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The International Strategy of Firms:

the Role of Endogenous Product Differentiation

Abstract

We study the impact of trade liberalization on the international strategy of firms (to export and/or invest abroad as well as the number of products to be produced and exported) when product differentiation is endogenous. By considering product differentiation as a strategic variable, our analysis sheds new light on the impact of trade barriers on the decision to produce abroad and on the choice of product range, in accordance with recent empirical evidence. Indeed, we show that, even though technology exhibits the same productivity for each variety, firms drop some varieties with trade integration. In addition, our results reveal that, contrary to the standard theoretical literature, the relationship between the decision to export and trade costs is non-linear. When trade costs are relatively high, each firm export and is multi-product. Then, when trade costs take intermediate values, firms may invest abroad and the choice of producing abroad results from a prisoner's dilemma game. Finally, when trade costs are low, firms export but become single-product.

Keywords: Foreign direct investment, exports, multi-product competition, endogenous differentiation product, trade integration

JEL Classification: F12, F23, L11, L25

Stratégie internationale des firmes :

le rôle de la différenciation endogène des produits

Résumé

Nous étudions lôimpact de la libéralisation des échanges sur la stratégie internationale des firmes lorsque la différenciation des produits est endogène. En considérant la différenciation des produits comme une variable stratégique, notre analyse apporte un nouvel éclairage sur lôimpact des barrières aux échanges sur les décisions dôexporter ou de délocaliser ainsi que sur le nombre de variétés à produire et à exporter, en accord avec les observations empiriques récentes. Nous montrons quôavec lôintégration internationale, les firmes cessent de produire des variétés même si elles ne sont pas produites avec une productivité moindre. De plus, nos résultats montrent que, contrairement à la théorie standard, la relation entre la décision dôexporter et les barrières aux échanges nôest pas linéaire. Les firmes préfèrent exporter et être multi-produit lorsque les barrières aux échanges sont élevées. Des valeurs intermédiaires incitent en revanche les firmes à produire à lôétranger et ce choix résulte dôune configuration du dilemme du prisonnier. Finalement, lorsque les barrières aux échanges prennent des valeurs relativement faibles, les firmes exportent de nouveau mais deviennent mono-produits.

Mots-clefs : Investissement direct à lôétranger, exportation, firmes multi-produit, différentiation endogène des produits, intégration internationale

Classification JEL : F12, F23, L11, L25

The international strategy of firms:
the role of endogenous product differentiation

1 Introduction

It is well documented that large and multi-product firms dominate international trade (Bernard *et al.*, 2009a). For example, in the United States in the year 2000, the top one percent of trading firms accounted for over 80% of total trade value while the share of exports due to firms exporting a single product was only about 0.4%. Recent empirical studies focused on the product-range decision at the firm level in response to trade liberalization. This literature suggests that trade liberalization has induced firms located in different countries (Canada, France, Mexico, U.S.A.) to reduce the number of products they produce (see Baldwin and Gu, 2009; Bernard *et al.*, 2009b; Berthou and Fontagné, 2009; Iacovone and Javorcik, 2008; Mayer *et al.* 2009). In other words, trade openness leads to an *anti-variety effect* or, equivalently, a reduction in the range of products at the firm level. According to this literature, the main explanation lies in the fact that the liberalization causes a rationalization of production (due to tougher product competition), firms dropping their low-productivity products and concentrating on their most successful varieties. Yet, the existing approaches have failed to consider two characteristics of firms dominating international trade when assessing the impact of falling trade barriers on the product selection of the firm.

First, the literature on the export strategy does not take into account the fact that the *product differentiation* may be a strategic variable for large firms. Yet, we know from the industrial organization literature that the introduction/removal of a new variety and the degree of differentiation within the product-range are two strategic decisions that are strongly connected within firms (see Manez and Waterson, 1998 for a review). For example, as suggested by Brander and Eaton (1984), each firm has an incentive to produce an additional variety in order to increase its operating profits (revenue effect) but, by introducing a new variety, the firm's profit may decrease because of fiercer price competition between the varieties supplied on the market (cannibalization effect). Clearly, the large firms are able to manage both effects by adjusting the degree of product differentiation between their varieties and the varieties supplied by their rivals in order to relax price competition.

Second, large firms can also react to trade liberalization by shifting the *production of some varieties abroad*. Indeed, trade liberalization has also been accompanied by an increase in foreign direct investment (hereafter FDI) flows, especially in major industrialized countries (UNCTAD, 2006). During the period 2000-2005, average annual FDI outflows in developed countries amounted to 67% of total FDI inflows whereas average annual FDI inflows in developed countries reached 74% of FDI outflows. It is also well documented that these inward and outward FDI flows (cross-hauling FDI flows) take place within the same industry (Rugman, 1987; Greenaway *et al.*, 1998). For example, US car makers such as Ford produce in Europe and, reciprocally, European car makers such as Volkswagen own subsidiaries in NAFTA member countries. In this context, multinational firms (MNFs) can supply a large product-range abroad in order to prevent their foreign rivals from developing their own

product range. As underlined by Markusen (1995), multinational corporations are characterized by high levels of product differentiation and advertising. Hence, the choice of degree of product differentiation and the geographical location of production are both strategic choices to handle international competition between rival firms.

This paper deals with both dimensions. More precisely, our objective is to propose a unified framework to study the trade integration effect on the international strategies of multi-product firms when they decide *strategically* the degree of product differentiation of their varieties and to produce or not abroad. To achieve this goal, we adopt a game theory approach and develop a two-country model with endogenous product differentiation in the spirit of Hotelling. In our framework, the ability of firms to adjust the characteristics of their products impacts the two following (traditional) trade-offs: (i) to serve a foreign country between producing in the foreign country to save *trade costs* and exporting to save *additional fixed costs* related to the setting up a new affiliate; and (ii) the introduction or removal of a new variety to avoid the *revenue effect* or to exploit the *cannibalization effect*. To this end, we analyze the role of endogenous product differentiation on the relationship between falling trade barriers and the international strategies of firms.

Our analysis contributes to two literatures. First, the recent literature on the export strategies considers that firms are multi-product and are heterogeneous in productivity (Baldwin and Gu, 2009; Bernard *et al.*, 2009; Mayer *et al.* 2009). However, this literature does not consider endogenous product differentiation and the cannibalization effect. Feenstra and Ma (2008) and Eckel and Neary (2009) developed models of multi-product heterogeneous firms incorporating the cannibalization effect. Nevertheless, these authors restrict their analysis to a single globalized world with no trade costs and to exogenous product differentiation. Our model captures the relationship between trade barriers, product differentiation and the cannibalization effect.

Second, the role of endogenous product differentiation in the emergence of FDIs has also received little formal attention. In most theoretical works on MNFs, product differentiation is exogenous and/or firms produce a single product (see Markusen, 2002; Navaretti and Venables, 2004). Lyons (1984) first proposed a framework incorporating endogenous product differentiation based on Hotelling (1929) but the author considers that firms pursue cooperative pricing and differentiation to prevent the entry of potential competitors.[1] The analyses of Motta (1994), Mathieu (1997) and DeFraja and Norman (2004) are also among the exceptions. Motta (1994) focuses on the role of vertical differentiation and trade costs in international trade and investments. However, the decision of each firm concerning internationalization is made by taking its product quality as given. Mathieu (1997) and DeFraja and Norman (2004) analyze how product differentiation influences a firm's choice between exporting and producing abroad when consumers are heterogeneous. However, our analysis is more general since we consider that firms may produce more than one variety. Note that multinationals are multi-product firms in Baldwin and Ottaviano (2001), but the degree of product differentiation is exogenous and the way in which the multinational firm handles the

[1] Lyons (1984) determines whether a first mover can establish a monopoly outcome in its domestic market by implementing a strategy of product proliferation under sequential entry. He shows that the production of varieties by a MNF (or MNFs that cooperate) in different countries raises barriers to entry.

cannibalization effect is only to produce some varieties abroad.
Two main conclusions concerning the effect of trade liberalization on the international strategy of large firms can be drawn from our theoretical analysis. The first one concerns the decision to export as an equilibrium outcome. *Exports occur even though trade costs are relatively high and sunk costs related to setting up an affiliate abroad are relatively low.* This is the result of the ability of firms to be multi-product producers. High tariff barriers introduce an asymmetry in competition in favor of each firm on its domestic market. High trade costs relax price competition and favor the revenue effect at the expense of the cannibalization effect. As a result, each company is multi-product and prefers to export than to be multinational to prevent fiercer price competition. This result differs from those in the traditional literature on FDI in which FDI occurs when trade costs are high enough. In our case, firms are not prompted to invest abroad. Indeed, if a firm becomes multinational in the case of high trade barriers, price competition is so fierce that the firm becomes single-product and operating profits fall. However, when trade costs reach low enough, each firm exports, but the two rivals both become single-product and the differentiation product is maximum due to a strong cannibalization effect.
Second, the decision to produce abroad is chosen when trade costs are intermediate. However, two types of outcome are possible depending on the level of sunk costs involved in setting up a plant abroad. First, when this additional cost is low enough, both firms are multinational. Each company has an incentive to set up a second plant abroad rather than to export. Consequently, price competition becomes fierce enough so that each firm prefers to eliminate one of its products and chooses the maximum differentiation vis-à-vis its rival (in this case, the cannibalization effect dominates the revenue effect). Note that FDI is cross-hauling between countries, in accordance with empirical evidence. In addition, this two-way FDI results from a prisoner's dilemma game where the configuration in which both firms export is a Pareto optimal outcome. Hence, *firms may end up being trapped into a prisoner's dilemma when trade costs take intermediate values*, provided that the sunk cost in setting up of a plant abroad is low enough. Second, when the foreign fixed plant-specific cost is not too low, one-way FDI and exports are modeled as a chicken game. Hence, there exist two Pareto optimal Nash equilibria where one firm becomes a multinational while its rival produces at home and exports abroad. It is important to stress that such an asymmetric outcome can occur in a perfectly symmetric environment. In other words, *a multinational corporation and a national firm may coexist even though the countries and technologies of the firms are identical.*
These two results allow us to show that trade liberalization (a fall in trade costs in our approach) leads to a decline in the number of varieties supplied (the available range of product varieties decreases), in contrast to the well-known Krugman variety effect. More precisely, we show that, for a given number of firms, each rival reduces the number of varieties it supplies when trade costs are low enough. In Bernard *et al.* (2009), trade liberalization implies a rationalization of production where firms drop their low-productivity products. In our case, *firms rationalize their product range, even if technology exhibits the same productivity for each variety, by dropping some of varieties with trade integration.* This is due to the fact that FDI can occur in our model and that product differentiation is endogenous. In addition,

this allows us to show that the relationship between the decision to produce abroad and trade costs is non linear, that is consistent with the weak empirical relationship between trade costs and the probability of producing abroad (see Brainard, 1997 and Ekholm, 1997).[2]
The paper is organized as follows. The model is described in section 2. In section 3, two polar cases are analyzed: autarky (prohibitive trade costs) and free trade (zero trade costs). This gives a first explanation of how firms manage the cannibalization effect. Section 4 is dedicated to equilibrium prices and the supply of varieties. More specifically, we analyze how trade integration can affect prices, product differentiation and product range when the location of plants is fixed. In section 5, we determine the conditions under which firms decide strategically to become multinational or to serve the foreign market via exports. Finally, in section 6, we draw some conclusions.

2 A two-country model of multi-product competition with endogenous product differentiation

The basic structure. Consider an economy with two countries ($r = H$, F) and two rival firms ($f = A$, B). We consider one firm per nation: the headquarter plant of firm A (resp. B) is always located in country H (resp. F). Each firm supplies the same variety in their home country and in the foreign country.[3] Each unit of a variety is carried between the two countries at a positive specific cost t. This trade cost is borne by firms and includes transport, tariffs, customs, bureaucracy, and any other socio-legal constraints associated with selling in a foreign environment. The firms practice third degree price discrimination without the threat of arbitrage by consumers.
Each firm may be multi-product but, for the sake of convenience, it can supply at most two products/varieties. Each rival firm has either one plant located in their home country which produces at most two varieties or two plants, one located in each country, each producing one variety. Each variety i can be described by a set of technical characteristics, x_i, which are positioned along a line in the tradition of Hotelling (1929) with $x_i \in [0, 1]$. Notice that x_i is not specific to a country. Since at most four varieties can be produced, we have i =*1,2,3,4* (at most four varieties are available in the economy). Moreover, we assume, without loss of generality, that $0 \leq x_1 \leq x_2 \leq x_3 \leq x_4 \leq 1$.
Technology. Firms use the same technology which implies the following cost function: $cq_f + \Phi$ where Φ is a sunk fixed cost, q_f the total output of each firm f, c a constant marginal cost which is normalized at 0 ($c = 0$), without loss of generality. Note that, in order to focus on the role of product differentiation, we assume that there is no additional sunk cost due to the introduction of a new variety and that the cost of production of any particular variety is the same for each firm, regardless of the number of varieties that it may produce. When a firm exports from its home country we have $\Phi = \Phi_N$ while $\Phi = \Phi_N + \Gamma$ when the firm is multinational and produces in both countries. In fact, Φ_N can be viewed as a firm-specific

[2]These results are obtained by performing a probit analysis since the authors test the investment decision itself. However, empirical studies on the level of foreign activities show that trade costs have a signifcantly positive effect on the relative importance of affiliate sales (see Navaretti and Venables, 2004 and Neary, 2005).
[3]See Ojah and Monplaisir (2003) or Iacovone and Javorcik (2008) for empirical evidence.

cost as in Horstman and Markusen (1992), *i.e.* a cost resulting from specific assets developed by the firms and, in a wider extent, based on R&D. Furthermore, Γ is a positive plant-specific cost borne by the firms for the creation of a foreign subsidiary. This cost can come from the transfer of firm-specific assets abroad and from the entry into the foreign market.

Demand. Consumers are assumed to have different tastes, which can be represented by a position along the same line as that describing the technology. Thus, in each country $r = H, F$, the consumers are located, according to their preferences, on the interval $[0, 1]$ with a uniform density Δ_r. We assume that this density is the same for both markets ($\Delta_H = \Delta_F = 1$), which are thus the same size. When consumer j in country r consumes one unit of variety i, her/his preferences are represented by the following indirect utility function:

$$V_{rj} = R - (x_i - x_j)^2 - p_{ri} \tag{1}$$

where R is the individual income, which is the same for all consumers in the two countries, $x_j \in [0, 1]$ the technical characteristic of the ideal good of this consumer, x_i is the technical characteristic of variety i, and p_{ri} is its selling price in country r. The term $(x_i - x_j)^2$ measures the disutility incurred by consumer j when s/he consumes a variety other than her/his ideal product. Product i is effectively purchased by this consumer as soon as its purchase leads to a maximum level of indirect utility with respect to other products supplied and as long as the value of the utility function is positive. We assume that each consumer always buys one unit of a variety. Notice that x_j is not specific to a country because we assume that the structure of preferences is identical in both countries. However, because of trade costs, the price of a variety (p_{ri}) varies according to the country in which the consumer lives so that the indirect utility is specific to a consumer and to a country.

A consumer chooses good i if her/his utility is higher than the one s/he would get by consuming of another product such as $i + 1$ or $i - 1$. As a result, all consumers located in the interval $[0, x_{r12}]$ (resp., $[x_{r12}, x_{r23}]$, $[x_{r23}, x_{r34}]$, and $[x_{r34}, 1]$) will address their demand to the producer of variety *1* (resp., *2*, *3* and *4*), where $x_{r,i,i+1}$ corresponds to the set of technical characteristic that is most preferred by the consumers who are indifferent between purchasing good i or $i+1$ given prices p_{ri} and p_{ri+1} and technical characteristic x_i and x_{i+1}. Thus, from (1), we obtain:

$$x_{ri,i+1} = \frac{p_{ri+1} - p_{ri}}{2(x_{i+1} - x_i)} + \frac{x_{i+1} + x_i}{2}$$

for each country. Therefore, the demand for each variety i =*1,2,3,4* prevailing in country r is expressed as follows:

$$q_{r1} = x_{r12} - 0 = \frac{p_{r2} - p_{r1}}{2(x_2 - x_1)} + \frac{x_2 + x_1}{2} \tag{2}$$

$$q_{r2} = x_{r23} - x_{r12} = \frac{p_{r3} - p_{r2}}{2(x_3 - x_2)} - \frac{p_{r2} - p_{r1}}{2(x_2 - x_1)} + \frac{x_3 - x_1}{2} \tag{3}$$

$$q_{r3} = x_{r34} - x_{r23} = \frac{p_{r4} - p_{r3}}{2(x_4 - x_3)} - \frac{p_{r3} - p_{r2}}{2(x_3 - x_2)} + \frac{x_4 - x_2}{2} \tag{4}$$

$$q_{r4} = 1 - x_{r34} = 1 - \frac{p_{r4} - p_{r3}}{2(x_4 - x_3)} - \frac{x_3 + x_4}{2}. \tag{5}$$

Type of product competition. Without loss of generality, we assume that firm A always produces variety *1*. Nevertheless, this firm can also choose to produce a second variety among

varieties *2*, *3* or *4*. Hence, three types of product competition may arise (see Figure 1): (i) *head-to-head competition*: firm A also produces variety *2* so that varieties *3* and *4* belong to firm B; (ii) *interlaced competition*: firm A produces varieties *1* and *3* whereas varieties *2* and *4* are supplied by firm B. In this case, the best substitutes are supplied by both rivals; (iii) *surrounded competition*: firm A produces varieties *1* and *4*. In this case, the worst substitutes are produced by firm A. Ideally, one would determine the choice of varieties produced by each firm (or, equivalently, among the three types of competition) by using a game theory approach (see for example Klemperer, 1992). However, it is straightforward to check that head-to-head competition is the configuration that dominates the two others.[4] Therefore, throughout this paper we consider that head-to-head competition prevails, regardless of trade costs. It is worth stressing that under head-to-head competition, the choice of each firm to produce a single variety or two varieties is endogenous. More precisely,

Definition 1. *Firms are single-product when* $x_1 = x_2$ *and* $x_3 = x_4$.

Definition 2. *Firms are multi-product when* $x_1 < x_2$ *and* $x_3 < x_4$.

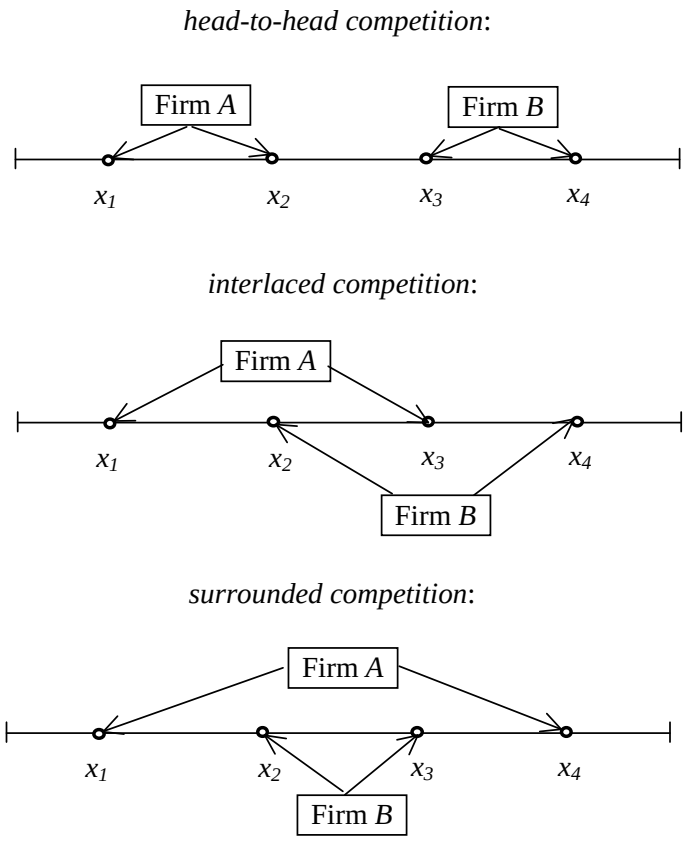

Figure 1. Types of product competition

Types of trade. From the previous assumptions, three types of international relationships can emerge: (i) *NN-configuration*: both firms are N-type, *i.e.* each firm exports from its home

[4]We do not provide details of calculations but this result is very intuitive. Indeed, observe that the interlaced competition is equivalent to the configuration of four firms producing a single product while the surrounded competition is equivalent to a configuration in which two single-product firms compete with a multi-product firm. As a result, the price competition is more aggressive under these two configurations (especially under the interlaced competition) than under head-to-head competition. Consequently, the second type of product competition always provides the highest profits for both rivals.

country to serve the foreign market. In this case, the intra-industry trade occurs while no FDI takes place; (ii) *MM-configuration*: both firms are M-type, that is each sets up a second plant abroad. Hence, cross-hauling FDI in the same industry prevails; (iii) *NM-configuration*: one firm is N-type while its rival is M-type. Under this asymmetric configuration, one country exports and has inward FDI while the other country imports with outward FDI.
Under the symmetric MM-configuration, international trade is not an outcome when each multinational becomes single-product. Indeed, the same variety is produced at home and abroad. In other words, intra-industry trade and cross-hauling FDI are substitutes when multinationals are single-product. Thus, intra-industry trade and cross-hauling FDI emerge simultaneously only if multinationals are multi-product.
Sequence of events. Like DeFraja and Norman (2004) and Mathieu (1997), we represent competition between firms by a three-stage game: 1) type of internationalization; 2) product specification; and 3) price competition. The decisions are taken simultaneously by the two firms in each stage depending on the choices made in the previous stages. The solution concept is a subgame perfect Nash equilibrium. In stage one, each firm decides either to produce their varieties at home (N-type) or to be multinational (M-type).[5] In the second stage, each rival chooses the technical characteristic of its varieties. In this way, each firm determines the number of varieties to be supplied and their degree of differentiation. These two elements characterize the product range of both firms. In the last stage, the prices of each variety are set in a Bertrand competition sub-game. The order of the three stages can be justified by the fact that prices are more flexible than the product specifications and plant location is less flexible than the product specification. This sequential game is solved, as usual, by backward induction. Thus, the perfect Nash equilibrium in pure strategies is obtained by solving the decision whether or not to produce abroad that maximizes the firms' profits, knowing the equilibrium prices and product ranges.

3 Two polar trade regimes: autarky and free trade

To understand how the decision to become multi-product and trade costs interact, we begin our analysis with two polar cases. We first consider the case when countries are in autarky configuration due to prohibitive trade costs (one firm per country). We then investigate the regime of free trade (trade costs are zero). No FDI is observed in either case and international trade occurs only in the second case. We analyze how the two firms manage the cannibalization effect in these two polar cases.

3.1 Autarky equilibrium under contestability

Despite openness to trade, autarky can be an equilibrium in our model. Such a regime can occur when the equilibrium price of the closest substitute of variety *2* (resp., *3*) produced by the rival, *i.e.* variety *3* (resp., *2*), cannot cover trade costs. In other words, we have $p_{H3} \leq t$ and $p_{F2} \leq t$. Hence, both markets have a monopoly structure. However, neither

[5] The configuration in which each firm produces all its own varieties in the foreign country is never an outcome because of the positive costs of multinationalisation (Γ).

firm fully behaves as a monopolist because of the existence of an entry threat from its rival. Each domestic market is contestable in the way defined by Baumol *et al.* (1988), even if the market contestability is not perfect. Trade costs act as a barrier to entry for the foreign firm. In this case, the profits of firm A (located in country H) and firm B (located in country F) are given by $\pi_A = p_{H1}q_{H1} + p_{H2}(1 - q_{H1}) - \Phi_N$ and $\pi_B = p_{F3}q_{F3} + p_{F4}(1 - q_{F3}) - \Phi_N$, respectively, where $p_{F2} = t$ and $p_{H3} = t$. Moreover, p_{H2} and p_{F3} are determined so that both markets are cleared or, equivalently, so that we have $x_{H23} = 1$ and $x_{F23} = 0$. Concerning variety *1*, firms A sets the price of this variety in order to maximize its profit, knowing the price of the other variety (*2*). The same principle is applied to determine the equilibrium price of the variety *4* by firm B. These equilibrium prices are given in Appendix A.1. They are then determined under the assumptions that $p_{F2} = t$ and $p_{H3} = t$ and that both markets are cleared. At these optimal prices, the differentiation of firm A's profit with respect to x_1 and x_2 gives the following expressions:

$$\begin{aligned} \frac{d\pi_A}{dx_1} &= -\frac{(x_1 + x_2)(3x_1 - x_2)}{8} \\ \frac{d\pi_A}{dx_2} &= \frac{(4 - x_2 - x_1)(4 - 3x_2 + x1)}{8} > 0 \end{aligned} \tag{6}$$

with $d^2\pi_A/dx_1^2 \leq 0$ and $d^2\pi_A/dx_2^2 \leq 0$. For firm B, first order conditions are identical, except that $x_4 = 1 - x_1$ and $x_3 = 1 - x_2$. As a result, regardless of the values taken by x_1 and x_4, $d\pi_A/dx_2 > 0$ and $d\pi_A/dx_3 < 0$. Since we must have $x_2 \leq x_3$, it appears that the optimal technical characteristic for varieties 2 and 3 are $x_2^* = x_3^* = 1/2$. In words, *the principle of minimum differentiation between the closest substitutes produced by the two rivals prevails when each rival is the only supplier on its contestable domestic market.* In addition, it is profitable for each firm to supply a second variety because $d\pi_A/dx_1 = 0$ and $d\pi_B/dx_4 = 0$ imply $x_1^* = x_2^*/3 = 1/6$ and $x_4^* = 5x_3^*/3 = 5/6$.[6] Hence, when trade costs are prohibitive, the revenue effect offsets the cannibalization effect and the intra-firm product differentiation is lower than the inter-firm product differentiation ($x_4^* - x_3^* = x_2^* - x_1^* > x_3^* - x_2^*$).
To summarize,

Proposition 1 *Assume two firms which may be multi-product and produce exclusively in their own country. Under autarky with contestable domestic markets, each firm takes the opportunity to produce a second variety and the product differentiation between the closest substitutes produced by the rival is minimum.*

3.2 Free trade equilibrium

Now consider the free trade regime ($t = 0$). The two firms, which may each produce at most two varieties, now compete on a market that is twice as large. Since the creation of a new plant abroad implies a positive fixed cost, no FDI occurs. Therefore, in this two-stage

[6] Notice that this result does not hold when domestic markets are uncontestable because there is no impact of foreign competition on the price setting. Without constestability, the monopolist produces a single product and chooses any variety. There is no incentive to produce a new variety even if the production costs remains constant.

sub-game, each firm chooses the technical characteristic of its varieties in the first stage and, second, the prices of the varieties are set in a Bertrand competition. For notational simplicity, we drop the subscript r since no ambiguity can arise. The profits are expressed as follows $\pi_A = 2(p_1q_1 + p_2q_2) - \Phi_N$ and $\pi_B = 2(p_3q_3 + p_4q_4) - \Phi_N$. By using (2), (3), (4) and (5), the application of the first order conditions on profit functions leads to the Nash equilibrium in prices, given in Appendix A.2. At optimal prices, the differentiation of firm A's profit with respect to x_1 gives the following expression:

$$\frac{d\pi_A}{dx_1} = -\frac{(x_1 + x_2)(3x_1 - x_2)}{8} \tag{7}$$

with $d^2\pi_A/dx_1^2 \leq 0$. Hence, the optimal technical characteristics for firm A are $x_1^* = x_2/3$ and $x_2^* = 0$ because

$$\left.\frac{d\pi_A}{dx_2}\right|_{x_1=x_1^*} = \frac{-(2 + x_3 + x_2)(2 + 3x_2 - x_3)}{18} < 0 \tag{8}$$

and $d^2\pi_A/dx_2^2 \leq 0$.
For firm B, differentiation of the profit function with respect to x_3 is given by

$$\frac{d\pi_B}{dx_4} = \frac{(2 - x_3 - x_4)(-3x_4 + x_3 + 2)}{8}$$

with $d^2\pi_B/dx_4^2 \leq 0$. The optimal technical characteristic for firm B are $x_4^* = (2 + x_3)/3$ and $x_3^* = 1$. Indeed, we have

$$\left.\frac{d\pi_B}{dx_3}\right|_{x_4=x_4^*} = \frac{(4 - x_3 - x_2)(4 + x_2 - 3x_3)}{18} > 0 \tag{9}$$

and $d^2\pi_B/dx_3^2 \leq 0$.
As a consequence, the Nash perfect equilibrium corresponds to $x_1^* = x_2^* = 0$ and $x_3^* = x_4^* = 1$ whereas equilibrium prices are given by $p_1^* = p_2^* = p_3^* = p_4^* = 1$. Hence, the profits are expressed as follows:

$$\pi_A = \pi_B = 1 - \Phi_N \tag{10}$$

The differentiation between the two varieties produced by each firm is minimum so that there is competition between two single-product exporters. Each firm is single-product because the price competition between varieties produced by rival firms is so aggressive that it dominates the revenue effect arising from an additional variety. Hence, *each firm prefers to choose the largest differentiation with respect to the varieties produced by its rival even if each company must stop producing its second variety.* Our result is close to the conclusion reached by Martinez-Giralt and Neven (1988). Indeed, in a shopping model where two firms supplying a homogenous good competing in price can locate two outlets along a linear city (in the tradition of Hotelling, 1929), they show that each firm prefers to eliminate one of its outlets in order to be maximally differentiated from its rival. Similar mechanisms are at work in our model.
To summarize,

Proposition 2 *Assume that firms may be multi-product. Under free trade, each firms supplies a single variety and the product differentiation is maximum.*

4 Equilibrium price and product range with international trade (stage 2 and 3)

In this section, we analyze the optimal price and product strategies of each firm, strategies corresponding to the stages two and three of our game described in section 2. Now, each firm can discriminate in price internationally (markets are segmented) and faces positive trade costs that lead to partial trade integration and reduce international competition. Consequently, the principle of maximum differentiation between varieties produced by rivals prevailing under free trade can be challenged. By relaxing price competition, positive trade costs allow firms to be multi-product. Optimal prices and product characteristic must be determined for each of the three following configurations that may arise in stage one of the game: (i) both firms export from their home country (NN-type); (ii) both firms are multinational (MM-type), the two symmetric configurations; (iii) only one firm is multinational while the other exports (MN-type), the asymmetric configuration. The equilibrium profits are also calculated in each case since their comparison allows us to determine the perfect Nash equilibrium in stage one of the game. In the next section, we will see that each of these three configurations can be a perfect Nash equilibrium.

4.1 Firms produce exclusively in their domestic country (NN-type)

For each firm, varieties are produced and sold at home and exported abroad. Therefore, in this configuration, no FDI takes place. However, tariff protection distorts competition and two opposite mechanisms are at work. First, trade barriers give an advantage to the domestic firm on its home market. Second, these barriers reduce the firm's access to the foreign market. The first mechanism alters the principle of maximum differentiation in order to increase the local market shares. In this way, it may be profitable for each rival to introduce a second variety (a revenue effect appears in this case). Conversely, the second mechanism favors maximum differentiation in order to limit the decline of the market share abroad. In fact, when the trade barriers are sufficiently high, the first mechanism prevails over the second and both firms are multi-product.
The profit functions for firms A and B are given by, respectively

$$\pi_A^{NN}(t) = p_{H1}q_{H1} + (p_{F1} - t)q_{F1} + p_{H2}q_{H2} + (p_{F2} - t)q_{F2} - \Phi_N \quad (11)$$

$$\pi_B^{NN}(t) = p_{F3}q_{F3} + (p_{H3} - t)q_{H3} + p_{F4}q_{F4} + (p_{H4} - t)q_{H4} - \Phi_N. \quad (12)$$

The profit maximizing prices for firms A and B are reported in Appendix A.3. Exports are profitable if and only if $p_{F2} - t > 0$ and $p_{H3} - t > 0$ (since $p_{F2} \leq p_{F1}$ and $p_{H3} \leq p_{H4}$) or, equivalently,

$$t < t_2^{\max} \equiv (x_3 + x_2 + 2)(x_3 - x_2) \in [0, 3] \quad (13)$$

$$t < t_3^{\max} \equiv (4 - x_3 - x_2)(x_3 - x_2) \in [0, 3]. \quad (14)$$

Knowing equilibrium prices, firm A's profit differentiation with respect to x_1 is given by (7) (up to a constant) so that $x_1^* = x_2/3$. Given the last equality, the profit differentiation with

respect to x_2 is expressed as follows:

$$\left.\frac{d\pi_A}{dx_2}\right|_{x_1=x_1^*} = \frac{t^2-\Lambda_A}{9(x_3-x_2)^2} \tag{15}$$

where

$$\Lambda_A \equiv (x_3-x_2)^2[4+8x_2-4x_2^2-(x_3-x_2)^2] \in (0, t_2^{\max}).$$

Similar expressions are obtained for firm B. Indeed, solving the first order conditions for variety *4* ($d\pi_B/dx_4 = 0$) leads to $x_4^* = (2+x_3)/3$ and, then, we have

$$\left.\frac{d\pi_B}{dx_3}\right|_{x_4=x_4^*} = \frac{t^2-\Lambda_B}{9(x_3-x_2)^2} \tag{16}$$

where

$$\Lambda_B \equiv (x_3-x_2)^2[8-4x_3-(x_3-x_2)^2] \in (0, t_3^{\max}).$$

Two sub-cases must be distinguished according to the level of trade costs, to determine the optimal technical characteristics of varieties *2* and *3*.

a. Like under free trade, low trade costs imply maximum product differentiation between varieties produced by the rivals. More precisely, the outcome $x_1^* = x_2^* = 0$ and $x_3^* = x_4^* = 1$ remains an equilibrium if and only if $t < \underline{t} \equiv \sqrt{3}$ where $\underline{t} < t_i^{\max}$ (with i = *2,3*). Indeed, the expressions of profit differentiation are given by

$$\left.\frac{d\pi_A}{dx_2}\right|_{x_1=x_2=0} = -\left.\frac{d\pi_B}{dx_3}\right|_{x_3=x_4=1} = \frac{t^2}{9}-\frac{1}{3}$$

and is negative (resp. positive) for firm A (resp. firm B) when $t < \underline{t}$. Consequently, each firm becomes single-product when trade costs reach low values. In other words, when trade costs are low enough, the minimum differentiation between varieties *1* and *2* holds even though the variety produced by the foreign rival is imported with positive trade costs. Hence, equilibrium prices of varieties *1* and *2* are as follows:

$$p_{H1}^* = p_{H2}^* = 1+t/3 \text{ and } p_{F1}^* = p_{F2}^* = 1+2t/3 \tag{17}$$

and, by symmetry, the equilibrium prices of varieties *3* and *4* are given by $p_{F3}^* = p_{F4}^* = p_{H2}^*$ and $p_{H3}^* = p_{H4}^* = p_{F2}^*$, respectively. As a result, the domestic demand to each firm is given by $q_H^A = q_F^B = (1+t/3)/2 > 1/2$ while the foreign demands are $q_F^A = q_H^B = 1-q_H^A < 1/2$ when $t < \underline{t}$. Trade costs imply that the price at home is lower than the price abroad and correlatively that domestic sales are higher than foreign sales. Finally, the profits of each firm are equal and are given by $\pi_A^{NN}(t<\underline{t}) = \pi_B^{NN}(t<\underline{t}) = \Pi^{NN}(t<\underline{t}) - \Phi_N$ with

$$\Pi^{NN}(t<\underline{t}) \equiv 1+t^2/9. \tag{18}$$

When trade costs cross below $\underline{t}$, overall profits decline, even if operating profits arising from exports increase. In fact, the total sales $(q_{r1}+q_{s1})$ remain constant whereas the average price decreases because of fiercer price competition between the rivals.

b. When trade costs are high enough ($t > \underline{t}$) the maximum differentiation does not hold, like under autarky with contestability. Each firm has an incentive to produce a second variety due

to the advantage each firm has in its domestic market. The positive revenue effect dominates the competition effect when trade integration is weak. From the first order conditions for varieties *1* and *4*, we have $x_1^* = x_2/3$ and $x_4^* = (2 + x_3)/3$ while the first order conditions for varieties *2* and *3* now imply that $x_2^* > 0$ and $x_3^* = 1 - x_2^*$ when $t > \underline{t}$. However, given constraints (13) and (14), we must have $x_2^* < 1/2 - t/6$ and $x_3^* > 1/2 + t/6$ or, equivalently, $\underline{t} < 3(1 - 2x_2^*)$. As a result, we have $(3 - \sqrt{3})/6 > x_2^* > 0$ and $1 > x_3^* > (3 + \sqrt{3})/6$ when $t_i^{\max} > t > \underline{t}$. It is worth stressing that because $(3 - \sqrt{3})/6 \approx 0.21$, intra-firm product differentiation is less than inter-firm product differentiation, contrary to the autarky regime with contestable domestic markets. This reveals that price competition remains strong even though national economies are weakly integrated.
The equilibrium prices of each variety are now as follows:

$$\begin{aligned} p_{H1}^* &= 1 + t/3 + (x_2^*)^2/2 - 2x_2^* = p_{F4}^*, \quad p_{H2}^* = 1 + t/3 - 2x_2^* = p_{F3}^*, \\ p_{F1}^* &= 1 + 2t/3 + (x_2^*)^2/2 - 2x_2^* = p_{H4}^*, \quad p_{F2}^* = 1 + 2t/3 - 2x_2^* = p_{H3}^*. \end{aligned} \tag{19}$$

The introduction of a new variety by each rival reduces the equilibrium prices of the initial variety produced by each firm. The principle of reciprocal dumping is still valid as in Brander and Krugman (1983) when oligopolistic firms become multi-product. Each firm has a smaller markup for each variety in its export market than at home. However, the difference between the f.o.b price for exports and the domestic price for each variety is less than trade costs and is not affected by the intra-firm product differentiation.
In addition, the price wedge between varieties belonging to each firm depends only on the degree of intra-firm product differentiation because we have $p_{r2}^* - p_{r1}^* = -(x_2^*)^2/2$ and $p_{r3}^* - p_{r4}^* = -(1 - x_3^*)^2/2$. This means that increasing intra-firm product differentiation increases the market share of the first variety in the domestic country, regardless of trade costs ($q_{H1}^* = x_2^*/3$) as well as the domestic market share of the second variety when $t > \underline{t}$ ($q_{H2}^* = 1/2 + t/[6(1 - 2x_2^*)] - x_2^*/3 > (1 + t/3)/2$ and $q_{F2}^* = 1 - q_{H2}^*$). Similar expressions are valid for firm B. Consequently, the production of a new variety by a firm raises the level of demand in its domestic market and by symmetry reduces its market share in the foreign country. Thus, the revenue effect due to the introduction of a new variety only works in the domestic market.
Hence, when $t_i^{\max} > t > \underline{t}$, given equilibrium outputs ($x_1^* = x_2^*/3$, $x_3^* = 1 - x_2^*$ and $x_4^* = (3 - x_2^*)/3$) as well as equilibrium prices, the profit of each firm is given by $\Pi^{NN}(t > \underline{t}) - \Phi_N$ with

$$\Pi^{NN}(t > \underline{t}) \equiv 1 + \frac{t^2}{9(1 - 2x_2^*)} + \frac{8(x_2^*)^3}{27} - 2x_2^* \tag{20}$$

where $\Pi^{NN}(t > \underline{t}) \in (1, 1 + t^2/9)$ when $t_i^{\max} > t > \underline{t}$.
To summarize,

Proposition 3 *Assume that each firm exports to serve the foreign market. When trade costs are high enough, each firm is multi-product. When trade costs are low, both rivals are single-product.*

Hence, when firms export, high trade costs favor the emergence of multi-product firms. High tariff barriers distort competition so that the cannibalization effect is weak. In this context,

each firm has an incentive to be multi-product due to the increase in domestic revenues which are higher than the fall in revenues from foreign sales. However, when trade costs shrink, the cannibalization effect becomes stronger so that intra-firm product differentiation decreases. When trade costs become low enough, firms become single-product.

4.2 Firms are multinational (MM-type)

We now consider the case where each firm is a multinational. A second plant is now located abroad. At most, four varieties can be produced and traded with a positive trade cost. Without loss of generality, variety *1* is always produced in the home country of firm A whereas variety *2* is produced abroad. For firm B, two cases can be studied. The first case corresponds to the configuration in which firm B produces variety *4* in its home country and variety *3* in the foreign country. This case means that the production of the best substitute for variety *3* produced by the rival (variety *2*) does not occur in the same country. The other case implies that the production of the best substitute for variety *3* produced by the rival (variety *2*) takes place in the same country. Both cases lead to maximum differentiation between varieties produced by rival firms. Consequently, we present only the first case where price competition is less fierce.
When varieties *1* and *3* are produced in country H whereas varieties *2* and *4* are produced in country F, the expressions of the profits are:

$$\pi_A^{MM}(t) = p_{H1}q_{H1} + (p_{F1} - t)q_{F1} + (p_{H2} - t)q_{H2} + p_{F2}q_{F2} - \Phi_M \tag{21}$$
$$\pi_B^{MM}(t) = p_{H3}q_{H3} + (p_{F3} - t)q_{F3} + (p_{H4} - t)q_{H4} + p_{F4}q_{F4} - \Phi_M. \tag{22}$$

At equilibrium prices (given in Appendix A.4), the differentiation of firm A's profit with respect to x_1 is given by (7) (up to a constant) so that $x_1^* = x_2/3$. Given the last equality, the expression of profit differentiation for firm A with respect to x_2 is now given by

$$\left.\frac{\mathrm{d}\pi_A^{MM}}{\mathrm{d}x_2}\right|_{x_1=x_1^*} = \frac{-\Lambda_A^2 - 2t^2}{9(x_3 - x_2)^2} < 0.$$

The first order condition for firm B ($\mathrm{d}\pi_B/\mathrm{d}x_4 = 0$) gives $x_4^* = (2 + x_3)/4$ while the profit differentiation for firm B with respect to x_3 gives:

$$\left.\frac{\mathrm{d}\pi_B^{MM}}{\mathrm{d}x_3}\right|_{x_4=x_4^*} = \frac{\Lambda_B^2 + 2t^2}{9(x_3 - x_2)^2} > 0 \tag{23}$$

Hence, $\mathrm{d}\pi_B/\mathrm{d}x_3 > 0$ and $\mathrm{d}\pi_A/\mathrm{d}x_2 < 0$, regardless of trade costs. In other words, x_2 tends towards 0 while x_3 tends towards 1. However, each firm becomes single-product before that cannibalization effect becomes total. Consequently, competition between single-product firms occurs so that product differentiation is maximum. Indeed, we have $x_1^* = x_2^* = 0$ and $x_3^* = x_4^* = 1$ and equilibrium prices are $p_{ri}^* = 1$ with $r = H, F$ and i =*1,..,4*. In other words, rival firms have the same market share in the two countries. Consequently, the equilibrium profits are expressed as follows:

$$\pi_A^{MM} = 1 - \Phi_M = \pi_B^{MM}. \tag{24}$$

Despite the trade barriers, the product differentiation is maximum among varieties produced by rival firms. When firms produce in both countries, the competition distortion arising from trade barriers is very weak. Because of direct investments, no domestic market is protected from international competition. Therefore, whatever the level of trade integration, each MNF does not take up the opportunity to be multi-product and the principle of maximum differentiation among rival varieties holds.
To summarize,

Proposition 4 *Assume that both firms are multinational. Whatever the level of trade costs, each firm is single product and the product differentiation is maximum so that no intra-industry trade occurs.*

Hence, the same product is produced and sold in both markets/countries by each MNF. Thus, foreign investments and exports are substitutes. More precisely, this implies that when cross hauling foreign investments takes place, no international intra-industry trade occurs. This result is discussed below.
Additionally, operating profits in domestic and foreign markets are identical for each firm. However, the fixed cost associated with the domestic production is lower than the fixed cost associated with the foreign production. Hence, each firm accepts a smaller profit for each unity of variety produced abroad than for that produced at home. Thus, in the sense of Baldwin and Ottaviano (2001), the two-way FDI can be viewed as reciprocal FDI dumping.

4.3 Asymmetric configuration (MN-type)

Now we assume that only one firm must export to serve the foreign country (say firm A) while the other firm (firm B) is multinational so that varieties *1* and *2* are always produced in country H. The profit function of firm A is given by (11). For firm B, it is straightforward to demonstrate that the multinational prefers to produce variety *3* in its home country and, thus, to produce variety *4* in country H.[7] By producing variety *3* in country F and not variety *4*, it can enjoy a higher level of market power at home. Trade barriers reduce the price competition between varieties *2* and *3*. Hence, the profits of the multinational are given by

$$\pi_B^{NM}(t) = p_{F3}q_{F3} + (p_{H3} - t)q_{H3} + (p_{F4} - t)q_{F4} + p_{H4}q_{H4} - \Phi_M.$$

As under the configuration in which both firms export, three subcases must be distinguished according to the level of trade costs, to determine the optimal technical characteristics of varieties.
(a) When trade costs reach low values ($t < 1$), it is straightforward to check that $x_1^* = x_2^* = 0$ and $x_3^* = x_4^* = 1$ is always an equilibrium. Low trade costs increase price competition so that firms become single-product and product differentiation is maximum even though asymmetry

[7] Indeed, under the configuration in which firm B produces variety *3* in country H, its profit function is given by (22). It appears that $\mathrm{d}\pi_A^{NM}/\mathrm{d}x_2 < 0$ and $\mathrm{d}\pi_B^{NM}/\mathrm{d}x_3 > 0$ so that the product differentiation is maximum between varieties *2* and *3* because the price competition between rivals prevailing in country H is very aggressive. However, we also have $\mathrm{d}\pi_B^{NM}/\mathrm{d}x_4 < 0$ whereas we must have $x_3 \leq x_4$. This means that the multinational company has an incentive to produce variety *3* in its home country and variety *4* abroad.

exists. Indeed, in this sub-case ($t < 1$), equilibrium prices are given by $p^*_{H1} = p^*_{H4} = 1$, $p^*_{F1} = 1 + 2t/3$ and $p^*_{F4} = 1 + t/3$ while expressions of equilibrium output are expressed as follows: $q^A_H = q^B_H = 1/2$, $q^A_F = (1 - t/3)/2$ and $q^B_F = 1 - q^A_F$. As a result, equilibrium profits for firms A and B are given by

$$\pi^{NMa}_A = [1 + (1 - t/3)^2]/2 - \Phi_N \quad (25)$$
$$\pi^{NMa}_B = [1 + (1 + t/3)^2]/2 - \Phi_M. \quad (26)$$

The operating profits are higher for the multinational because its domestic market F is protected by trade costs (firm A exports) while no firm has an advantage in country H. As a result, the multinational has the same market share in country H as its rival firm while its market share is higher in its home country.

(b) When trade costs are intermediate ($4/3 > t > 1$), the market share of variety *3* (resp., *4*) in country H (resp., F) is not positive. The production of one variety by the multinational in one country prevents imports of its other variety from the other country. For example, in country H, individuals prefer to consume variety *4* instead of variety *3* because the price wedge between these varieties is too high when trade costs are high enough. This is a "partial" cannibalization effect. This cannibalization effect does not lead to the production of a single variety by the MNF but eliminates the opportunity to sell the same variety in both countries. Consequently, when $4/3 > t > 1$, the nature of competition between the rivals changes. Indeed, in each market, the closest substitute of the varieties produced by the MNF is now a variety produced by its rival. Moreover, the cannibalization effect implies that no intra-firm trade occurs for the MNF even if this firm is a multi-product producer. In fact, the two countries are only linked by exports of varieties produced by firm A from country H to country F.

Let x^H_B (resp., x^F_B) the variety produced by firm B – the multinational – in country H (resp., country F) to serve exclusively this country. Now, we must have $x^H_B > x_2 > x_1$ and $x^F_B > x_2 > x_1$. It is not surprising to check that $d\pi^{NMb}_B/dx^H_B > 0$ and $d\pi^{NMb}_A/dx_2 < 0$, regardless of trade costs. Then, firm A becomes single-product ($x^*_1 = x^*_2 = 0$) and product differentiation between rival varieties produced in country H is maximum. Again, since no imports from country F prevail, the price competition is very fierce in country H.

Concerning the variety produced by the multinational and consumed exclusively in its home market (country F), its optimal technical characteristic is given by

$$x^F_B(t) = 2/3 + \sqrt{4 - 3t}/3 \in [2/3, 1]$$

when $t \in [1, 4/3]$ whereas the expression of its equilibrium price is $p^F_B = (4x^F_B(t) - x^F_B(t)^2 + t)/3$. Hence, the general expression of equilibrium profits is as follows:[8]

$$\pi^{NMb}_A = \Pi^{NMb}_A - \Phi_N \quad (27)$$
$$\pi^{NMb}_B = \Pi^{NMb}_B - \Phi_M \quad (28)$$

[8] Note that there is no discontinuity when the regime moves from case (a) to case (b). Indeed, when $t = 1$, $x^F_B(t) = 1$ and, thus, (27)=(25) as well as (28)=(26).

where

$$\Pi_A^{NMb} \equiv \frac{1}{2} + \left(\frac{2x_B^F(t) + x_B^F(t)^2}{3} - \frac{t}{3}\right)^2 \frac{1}{2x_B^F(t)} \tag{29}$$

$$\Pi_B^{NMb} \equiv \frac{1}{2} + \left(\frac{4x_B^F(t) - x_B^F(t)^2}{3} + \frac{t}{3}\right)^2 \frac{1}{2x_B^F(t)}. \tag{30}$$

Hence, when t varies from 1 to 4/3, $x_3^*(t)$ decreases, meaning that the market share of the multinational increases in its home country. As previously, increasing trade costs raise its market power, leading to a fall in the degree of product differentiation in country F while the degree of product differentiation is not affected in country H.

(c) Finally, when trade costs become high enough ($t > 4/3$), we now have $\mathrm{d}\pi_B^{MNc}/\mathrm{d}x_B^F < 0$. In this case, the multinational (firm B) has an incentive to reduce differentiation between its own varieties (x_B^F converge to zero). However, there exists a limit value of x_B^F ($\overline{x}_B^F$) below which no export of the variety produced by firm A from country H to country F takes place. This threshold value is given by $\overline{x}_B^F \equiv \sqrt{1+t} - 1$. Hence, when x_B^F reaches $\overline{x}_B^F$, the multinational becomes the only supplier in its home market. As in section 2, market F becomes contestable because of the entry threat from firm A. Then, the MNF does not fully behave as a monopolist. The optimal price under this configuration is given by $2x_B^F/3 + 2t/3 - 2(x_B^F)^2/3$. As a result, the optimal technical characteristic is given by $x_B^F = 1/2$. It is easy to check that $1/2 < \overline{x}_B^F$. This implies that, at equilibrium, firm A is single-product and does not export. Thus, equilibrium profits are given by

$$\pi_A^{NMc} = 1/2 - \Phi_N \tag{31}$$

$$\pi_B^{NMc} = 1/2 + (1/6 + 2t/3) - \Phi_M. \tag{32}$$

To summarize,

Proposition 5 *Assume that one firm must export to serve the foreign country while the other firm is multinational. When trade costs are low enough ($t < 1$), both firms are single product. When trade costs become sufficiently high ($t > 1$), the multinational becomes multi-product, while its rival remains single-product. In addition, trade is unilateral when $1 < t < 4/3$ and no trade occurs when $t > 4/3$.*

Two comments are in order. First, when $t > 4/3$, the profits of the firm producing in its home country do not only depend on trade costs because this firm does not serve the foreign country. Such a result also occurs when rivals are multinational firms (see section 4.2). Hence, contrary to Baldwin and Ottaviano (2001), the existence and the direction of intra-industry trade is affected by foreign direct investments. Second, the fact that firm A does not export, does not depend on the type of product competition (head-to-head competition, interlaced competition, and surrounded competition). Indeed, when trade costs are high enough, the choice of $x_B^F = 1/2$ (and the selling price) by the multinational (firm B) for its home product implies that its rival will never be able to find a technical characteristic that makes it profitable to export to serve country F.

5 Exports vs. FDI (stage one)

In this section, we first determine the perfect Nash equilibria or equivalently when firms decide to become multinational or national. The analysis of the results are reported in the next subsection.

5.1 Perfect Nash equilibrium

Four stage-one outcomes must be considered: NN outcome, MM outcome and two MN outcomes. We show below that these four outcomes can be of perfect Nash equilibria. Before determining the equilibrium outcome, it is worth stressing that *profits reach higher values when both firms export than when they are multinational.* Comparisons between (24) and (18) or (20) show that operating profits are higher when firms export whatever trade costs. Indeed, price competition is lower when rivals produce exclusively in their own country. Moreover, MNFs incur additional fixed costs (Γ) in setting up a subsidiary abroad.[9]
To solve the first stage of the game, it may be useful to use the following profit bimatrix:

Table 1. Profits of both firms $(\pi_A; \pi_B)$[10]

Firm A \ Firm B	N	M
N	$\Pi^{NN}(t) - \Phi^N$; $\Pi^{NN}(t) - \Phi^N$	π_A^{NMk}; π_B^{NMk}
M	π_A^{MNk}; π_B^{MNk}	$1-\Phi_N - \Gamma$; $1-\Phi_N - \Gamma$

where $k = \{a, b, c\}$ (see section 4.3).

Three types of perfect Nash equilibria can emerge: (**i**) both firms are multinational; (**ii**) both firms export from their home country; (**iii**) one firm is multinational while its rival produces exclusively at home. The type of equilibrium depends on trade costs (t) and the multinationalization cost (Γ). The conditions under which such equilibria emerge are detailed below.

(i) both firms are multinational (or two-way FDI). Given the results obtained in the previous section, it is useful to distinguish between three subcases, as in section 4.3, to determine conditions under which each firm produces in both countries: **(a)** $t \leq 1$, **(b)** $1 < t < 4/3$, **(c)** $4/3 \leq t$. Hence, the configuration in which both firms are multinational (MM-type) is a perfect Nash equilibrium if and only if:

$$\begin{array}{lcll} \Gamma & < & t/3 - t^2/18 \equiv \Gamma_a^M & \text{when } t \leq 1 \\ \Gamma & < & 1 - \Pi_A^{NMb} \equiv \Gamma_b^M \in (0, 1/2) & \text{when } 4/3 > t > 1 \\ \Gamma & < & 1/2 \equiv \Gamma_c^M & \text{when } t \geq 4/3 \end{array}$$

where $\Pi_A^{NMb} \in [1/2, 1)$ is the operating profit when a firm decides to export while its rival is a multinational (see (29)). The details of calculation are provided in Appendix B.1. By

[9] This result differs from that obtained in Baldwin and Ottaviano (2001). The authors show that there exist some conditions under which profits reach their highest levels when both firms are multinational. When product differentiation is endogenous, profits are always higher when both firms export.

[10] N is the strategy consisting in only producing in its home country and M is the strategy consisting in producing in both countries.

inspection, $\Gamma_a^M(t)$ and $\Gamma_b^M(t)$ increase with trade costs as long as $t < 4/3$ (see Figure 2). In other words, below a limit value of trade costs ($t = 4/3$), the MM configuration in which each firm is a multinational is a perfect Nash equilibrium becomes less and less likely when trade costs decline. When trade costs are high ($t \geq 4/3$), the existence of two-way FDI does not depend directly on the level of trade costs. Two reasons explain such a result. First, when both firms are multinational, neither firm exports so that equilibrium prices and ouputs are unaffected by trade costs (see section 4.2). Second, when a firm decides to produce exclusively in its home country when its rival is a multinational, the former firm does not export when $t > 4/3$ so that its profits do not depend on trade costs (see section 4.3.c). As a consequence, the limit value below which each firm remains a multinational when its rival also produces in both countries is not affected by trade costs as long as $t > 4/3$. Finally, it should be also noted that $\Gamma_b^M(4/3) = \Gamma_c^M$ and $\Gamma_a^M(1) = \Gamma_b^M(1)$ because $x_B^F(t) = 1$ (see Figure 2). In other words, the threshold value of Γ below which two-way FDI occurs displays no discontinuity.

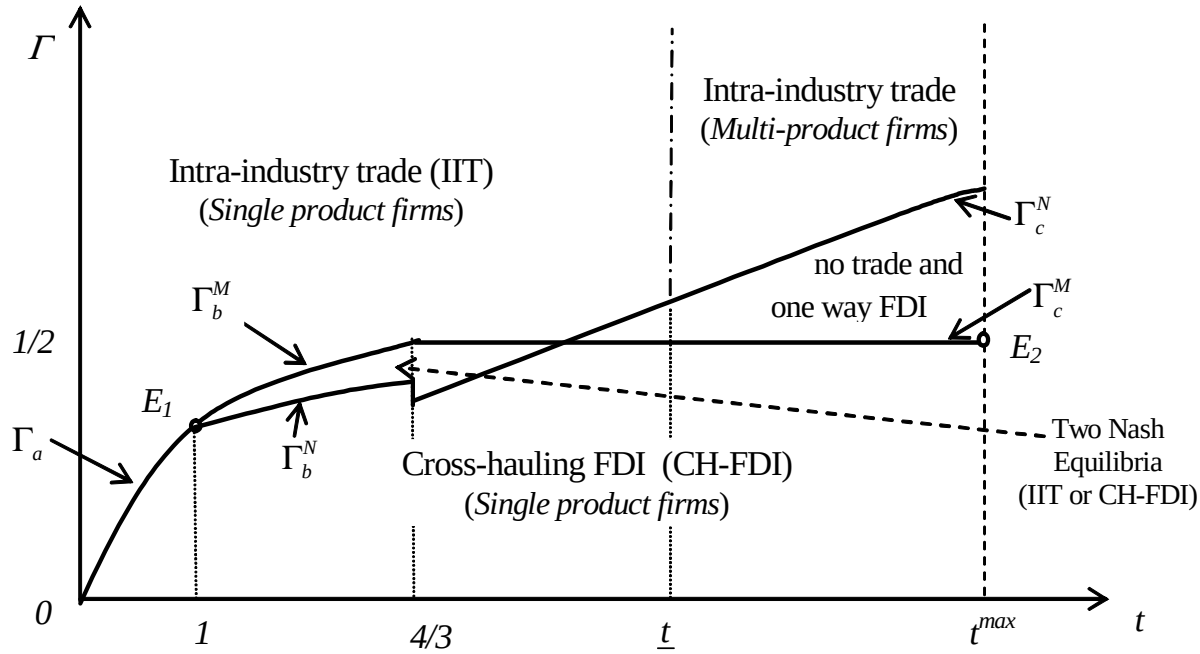

Figure 2. FDI vs. Exports

(ii) Both firms only produce in their home country. Again, the details of the calculations are provided in Appendix B.2. We have a Nash equilibrium where both firms export from their home country if and only if:

$$\begin{aligned}
\Gamma &> t/3 - t^2/18 \equiv \Gamma_a^N > 0 && \text{when } 1 \geq t \\
\Gamma &> \Pi_B^{MNb} - \left(1 + t^2/9\right) \equiv \Gamma_b^N > 0 && \text{when } 4/3 > t > 1 \\
\Gamma &> 2/3 + 2t/3 - \Pi^{NN}(t) \equiv \Gamma_c^N > 0 && \text{when } t \geq 4/3
\end{aligned}$$

where Π_B^{MNb} corresponds to the operating profits when a firm becomes multinational while its rival exports (see (30)). We also have $\Pi^{NN}(t) = 1 + t^2/9$ when $4/3 \leq t < \underline{t}$ and $\Pi^{NN}(t) \in [1, 1 + t^2/9]$ when $t > \underline{t}$. By inspection, we can check that Γ_a^N, Γ_b^N and Γ_c^N increase with trade costs. Hence, when $t > 4/3$, the limit value of Γ above which both firms produce only in their home country depends on trade costs contrary to the limit value of Γ below which both

firms are multinational (see Figure 2). Finally, it is easy to check that $\Gamma_a^N = \Gamma_b^N$ when $t = 1$ as well as $1/2 > \Gamma_c^N > \Gamma_b^N$ when $t = 1$ and that $\Gamma_c^N > 1/2$ when $t = t^{\max}$ (see Figure 2).

(iii) A single multinational firm (or one-way FDI). The configuration in which a firm is a multinational whereas its rival exclusively produces in its home country is a perfect Nash equilibrium if and only if $\Gamma_k^N > \Gamma > \Gamma_k^M$ with $k = a, b, c$. In fact, case a and b are not pertinent since the asymmetric configuration is never an equilibrium as long as $t < 4/3$. Trivial comparison shows that $\Gamma_a^N = \Gamma_a^M \equiv \Gamma_a$ when $t < 1$. Then, when $t \in (1, 4/3)$, it is easy to check that $\Gamma_b^N = \Gamma_b^M$ when $t = 1$ and $\Gamma_b^N < \Gamma_b^M$ when $4/3 > t > 1$. Finally, when $t \geq 4/3$, we have $\Gamma_c^N > \Gamma_c^M = 1/2$. However, by inspection, Γ_c^N increases with trade costs whereas Γ_c^M is unaffected by trade costs and there exists a range of trade costs for which $\Gamma_c^N > \Gamma_c^M$ (see Figure 2). In this case of asymmetric equilibrium, one firm produces exclusively in its home country. Indeed, as its rival is multinational, it cannot increase its profits by producing abroad itself because of high multinationalization costs (Γ). As a result, the competitive distortion is in favor of the multinational. The multinational firm acts as a contestable monopoly in its home market and is multi-product while its rival is single-product and does not export.
To sum up and as illustrated in Figure 2, we provide the following proposition.

Proposition 6 *Cross-hauling FDI emerges when* $\Gamma < \Gamma_a^M$ *and when* $\Gamma < \min\{\Gamma_k^M, \Gamma_k^N\}$ *with* $k = b, c$ *while intra-industry trade occurs when* $\Gamma > \Gamma_a^M$ *and when* $\Gamma > \max\{\Gamma_k^M, \Gamma_k^N\}$ *with* $k = b, c$. *When* $\Gamma_c^N > \Gamma > \Gamma_c^M$, *one-way FDI takes place while no trade emerges.*

5.2 Additional comments

Some comments are in order. First, even though the countries are identical ex-ante and the firms have the same technology, an asymmetric outcome can emerge when a firm becomes a multi-product multinational while its rival remains single-product. To the best of our knowledge, the theoretical literature shows that intra-industry FDI, either in homogeneous or differentiated products, is a two-way FDI. With our framework, our analysis reveals that *one-way FDI can emerge even if the countries and technologies of firms are identical.* Such a configuration arises when trade costs and multinationalization costs are high enough. Indeed, high trade costs induce that each firm has a strong incentive to also produce abroad, leading to higher profits. However, when a firm becomes multinational, its rival prefers to produce only in its home country because the increase in its operating profits from producing abroad are less than the cost of multinationalization. Hence, a different strategy is preferred by each firm. In other words, *one-way FDI corresponds to a chicken game.*
Second, when the multinationalization costs are low enough ($\Gamma < 1/2$), it appears that cross-hauling FDIs emerge if and only if trade costs are high enough (see Figure 2). Such a result is obtained by many theoretical models concerning the cause of horizontal FDI. However, our analysis reveals that *two-way FDI corresponds to a prisoner's dilemma game.* Despite the outcome that both rivals export leads to the highest levels of profits, it is rational for each firm to set up a second plant producing the same variety abroad in order to increase its market share in the foreign market. Consequently, the export strategy is dominated by the multinational strategy leading to fierce price competition.

Third, as long as $\Gamma > 1/2$, the relationship between trade and trade costs is non linear (see Figure 2). Indeed, intra-industry trade can occur when trade costs are high enough. Such a result may explain why the empirical relationship between trade costs and FDI is not clear-cut. For example, by performing a probit analysis, Brainard (1997) and Ekholm (1997) show that the probability of observing affiliate activity is not positively and significantly related to trade costs.[11] Neary (2005) proposes two explanations. First, foreign countries hosting foreign plants are export platforms to serve several countries belonging to the same trading bloc. Second, low trade costs favor cross-border mergers, which are quantitatively more important than greenfield FDI. Our explanation is based on the fact that firms are multi-product and decide strategically the degree of product differentiation. Indeed, each rival may prefer to export two products from its home country rather than to remain multinational for the following reason. By exporting to serve the foreign country, the firms benefit from the asymmetric competition introduced by high trade barriers while cross-hauling FDI implies that MNFs are single-product and price competition is fierce. If we had considered that firms were exclusively single-product, high trade barriers would have favored FDIs, as shown by Mathieu (1997) and, in this case, E_1 and E_2 would have merged into one in Figure 2. Hence, *high trade barriers do not necessarily trigger foreign direct investments.*

Finally, an important issue in the theory of the multinational firm is whether FDI and trade move together as complements or are substitutes. A plausible explanation of their complementarity is the fact that MNFs export intermediate goods to their foreign subsidiaries for the production of a final good, which is itself shipped back to the MNF's home country. In this context, a vertical FDI is more likely to be achieved with low trade costs rather than with high trade costs, (see, among others, Helpman, 1984; Markusen, 2002; Hanson *et al.*, 2006). However, Baldwin and Ottaviano (2001) show that the intra-industry trade and cross-hauling horizontal FDI can be complements by developing a model where two multi-product firms provide four imperfectly substitutable varieties. Since, by assumption, households consume all varieties, international trade occurs automatically when two-way FDI takes place. In our case, when intra-industry trade takes place, no cross-hauling FDI occurs, and vice-versa, even though firms may be multi-product. When each firm produces abroad, maximum differentiation between varieties produced by rival firms prevails. This means that, when the degree of product differentiation is a strategic variable, *horizontally integrated multinational corporations do not appear to simultaneously undertake both cross-hauling FDI and intra-industry trade between parent and affiliates.*[12] This result agrees with recent empirical works suggesting that the trade and FDI are substitutes rather than complements.[13] Using product-

[11] However, empirical studies on the relative importance of foreign activities show that trade costs have a positive effect on the share of FDI in affiliates' sales plus exports (see Navaretti and Venables, 2004 and Blanchard *et al.*, 2007).

[12] Note that we have introduced a second deviation from Baldwin and Ottaviano (2001): Bertrand competition. However, as written by Baldwin and Ottaviano (2001, p. 435), Cournot or Bertrand competition leads to the same (qualitative) result in their framework because, in both cases, the equilibrium operating profit from sales in a given market increases and is convex in equilibrium sales. As a result, the differences in results between Baldwin and Ottaviano (2001) and our approach arise from the introduction of endogenous product differentiation.

[13] At the industry level, several empirical studies show the co-existence of intra-industry trade and intra-industry FDI (Brainard, 1997; Greenaway *et al.*, 1998).

level data on a set of Japanese-produced final consumer good, Blonigen (2001) shows that the relationship between US production by Japanese firms and Japanese exports to the United States is negative for the large majority of products. This confirms the finding by Swenson (1999) from a larger set of products identified in US data. In addition, although Head and Ries (2001) show that more FDI generates higher exports, they also find marked heterogeneity across firms. Indeed, the large car makers operating in differentiated product markets exhibit substitution between exports and FDI.

To conclude, *trade and FDI are substitutes when multi-product multinationals choose strategically the technical characteristic of their products.* Although the implications of our model differ from the results obtained in Baldwin and Ottaviano (2001), both models should be viewed as complements. Indeed, the framework developped in Baldwin and Ottaviano (2001) seems to be appropriate for market characterized by preference for diversity such as standard goods for households. In our model, we consider the diversity in preferences so that our analysis is more appropriate for the industry of household equipment goods. Hence, the substitution or the complementarity between FDI and export could depend on the type of horizontal product differentiation.

6 Concluding remarks

By considering product differentiation as a strategic variable for large firms, we shed new light on the decision to produce abroad combined with the product range. Indeed, even when technology has the same productivity for each variety, firms drop some of varieties with trade integration. In addition, we have shown that each rival firm may prefer to export its varieties when trade costs are high rather than to shift production of one variety abroad. Our analysis also suggests that the two-way FDI can be modeled as a prisoner's dilemma game. Indeed, despite the configuration in which firms export is an optimal outcome, each firm produces in both countries when trade costs take intermediate values. Finally, when trade costs are low enough, firms export and produce a single variety. Such findings reveal that the relationship between the decision to produce abroad and trade costs is non linear and intra-industry trade and two-way FDI are substitutes, even though firms can be multi-product. Endogenous product differentiation is at the heart of the explanations of our results.

A future topic in the research agenda of FDI models with endogenous product differentiation should include a welfare analysis. Indeed, the gains from trade integration are ambiguous in our setting. On the one hand, the number of varieties available in each country declines when trade costs fall. On the other hand, trade liberalization implies low prices. Such a study implies taking free entry into account.

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Appendix A. Equilibrium prices (stage 3)

1. The Nash equilibrium in prices under autarky with contestability:

$$\begin{aligned}
p_{H1} &= t + x_3^2 - x_2^2/2 - 2(x_3 - x_2) - x_1^2/2 \\
p_{H2} &= t + x_3^2 - x_2^2 - 2(x_3 - x_2) \\
p_{F3} &= t + x_2^2 - x_3^2 \\
p_{F4} &= t + x_2^2 - x_3^2/2 + x_4 - x_3 - x_4^2/2
\end{aligned}$$

2. The Nash equilibrium in prices under free trade:

$$\begin{aligned}
p_1 &= \frac{x_3^2}{3} + \frac{2x_3}{3} + \frac{x_2^2}{6} - \frac{2x_2}{3} - \frac{x_1^2}{2} \\
p_2 &= \frac{x_3^2}{3} + \frac{2x_3}{3} - \frac{x_2^2}{3} - \frac{2x_2}{3} \\
p_3 &= -\frac{x_3^2}{3} + \frac{4x_3}{3} + \frac{x_2^2}{3} - \frac{4x_2}{3} \\
p_4 &= -\frac{x_4^2}{4} + x_4 + \frac{x_3^2}{6} + \frac{x_3}{3} + \frac{x_2^2}{3} - \frac{4x_2}{3}
\end{aligned}$$

3. Under NN-configuration, the profit maximizing prices for firms A and B are given by:

$$\begin{aligned}
p_{H1} &= \frac{t}{3} - \frac{1}{2}x_1^2 + \frac{1}{6}x_2^2 - \frac{2}{3}x_2 + \frac{1}{3}x_3^2 + \frac{2}{3}x_3 = p_{F4} \\
p_{H2} &= \frac{t}{3} - \frac{1}{3}x_2^2 - \frac{2}{3}x_2 + \frac{1}{3}x_3^2 + \frac{2}{3}x_3 = p_{F3} \\
p_{F1} &= \frac{2t}{3} - \frac{1}{2}x_1^2 + \frac{1}{6}x_2^2 - \frac{2}{3}x_2 + \frac{1}{3}x_3^2 + \frac{2}{3}x_3 = p_{H4} \\
p_{F2} &= \frac{2t}{3} - \frac{1}{3}x_2^2 - \frac{2}{3}x_2 + \frac{1}{3}x_3^2 + \frac{2}{3}x_3 = p_{H3}
\end{aligned}$$

4. Under MM-configuration, the profit maximizing prices for firm A are given by:

$$\begin{aligned}
p_{H1} &= \frac{t}{6} - \frac{1}{2}x_1^2 + \frac{1}{6}x_2^2 - \frac{2}{3}x_2 + \frac{1}{3}x_3^2 + \frac{2}{3}x_3 \\
p_{H2} &= \frac{2t}{3} - \frac{1}{3}x_2^2 - \frac{2}{3}x_2 + \frac{1}{3}x_3^2 + \frac{2}{3}x_3 \\
p_{F1} &= \frac{5t}{6} + \frac{1}{6}x_2^2 - \frac{2}{3}x_2 + \frac{1}{3}x_3^2 + \frac{2}{3}x_3 - \frac{1}{2}x_1^2 \\
p_{F2} &= \frac{t}{3} - \frac{1}{3}x_2^2 - \frac{2}{3}x_2 + \frac{1}{3}x_3^2 + \frac{2}{3}x_3
\end{aligned}$$

and for firm B are given by:

$$\begin{aligned}
p_{H3} &= \frac{t}{3} + \frac{1}{3}x_2^2 - \frac{4}{3}x_2 - \frac{1}{3}x_3^2 + \frac{4}{3}x_3 \\
p_{H4} &= \frac{5t}{6} + \frac{1}{3}x_2^2 - \frac{4}{3}x_2 + \frac{1}{6}x_3^2 + \frac{1}{3}x_3 - \frac{1}{2}x_4^2 + x_4 \\
p_{F3} &= \frac{2t}{3} + \frac{1}{3}x_2^2 - \frac{4}{3}x_2 - \frac{1}{3}x_3^2 + \frac{4}{3}x_3 \\
p_{F4} &= \frac{t}{6} + \frac{1}{3}x_2^2 - \frac{4}{3}x_2 + \frac{1}{6}x_3^2 - \frac{1}{2}x_4^2 + \frac{1}{3}x_3 + x_4
\end{aligned}$$

Appendix B. Equilibrium FDI and exports

1. To determine whether firms decide to become multinational or not, we must distinguish three cases: (a) low trade costs ($t < 1$); (b) intermediate trade costs ($1 < t < 4/3$); and (c) high trade costs ($4/3 < t$).
(a) When $t \leq 1$, the two firms are multinational if and only if (25)<(24) or, equivalently,

$$\Gamma < \Gamma_a^M \equiv t/3 - t^2/18 > 0.$$

(b) When trade costs take intermediate values ($1 < t < 4/3$), comparison between (27) and (24) implies that the two firms are multinational if and only if

$$\Gamma < \Gamma_b^M \equiv 1 - \Pi_A^{NMb} > 0$$

where $\Pi_A^{NMb} \in [1/2, 1)$ is the operating profits when a firm decides to export while its rival is a multinational (see (29)).
When $t \geq 4/3$, the outcome where both firms are multinational is a perfect Nash equilibrium if and only if (31)<(24) or, equivalently,

$$\Gamma < \Gamma_c^M \equiv 1/2.$$

By inspection, Γ_a^M and Γ_b^M increase with trade costs when $t < 4/3$ and it is easy to check that $\Gamma_b^M(4/3) = \Gamma_c^M$ and $\Gamma_b^M(1) = \Gamma_a^M(1)$ because $x_B^F(t) = 1$ when $t = 1$ (see Figure 2). In other words, below a limit value of trade costs ($t = 4/3$), the occurence that firms are multinational is a perfect Nash equilibrium is less and less likely when trade costs decline. In addition, when trade costs are high the probability of producing abroad does not depend on trade costs.

2. To determine conditions under which the configuration where the two firms export is a Nash equilibrium, we also distinguish three cases: (a) low trade costs ($t < 1$); (b) intermediate trade costs ($1 < t < 4/3$); and (c) high trade costs ($4/3 < t$).
(a) When $t \leq 1$, both firms export if and only if (26)<(18) or, equivalently,

$$\Gamma > \Gamma_a^N \equiv -t^2/18 + t/3.$$

(b) When trade costs take intermediate values ($1 < t < 4/3$), comparison between (28) and (18) implies that both firms export from their home country if and only if

$$\Gamma > \Gamma_b^N \equiv \Pi_B^{MNb} - \left(1 + t^2/9\right) > 0$$

where $\Pi_B^{MNb} > 1$ is the operating profits when a firm becomes multinational while the other firm exports (see (30)). By inspection, Γ_b^N increases with trade costs when $t < 4/3$ and $\Gamma_a^N = \Gamma_b^N$ when $t = 1$ (see Figure 2).
(c) When $t \geq 4/3$, the outcome where both firms export from their home country is a perfect Nash equilibrium if and only if (32)<(20) or, equivalently,

$$\Gamma > \Gamma_c^N \equiv 2/3 + 2t/3 - \Pi^{NN}(t)$$

where

$$\Pi^{NN}(t) \equiv \begin{cases} \Pi^{NN}(t < \underline{t}) = 1 + t^2/9 & \text{when } t < \underline{t} \\ \Pi^{NN}(t > \underline{t}) \in [1, 1 + t^2/9] & \text{when } t > \underline{t}. \end{cases}$$

It is worth stressing that Γ_c^N increases with trade costs (t).

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