of conclusions can be drawn from this analysis. First, we observe that protection is lower with more intense domestic rivalry (as proxied by the number of competitors). Importantly, this suggests that the distinction drawn by Art. III of the GATT between “like” and “directly competitive and substitutable” products *is unlikely to be very useful*. The presumption that “like” products will always be protected is simply not supported by economic principles<sup>9</sup>.

One can also wonder about the protection that is granted to domestic firms when the market structure approaches perfect competition. This can be evaluated by considering the change in domestic price as a function of the cost of the foreign firm when the number of firms becomes arbitrarily large. It is easy to check (using L’Hospital rule) that

$$\lim_{n \rightarrow \infty} \frac{\partial P^*}{\partial c_F} = 0, \lim_{n \rightarrow \infty} \frac{\partial p^*}{\partial c_F} = 0$$

Hence, whatever the degree of substitution between products, if the number of firms becomes arbitrarily large, domestic firms are unable to get any protection. This holds for price as well as quantity competition<sup>10</sup>.

This extreme result is however due to the fact that the number of foreign firms is kept constant in the counterfactual that we have considered. By increasing the number of firms and keeping a single foreign firm, the market share of the latter decreases and its effect of equilibrium prices becomes negligible. An alternative counterfactual is to

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<sup>9</sup> It is worth emphasising that our model assumes the absence of capacity constraints and that this assumption matters. Clearly, if there is a capacity constraint on the output of domestic firms, they can collectively benefit from an increase in cost of the foreign firm even if there is perfect competition in the domestic market (see Scheffman, 1992 for a discussion of this case). Similarly, domestic firms can benefit from a capacity constraint (quota) imposed on foreign firms, even when there is perfect competition in the domestic market.

<sup>10</sup> Under the assumptions of our model, neither the domestic firms nor the foreign firm would profit from an increase in cost of the latter when  $n$  is large.

consider a increase in the number of firms while keeping the proportion of domestic firms constant. Having derived equilibrium prices for arbitrary values of  $k$  and  $m$  (the number of domestic and foreign firms), one can show<sup>11</sup> that :

$$\lim_{n \rightarrow \infty | k=m} \frac{\partial P^*}{\partial c_F} = \frac{(1+g)g}{(2+3g+g^2)}$$

$$\lim_{n \rightarrow \infty | k=m} \frac{\partial p^*}{\partial c_F} = \frac{g}{4(2+g)}$$

Hence, when the number of foreign is maintained at par with the number of domestic firms, the protection which is granted to domestic firms converges to a strictly positive lower bound (for both Bertrand and Cournot competition). This lower bound is also increasing with the degree of substitution between products. When products are homogenous ( $g \rightarrow \infty$ ), the lower bound takes the value of  $\frac{1}{4}$  (for both Bertrand and Cournot competition). Hence, in perfect competition, domestic firms will be able to increase price by at most one quarter of the increase in cost incurred by foreign firms and this arises when there is no differentiation between products (products are exactly “like”).

Second, the analysis confirms that price is a robust measure of protection. Protection as measured by price is a monotonic increasing function of the cost disadvantage suffered by the foreign firm (for both price and quantity competition).

Third, price is a robust measure of the harm imposed on foreign firms. The price and the profits of the foreign firm are monotonic functions of its cost disadvantage<sup>12</sup>.

Fourth, with respect to price effects, the distinction between protection of domestic firms and harm to foreign firms appears to be unimportant. That is, the extent

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<sup>11</sup> Derivations are available upon request from the author.

<sup>12</sup> Changes in prices are consistent with changes in profit as a response to an increase in cost for both domestic and foreign firms. The relationship between the change in profit and market characteristics

to which domestic firms are protected and the extent to which foreign firms are harmed are determined by the same factors.

Fifth, the value of imports appears to be less robust. With price competition, the value of imports is not always decreasing with the cost level of the foreign firm, whereas for quantity competition, imports always fall with the level of cost. The observation that the value of imports might increase with the level of cost of the foreign firm is in principle not unreasonable. Indeed, the increase in foreign price that follows the increase in cost will tend to increase the value of imports; of course, the quantity being imported will also fall. If initial quantities are large, the infra-marginal effect (higher unit revenues) might very well compensate for the marginal effect (reduced quantities). This will also arise for reasonable values of the parameters.

Assume for instance that  $n = 2, g = 1, c_F = 0$ . This would correspond to a duopoly with an intermediate degree of substitution between domestic and foreign products. It is easy to check that for such parameter values :

$$\frac{\partial I^*}{\partial c_F} = \frac{85}{882}v, \frac{\partial i^*}{\partial c_F} = -\frac{17}{980}v$$

Hence, for these parameters, the increase in price for the foreign firm under price competition will actually more than compensate for the reduction of quantity that it sells in the domestic market and total imports will increase. With quantity competition, the value of imports falls. The difference between price and quantity competition can also be explained as follows : with price competition, initial quantities will be higher (for any value of the parameters) by comparison with quantity competition. Firms will thus operate at a level where their own revenue increases faster with own price, taking the price of competitors as given (in other words, the infra-marginal effect will be stronger with price competition). Hence, as long as the price of competitors increases sufficiently in equilibrium (so that the marginal effect is not too strong), it is not a

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(substitution and rivalry) is however more complex than the relationship between the change in price and market characteristics (as detailed above).

surprise that equilibrium revenues (and hence imports) will fall less (or increase) with price competition – as compared to quantity competition.

Accordingly, price appears to be a better measure than trade flows and in what follows we focus on the former. To the extent that a price measure for protection is consistent with a price measure of harm to exporters, focusing on price also allows us to capture both effects.

### *3.5. How much does market structure matter for protection ?*

As discussed above, market structure, and in particular the degree of competition in the domestic market matters for protection. The question then arises of whether the effect of market structure is quantitatively important, in absolute term and relative to the importance of product differentiation. Indeed, if it is found that the degree of substitution has overwhelming effects, conditions of competition could be safely neglected in practice.

In order to address this question, we have simulated the derivative of the domestic price with respect to a change in cost of the foreign firms for a range of parameter values. The key results are summarised in figure 1.1. and 1.2.. In figure 1.1., the number of foreign firms is fixed at 2 ( $m=2$ ) and we allow both the number of domestic firms and the degree of substitution to vary (allowing for up to four domestic firms and allowing value of  $g$  from 1 to 10)<sup>13</sup>. We observe the protection granted to domestic firms does indeed increase with the degree of substitution between products but that the effect of market structure is at least of the same order of magnitude in this parameter range. For instance, moving from a single domestic firms to four domestic competitors will reduce the degree of protection by half (from about 0.3 to 0.15). Increasing the degree of substitution ( $g$ ) from 1 to 10 increase protection from about 0.08 to 0.15 with a domestic triopoly.

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<sup>13</sup> The results reported here assume Bertrand competition. Similar results are found with Cournot competition.

Additional simulations also indicate that the effect of market structure is important for up to 10 firms (in total) and becomes unimportant thereafter and that the effect of product differentiation levels out quickly for values of  $g$  beyond 10. Hence, it appears that in general market structure matters as much as the “likeliness” of products as a determinant of protection.

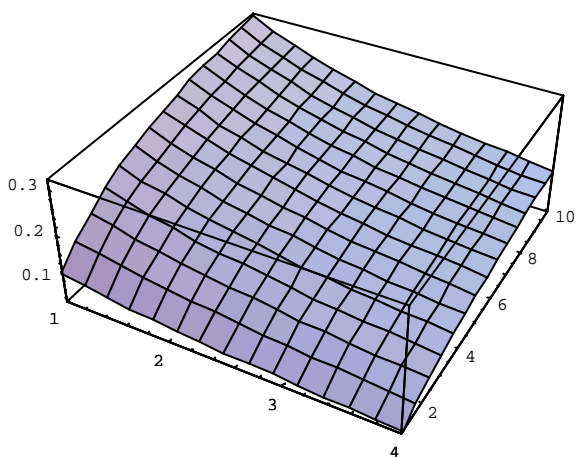


Figure 1.1. Protection as a function of  $k$  and  $g$  (with  $m=2$  – Bertrand competition)

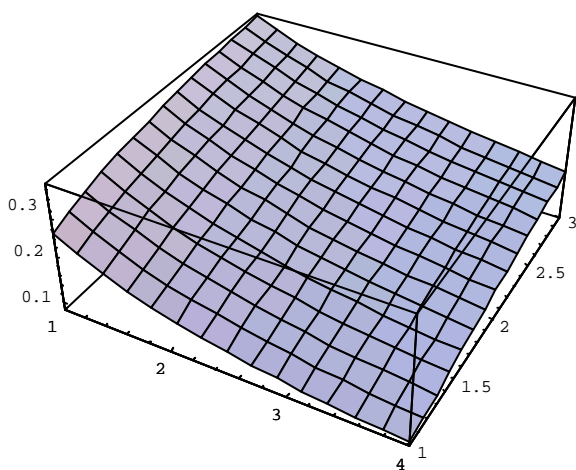


Figure 1.2. Protection as a function of  $k$  and  $m$  (with  $g=10$  – Bertrand competition)

The importance of market structure is confirmed in figure 1.2. which presents the level of protection as a function of the number of domestic (up to 4) and foreign firms (up to

3), for a given degree of product differentiation. It appears that both domestic and foreign competition have an effect while the former is understandably more important.

#### **4. A proposal for the evaluation of protection**

Evaluating protection in terms of price will require to set a benchmark expressing an upper limit on the ability to raise price for domestic firms which is considered acceptable. The question then also arises of how to evaluate in practice the extent to which a disputed measure allows (or would allow) domestic firms to raise price.

A comparison with antitrust proceeding is instructive. In antitrust proceedings, the authorities need to evaluate whether firms can effectively exercise market power, i.e. raise price above the competitive level. This evaluation is usually undertaken by first calibrating the relevant market; that is, authorities proceed by first delineating the set of products over which a hypothetical monopolist could exercise a given degree of market power. This is usually expressed as the ability to profitably increase<sup>14</sup> price by 5-10 % (see for instance the US Merger Guidelines or the EU Notice on Market Definition). This market is defined both in terms of product characteristics and in terms of geographical scope. The main benefits from this approach are two-fold: first, the procedure sets an explicit upper limit on the level of market power. An ability to increase price by 5-10 % above the competitive level is considered excessive. Second, the procedure ensures that the competitive analysis will be meaningful. By making sure that a market share of 100 % (that of the hypothetical monopolist) would lead to the exercise of market power, the market power associated with lower level of market shares is effectively calibrated. The procedures thus ensures that market shares can be meaningfully interpreted in terms of potential market power.

As discussed in the previous section, the protection enjoyed by domestic firms, for a given barrier (cost disadvantage for the foreign firm) will be determined by the substitution between domestic and foreign products and by the degree of rivalry

between domestic firms<sup>15</sup>. Hence, in order to make sure that the analysis of domestic competition is meaningful, it may be useful, as in antitrust proceedings, to delineate first the market in which in the absence of competition, domestic firms would benefit from the existence of the barrier; that is, it may be useful to first delineate the set of product over which a *hypothetical domestic monopolist* could obtain a given degree of protection. If price is taken as the measure of protection, this would entail finding a set of products such that a domestic monopolist controlling these products would be able to raise price above the competitive level by some percentage<sup>16</sup>. The percentage which is chosen would give an explicit benchmark about the level of protection which is considered excessive. The analysis should also consider that factors that are considered in antitrust proceedings; it should consider both demand and supply substitution.

At this stage two possibilities can arise. On the one hand, it is entirely possible that there is no set of products over which a domestic monopolist would be able to raise price. This might happen for instance if demand substitution is important (so that consumer will switch away and purchase products abroad if the domestic price is increased) or if the disputed barrier is unimportant and foreign competition is intense (so that supply substitution is significant). If no such market can be found, it implies that even a hypothetical domestic monopolist could not obtain protection and the complaint should be dismissed (see figure 2).

On the other hand, if a market has been identified where a domestic monopolist could obtain protection, one should proceed by undertaking a competitive analysis in this market. The analysis should follow the usual approach of the evaluation of dominance in antitrust. If it is found that competition is intense, for instance because concentration is low and entry barriers are unimportant, there will be again a strong

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<sup>14</sup> Neglecting the distinction between the profit maximising increase in price and a profitable price increase.

<sup>15</sup> As discussed above, domestic competition matters for protection only to the extent that there is no capacity constraint. The procedure discussed here is thus not appropriate to consider quotas on foreign firms or situations where the output of domestic firms is limited.

<sup>16</sup> The reference to the competitive level should be emphasised. To the extent that the disputed barrier is already in place, the observed price might already entail some protection (will be above the competitive



presumption that domestic firms will not be able to obtain protection. In this event, the complaint should again be dismissed.

If competition is weak, the investigation should proceed by analysing the extent to which the disputed measure enables the domestic firms to raise price. This would entail considering explicitly the increase in cost associated with the imposition of the differential treatment on foreign firms. If it is found that the change in cost is significant, one should conclude that the disputed measure grants a significant protection to domestic firms. What is meant by a “significant” increase in cost should also be considered in line with the benchmark that is chosen for the potential increase in price. For instance, if a price increase of 5 % is considered at the market definition stage, larger percentages of cost increases should be considered as significant (given that the pass-through is less than 1, even when the domestic market structure is very concentrated).

## **5. Conclusion**

To sum up, this paper considers the economic analysis of non-tariff barriers in the context of disputes under Art. III of the GATT. We first observe that under Art. III, some protection can be lawfully granted to domestic products which are directly competitive and substitutable to foreign products. Yet, the questions of how much protection can be granted and how protection should be measured has hardly been discussed in the case law. The question of what determines protection has not been considered either. The Panels have also often failed to recognise that protection is determined jointly by the importance of the barrier and the degree of substitution between domestic and foreign products and tend to presume that a strong substitution between domestic and foreign products always lead to substantial protection.

Next, we consider a stylised model of trade where we experiment with various measures of protection and harm to foreign firms. Our model can be used to evaluate the effect of any instrument which effectively raises the marginal cost of foreign firms.

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level). A similar issue arises in market delineation for cases of alleged abuse of dominance.

This includes tariffs as well as non-tariff barriers but excludes quantitative restraints. We investigate the interplay between the degree of product differentiation and the degree of rivalry in the domestic market in determining both protection and harm. We conclude that the ability to raise price is a robust measure of protection and that protection falls (for a given barrier) with the degree of rivalry and the degree of substitution between products. Similarly, we find that the extent to which foreign firms increase price is a robust measure of the harm that they suffer. Prices measures of protection and harm are also consistent with one another so that, at least in this context, the distinction between protection of domestic firms and harm to exporters is unimportant. We also observe that the value of imports is not a robust measure of protection (or harm). When competition is in price, the imposition of barriers can indeed sometimes lead to an increase in imports.

Hence, the presumption that a strong substitution between domestic and foreign products always lead to substantial protection should be qualified. When domestic rivalry is intense, domestic firms will not benefit from non-tariff barriers even if the substitution between domestic and foreign firm is strong. Hence, the distinction between “like” and “directly competitive and substitutable” products does not appear to be helpful. Applying different standards according to the degree of substitution is unwarranted and when determining the extent to which domestic firms are protected, one should jointly consider the degree of substitution between domestic and foreign firms and the degree of rivalry in the domestic market.

Finally, we suggest a method to evaluate protection in trade disputes which is inspired by the definition of the relevant market in antitrust. We suggest that a set of products should first be found in which a hypothetical monopolist controlling the domestic supply would be able to raise price by  $x\%$ . If this market cannot be found, or if it is found that competition in this market is intense, the complaint should be dismissed. Only if competition is weak should the investigation attempt to measure the importance of the disputed barrier.

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Comparisons with price levels in others countries can provide indications on the competitive level.

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## **References**

Baldwin, R., Venables, A., 1995, Regional Economic Integration, Handbook of international economics, Volume 3, G: Grossman, and K. Rogoff, eds., Handbooks in Economics, vol. 3., Elsevier, North-Holland, Amsterdam; New York and Oxford, 1597-1644

Bronckers, M., McNelis, N., 2000, Rethinking the “like” product definition in GATT: antidumping and environmental protection, Regulatory barriers and the principle of non discrimination in world trade law, World Trade Forum Series, Michigan University Press, Ann Harbor, 345-387

Horn, H., Mavroidis, P., 2000, Economic and legal aspects of the Most-Favoured-Nation clause, CEPR Discussion Paper

Krattenmaker, T., Salop, S., 1986, Anticompetitive exclusion: raising rival’s costs to achieve power over price, The Yale Law Journal, vol 96, 2, 209-293

Krugman, P, 1991, The Move Toward Free Trade Zones", in Policy Implications of Trade and Currency Zones, A Symposium Sponsored by The Federal Reserve Bank of Kansas City, The Federal Reserve Bank of Kansas, Jackson Hole, Wyoming, 7-41

Mattoo, A., Subramanian, A., 1998, Regulatory autonomy and multilateral discipline : the dilemma and a possible resolution, *The Journal of International Economic Law*, 1, 303-322

Mavroidis, P., 2000, "Like product" : Some Thoughts at the Positive and Normative Level, Regulatory barriers and the principle of non discrimination in world trade law, *World Trade Forum Series*, Michigan University Press, Ann Harbor, 125-137

Salop, S., Scheffman, D., 1987, Cost-Raising Strategies, *The Journal of Industrial Economics*, Vol XXXVI, 1, 19-34

Scheffman, D., 1992, The application of raising rivals' costs theory to antitrust, *The Antitrust Bulletin*, 187-206.

Shubik, M., Levitan, R., 1980, *Market structure and behaviour*, Harvard University Press, Boston

## **Appendix 1**

### **Article III\***

#### *National Treatment on Internal Taxation and Regulation*

1. The contracting parties recognize that internal taxes and other internal charges, and laws, regulations and requirements affecting the internal sale, offering for sale, purchase, transportation, distribution or use of products, and internal quantitative regulations requiring the mixture, processing or use of products in specified amounts or proportions, should not be applied to imported or domestic products so as to afford protection to domestic production.\*

2. The products of the territory of any contracting party imported into the territory of any other contracting party shall not be subject, directly or indirectly, to internal taxes or other internal charges of any kind in excess of those applied, directly or indirectly, to like domestic products. Moreover, no contracting party shall otherwise apply internal taxes or other internal charges to imported or domestic products in a manner contrary to the principles set forth in paragraph 1.\*

#### *Ad Article III*

Any internal tax or other internal charge, or any law, regulation or requirement of the kind referred to in paragraph 1 which applies to an imported product and to the like domestic product and is collected or enforced in the case of the imported product at the time or point of importation, is nevertheless to be regarded as an internal tax or other internal charge, or a law, regulation or requirement of the kind referred to in paragraph 1, and is accordingly subject to the provisions of Article III.

#### *Paragraph 1*

The application of paragraph 1 to internal taxes imposed by local governments and authorities with the territory of a contracting party is subject to the provisions of the final paragraph of Article XXIV. The term "reasonable measures" in the last-mentioned paragraph would not require, for example, the repeal of existing national legislation authorizing local governments to impose internal taxes which, although technically inconsistent with the letter of Article III, are not in fact inconsistent with its spirit, if such repeal would result in a serious financial hardship for the local governments or authorities concerned. With regard to taxation by local governments or authorities which is inconsistent with both the letter and spirit of Article III, the term "reasonable measures" would permit a contracting party to eliminate the inconsistent taxation gradually over a transition period, if abrupt action would create serious administrative and financial difficulties.

#### *Paragraph 2*

A tax conforming to the requirements of the first sentence of paragraph 2 would be considered to be inconsistent with the provisions of the second sentence only in cases where competition was involved between, on the one hand, the taxed product and, on the other hand, a directly competitive or substitutable product which was not similarly taxed.

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<sup>1</sup>This Protocol entered into force on 14 December 1948.

## Appendix 2

For strategic complements, the comparative statics of the equilibrium prices are given by :

$$\frac{\partial P_F^*}{\partial c_F} = \frac{2g^2 + ng(4+3g) + n^2(2+3g+g^2)}{(g^2 + ng(4+3g) + 2n^2(2+3g+g^2))}$$

$$\frac{\partial P^*}{\partial c_F} = \frac{g(n+g+ng)}{(g^2 + ng(4+3g) + 2n^2(2+3g+g^2))}$$

The marginal effects of the number of firms and of the degree of product differentiation on the price of the domestic firms can then be written as :

$$\frac{\partial^2 P^*}{\partial c_F \partial g} = \frac{n(3g^2 + 4n^2(1+g)^2 + ng(8+7g))}{(g^2 + ng(4+3g) + 2n^2(2+3g+g^2))^2}$$

$$\frac{\partial^2 P^*}{\partial c_F \partial n} = -\frac{g(2n^2(1+g)^2(2+g) + g^2(3+2g) + 4ng(2+3g+g^2))}{(g^2 + ng(4+3g) + 2n^2(2+3g+g^2))^2}$$

And for the foreign firm :

$$\frac{\partial^2 P_F^*}{\partial c_F \partial g} = \frac{n(4g^2 + 3ng(4+3g) + n^2(8+12g+5g^2))}{(g^2 + ng(4+3g) + 2n^2(2+3g+g^2))^2}$$

$$\frac{\partial^2 P_F^*}{\partial c_F \partial n} = -\frac{g(g^2(4+3g) + 6ng(2+3g+g^2) + n^2(8+18g+13g^2+3g^3))}{(g^2 + ng(4+3g) + 2n^2(2+3g+g^2))^2}$$

With respect to the value of imports, one obtains that

$$\text{Sgn } \frac{\partial I^*}{\partial c_F} = \text{Sgn} \left[ (n + \mathbf{g} + n\mathbf{g})(\mathbf{g}(3\mathbf{g} + n(4 + 3\mathbf{g}))(n(-c + v)\mathbf{g} - c\mathbf{g}^2 + n^2(1 + \mathbf{g})(2v + c\mathbf{g})) \right. \\ \left. - 2c_F \left( -2\mathbf{g}^4 - n\mathbf{g}^3(4 + 3\mathbf{g}) + n^2\mathbf{g}^2(2 + 3\mathbf{g} + \mathbf{g}^2) + n^4(2 + 3\mathbf{g} + \mathbf{g}^2)^2 + n^3\mathbf{g}(8 + 18\mathbf{g} + 13\mathbf{g}^2 + 3\mathbf{g}^3) \right) \right]$$

For quantity competition, the comparative statics of the increase in domestic price is given by :

$$\frac{\partial p^*}{\partial c_F} = \frac{\mathbf{g}(n + \mathbf{g})}{(2n + \mathbf{g})(\mathbf{g} + n(2 + \mathbf{g}))}$$

$$\frac{\partial p_F^*}{\partial c_F} = \frac{2n\mathbf{g} + \mathbf{g}^2 + n^2(2 + \mathbf{g})}{(2n + \mathbf{g})(\mathbf{g} + n(2 + \mathbf{g}))}$$

$$\frac{\partial^2 p^*}{\partial c_F \partial n} = -\frac{\mathbf{g}(2n^2(2 + \mathbf{g}) + 4n\mathbf{g}(2 + \mathbf{g}) + \mathbf{g}^2(3 + \mathbf{g}))}{(2n + \mathbf{g})^2(\mathbf{g} + n(2 + \mathbf{g}))^2}$$

$$\frac{\partial^2 p^*}{\partial c_F \partial \mathbf{g}} = \frac{n(4n^2 + 3\mathbf{g}^2 + n\mathbf{g}(8 + \mathbf{g}))}{(2n + \mathbf{g})^2(\mathbf{g} + n(2 + \mathbf{g}))^2}$$

And for the foreign firm :

$$\frac{\partial^2 p_F^*}{\partial c_F \partial \mathbf{g}} = -\frac{(-1 + n)n\mathbf{g}(2\mathbf{g} + n(4 + \mathbf{g}))}{(2n + \mathbf{g})^2(\mathbf{g} + n(2 + \mathbf{g}))^2}$$

$$\frac{\partial^2 p_F^*}{\partial c_F \partial n} = \frac{(-2n + n^2 - \mathbf{g})\mathbf{g}^2(2 + \mathbf{g})}{(2n + \mathbf{g})^2(\mathbf{g} + n(2 + \mathbf{g}))^2}$$

With respect to the value of imports (i), one obtains :

$$\frac{\partial i^*}{\partial c_F} = -\frac{((1 + \mathbf{g})((-1 + n)\mathbf{g}^2(2nv - c\mathbf{g} + cn\mathbf{g} + v\mathbf{g}) + 2c_F n(2 + \mathbf{g})(2n\mathbf{g} + \mathbf{g}^2 + n^2(2 + \mathbf{g}))))}{((2n + \mathbf{g})^2(\mathbf{g} + n(2 + \mathbf{g}))^2)}$$