Partial versus total disintegration of exporting firms

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Preliminary version
Not to be quoted

January 19, 2007

Abstract

The choice between total, partial vertical disintegration and pure integration in an uncertain environment is a strategic choice whenever perfect competition is assumed away. In an international stochastic quantity setting duopoly with transport and communication costs and countries showing different degree of home bias we analyze the decision concerning the vertical organisation of profit maximising firms. In many circumstances vertical integration appears the best choice for firms. However, if vertical integration is not allowed because of vertical restraint coming from some trade policies or other international hindrnces vertical disintegration may be sometimes more desirable if firms in the upstream and downstream sections may coordinate. In the case of input joint production (IJP) the dominant strategy becomes partial vertical disintegration even when vertical integration is allowed. This may make some trade policies imposing vertical restraints fairly desirable.

JEL classification:F12, L13, O31, R40.

Keywords: partial, total, disintegration, exporting firms

*A grant from the University of Bologna under the 60% scheme for the a.y. 2005- 2006 is acknowledged. The paper has been presented at the EVROPAEVM 5th Economic Workshop on "Game Theory and Applications in Problems of International Economics", University of Helsinki, 27-28 October 2006.

1 Prologue

Vertical disintegration (VD) and its contrary, vertical integration (VI), are the object of strategic choices of firms operating in non perfectly competitive environments (Acemoglu, Aghion, Griffith and Zilibotti, 2005; Acemoglu, Johnson and Mitton, 2005; Antras and Helpman, 2004).

Vertical relationships between Upstream (U) sections of the vertical chain and Downstream (D) sections can take many forms. In case of VI inputs are internally transferred at their opportunity cost, i.e. the marginal cost. Otherwise, with VD, linear pricing may occur even though fixed franchise fee or other arrangements may take place. In the case of simple linear pricing there arises an externality (Spengler, 1950; Rossini, 2005) whereby the increase in the price of the final good sold by the D firm affects negatively the profit of the U firm (*double marginalization*).

However, a different link goes between U and D if both parts bargain over the terms of trade of the input. This solution, quite common in the current literature (McLaren, 2000; Antras and Helpman, 2004) provides a distribution of profits reflecting the different baldness of U and D. From a social point of view it replicates the results of VI, where the vertical distribution of profits is indeterminate, or rather irrelevant from the firm's point of view, but not from the managers' standpoint. Other vertical arrangements are possible and the literature is rich with examples. When trade enters the picture VD and VI may be part of an internationalization process of firms (Amiti and Konings, 2005; Amiti and Shang-Jin, 2005; Antras and Helpman, 2004; Hummels, Ishii and Yi, 2001; Markusen, 2002; McLaren, 2000; ; Rossini, 2007; Rossini and Ricciardi, 2005). Producers can either decide to go multinational (MNF) by carrying out foreign direct investment (FDI) or outsource the production of some inputs from a foreign independent firm. A related possibility, exploited by many firms, is to get an input from a foreign firm that sells also to rival companies. Sometimes this company may be jointly owned with rival D firms. This happens quite frequently in many industrial agreements, for instance, in the automotive sector or in other industries where firms decide to outsource via some sort of joint input production (JIP). In this sense these firms operate a kind of partial collusive agreements since they aim at the maximization of their joint profits in the U section of production. This sort of arrangement may show some affinities with research joint ventures (RJV) (Banerjee and Lin, 2001).

The aim of this paper is to assess the choices of vertical arrangements of exporting firms in an environment in which there is uncertainty, international transport costs and home bias.

The results will show that, even with linear pricing, there are circumstances where VD may be preferred by firms to partial VD if there are some vertical restraints.

We adopt a three stage game framework. Firms interact in the D stage as Cournot duopolists (third stage). They vertically interact either in a VD, VI, partial VI-VD, JIP fashion in U (second stage). However, to begin with, firms

must choose the vertical arrangement (first stage).

2 An international duopoly with stochastic demand

We consider an international duopoly with two firms based in two separated countries H and F selling a differentiated good. Differentiation may actually be thought of as a signal of home bias and it is going to alter the degree of competition among the two firms. Demand uncertainty of the additive type is faced in each country. We shall examine cases where the volatility of demand differs across countries. The two firms export part of their production of the final good to the other country. Each firm can either produce or buy the input required to manufacture the final good it sells.

We assume that D firms can choose between three strategies.

In the first strategy each firm adopts VI and produces its own input at home while exporting part of the output to the country where the rival firm is based.

The second strategy is one whereby the input is internally produced only to serve the portion of production sold domestically, while, for the manufacturing of exports each firm buys the input abroad from the foreign rival. In this second strategy there is partial VD and partial VI and we label it VI-VD.

A third strategy is one in which each firm buys the entire input requirement from an independent foreign producer. A subcase of this strategy is one where the independent firm is a joint venture of the two D rivals doing joint input production(JIP).

First we list and explain these strategies. Then, we evaluate the solution of the entire game in different scenarios.

2.1 The first strategy (VI - VI)

Here we describe the demand functions for the final good. In country H we have:

$$p_H = a - hh - s\,t\,f + e_1 \tag{1}$$

p_H is the market price in country H.

a is the size of the H market or marginal willingness to pay of average H consumers.

hh is the quantity of the final good domestically produced and sold in the domestic market.

f is the quantity of the good imported in H and produced abroad by the foreign rival

$t \in (0, 1]$ is the transport cost (TC) of the usual iceberg type (Anderson and Van Wincoop, 2004; Laird and Yeats, 1990; Samuelson, 1954; Lambertini and Rossini, 2006), whereby a portion t of the good exported is used up in transport.

$s \in (0, 1]$ is the differentiation parameter (Singh and Vives, 1984; Pepall and Norman, 2001) which may be thought of as a measure of home bias, which grows as s tends to zero.

e_1 is the error term of market H.

e_2 is the error term of market F.

We assume that the additive shock term has zero expected value and constant second moment, i.e.:

$$Ee_1 = Ee_2 = 0; \qquad Ee_{1,2}^2 = \sigma^2; \qquad Ee_1e_2 = \sigma^2. \tag{2}$$

where E is the expectation operator.

Symmetrically the F country final demand is

$$p_F = a - ff - s\,t\,h + e_2. \tag{3}$$

Each firm needs an input to assemble the final product. The input is produced by both firms. As it is customary in most literature on VI, we adopt the hypothesis of *perfect vertical complementarity*, i.e.: one unit of input for each unit of output. In the first strategy the two firms adopt VI and produce internally their own input requirement.

As a result of that the respective profit functions of the two firms are:

$$\pi_{H1} = p_H\,hh + t\,p_F\,h - z\,(hh + h) \tag{4}$$

and

$$\pi_{F1} = p_F\,ff + t\,p_H\,f - z\,(ff + f), \tag{5}$$

z is the common constant marginal production cost of the input.

The assembly of the final good is assumed to bear zero cost, for the sake of simplicity.

The two D firms producing the final good in the two country are assumed to compete in quantities in a Cournot Nash fashion (Brander and Krugman, 1983; Spencer and Jones, 1991).

In this case of symmetric VI the game turns out to be a two stage game since the vertical interaction is internally solved without any strategic interaction between D and U sections of production.

Each firm maximizes expected profit using two controls, the quantity sold at home and the quantity shipped to the foreign market.

2.2 The second strategy (VI -VD)

Here, we consider an international vertical restraint whereby a firm has to buy some input in the country of destination of exports. This may simply reflect the fact that foreign goods have to be usually sold by domestic shops adding their intermediation input. Or it may be the result to some country specificities requiring further manufacturing in the country of destination. Or, finally, it

may simply be the result of a trade policy requiring that exports embody an input produced in the country of destination[1]. A trade policy of this kind is fairly consistent with WTO rules (WTO, 2005).

In this second scenario we assume that each firm produces the input for its own use plus the amount to be sold to the foreign rival. As far as the vertical relationships are concerned we assume linear pricing by the partially vertically integrated (VI) firm when selling the input to the rival for its exports. We do not introduce any friction in this sale, unlike some literature, from the classical contributions to more recent ones, does (Williamson, 1971; Heavner, 2004).

We further assume that only the final output bears a transport cost while inputs are of an intangible sort without having to bear any crossborder transport cost.

On the basis of these assumptions we write the profit functions of the two rival enterprises:

$$\pi_{H2} = p_H\, hh + t\, p_F\, h + g_H\ f - g_F\, h - (f + hh)\, z \tag{6}$$

and symmetrically

$$\pi_{F2} = p_F\, ff + t\, p_H\, f + g_F\, h - g_H\ f - (h\ + ff)z. \tag{7}$$

Each firm maximizes expected profit using three controls, the quantity sold at home, the quantity shipped to the foreign market and the price of the input sold to the rival. Therefore, firms compete in a Nash - Cournot fashion in quantities and input prices.

2.3 The third strategy (VD)

In the third strategy we assume that the input is produced by two independent firms, one in F and the other in H, operating in the U section of the vertical chain of production.

In this case the profit functions of the D firms are:

$$\pi_{H3} = p_H\, hh + t\, p_F\, h - g_F\, (h + hh) \tag{8}$$

and

$$\pi_{F3} = p_F\, ff + t\, p_H\, f - g_H\, (\, f\ + ff). \tag{9}$$

Now we have two new firms, and then, we have to add the profit functions of the two U firms, which are:

$$\pi_{UH3} = (g_F - z)\, (f + ff) \tag{10}$$

and

$$\pi_{UF3} = (g_F - z)\, (h + hh). \tag{11}$$

[1] For a similar assumption see Ishikawa (1999) and Rossini (2006).

From above profit specifications we understand that each D firm buys the entire input requirement from the foreign U firm.

Here the game turns out to be a three stage game: first the D firms decide the vertical arrangement, then the U firms set their prices as Stackelberg leaders, and finally D firms compete in quantities in a Nash Cournot fashion.

2.3.1 JIP

An alternative to this arrangement is one of joint input production (JIP) by the two D rivals. This is quite common practice in many industries and in particular in the automotive sector, where many engines are produced jointly for more than one D producer of cars. A similar regime can be found in case of RJV and it is justified by the externalities related to R&D (Rossini and Lambertini, 2003; Nemoto and Goto, 2004).

In this case we do not have the two (10) and (11), but a unique profit function, such as

$$\pi_{U3} = (g - z)\,(f + ff + h + hh). \tag{12}$$

This amounts to having a single independent U firm selling the input to both D firms, which share the ownership of it on an equal foot, i.e.: 50% -50%. As a result only one input price has to be set, i.e.: g.

2.4 The cross strategies

We describe also the profit functions that we encounter when considering the crossing of different strategies, i.e.: off principal diagonal cases.

2.4.1 Case 4: H does VI and F does VI-VD

Here, the profit functions are:

$$\pi_{H4} = p_H\, hh + t\, p_F\, h + g_H\, f - z\,(h + hh + f) \tag{13}$$

and

$$\pi_{F4} = p_F\, ff + t\, p_H\, f - g_H\ f\ - z\, ff. \tag{14}$$

2.4.2 Case 5: H does VI and F does VD

Here, the profit functions are:

$$\pi_{H5} = p_H\, hh + t\, p_F\, h + g_H(\, f + ff) - z\,(h + hh + f + ff) \tag{15}$$

and

$$\pi_{F5} = p_F\, ff + t\, p_H\, f - g_H\,(\, f + ff)\,. \tag{16}$$

2.4.3 Case 6: H does VI-VD and F does VD

Here, the profit functions are:

$$\pi_{H6} = p_H\, hh + t\, p_F\, h + g_H(\, f + ff) - z\,(f + ff + hh) - g_F\, h \qquad (17)$$

and

$$\pi_{F6} = p_F\, ff + t\, p_H\, f - g_H\,(\, f\, + ff) + h(g_F - z). \qquad (18)$$

When dealing with crossing cases we do not have any opportunity of JIP, which is confined to a case related to a symmetric strategy adoption, i.e.: on the principal diagonal.

3 The general game in normal form

We may sum up the entire set of strategic opportunities in the normal form of the game where the two firms have a strategy set made up of 3 possible choices: VI, VI-VD and VD.

In Table 1 below we present the three stage game in normal form.

Table 1: The game in normal form

		F		
		VI	VI-VD	VD
H	VI	1	4	5
	VI-VD	*4	2	6
	VD	*5	*6	3

In each cell we shall put the profits of the firm H and F. In cell 3 we shall also put the profits of the two independent U firms.

4 Different scenarios

We examine the above game in different scenarios. For each scenario we provide a numerical solution of the game, as a general analytical one is not feasible[2].

4.1 Scenario 1: no uncertainty

In this first scenario we assume that $e_1 = e_2 = 0; t = 0.6; s = 0.3; a = 20; z = 0.2$.

Calibration of the parameters take into account suggestions coming from Anderson and Van Wincoop (2004) and WTO (2005).

The results are in Table 1s below.

Table 1s: No uncertainty

		F		
		VI	VI-VD	VD
H	VI	185; 185	266; 63	355; 11
	VI-VD	63; 266	143; 143	186; 120
	VD	11; 355	120; 186	81; 81 [99; 99]

The numbers in square brackets in the lowest right hand cell refer to the profits of U firms.

As it can be seen the solution of the above game is $\{VI; VI\}$ since this strategy is dominant.

[2] Some analytical results, consistent with numerical solutions presented here, will be added in a larger version of this paper.

In case firms were allowed only to play VI-VD or VD, for instance as a result of a trade policy vertical restraint, the solution of the game would be $\{VI - VD; VI - VD\}$.

A different solution would be found if also U firms were allowed to play the entire game without being confined to play just in the subgame.

To this question we shall come back later.

4.2 Scenario 2: asymmetric uncertainty

Here we introduce asymmetric uncertainty.

We assume that demand is more volatile in country F than in country H.

In particular: $e_1 = 1; e_2 = 4; e_1 e_2 = 4; E(e_1) = E(e_2) = 0$.

In this case the game in normal form may appear as in Table 2s.

Table 2s: Asymmetric uncertainty

		F		
		VI	VI-VD	VD
H	VI	188; 192	269; 64	361; 12
	VI-VD	64; 269	150; 145	192; 121
	VD	12; 361	121; 192	105; 83 [99; 99]

As it appears the solution of the game is still the same as above, i.e.: $\{VI; VI\}$.

However, if only the strategies VD and VI-VD are available the U and D firms may try to find some sort of agreement and choose VD. In this case they are able to get a larger aggregate profit.

They have to design a rule to share it in a sustainable way. May be they could jointly own the U section and share the profit. As it will be seen later, this is quite a feasible solution.

4.3 Scenario 3: home bias

Now we go through the effects of extreme degrees of home bias.

We consider two cases.

4.3.1 High home bias

The *first* is one of high levels of home bias, i.e.: $s = 0.1$.

Uncertainty is assumed away and the set of remaining parameters does not change with respect to previous scenarios.

The game in normal form may appear as in Table 3as.

Table 3as: high degree of home bias

		F		
		VI	VI-VD	VD
H	VI	468; 468	653; 133	856; 30
	VI-VD	133; 653	317; 317	380; 311
	VD	30; 856	311; 380	179; 179 [245; 245]

Again the solution in dominant strategies is the same: $\{VI; VI\}$ .However, if VI is not possible the solution may be $\{VI - VD; VI - VD\}$ if U firms do not take part in the choice of the arrangement.

Otherwise $\{VD; VD\}$ may become an equilibrium solution of the game.

4.3.2 Low home bias

The *second* case is one of low levels of home bias, i.e.: $s = 0.8$. Again, uncertainty is assumed away and the set of remaining parameters does not change.

The game in normal form may appear as in Table 3bs.

Table 3bs: low degree of home bias

		F		
		VI	VI-VD	VD
H	VI	97; 97	152; 45	205; 6
	VI-VD	45; 152	99; 99	140; 60
	VD	6; 205	60; 140	51; 51 [55; 55]

Here, again the solution in dominant strategies is the same: $\{VI; VI\}$ .Unlike the case with high home bias, if VI is not possible, the solution $\{VI - VD; VI - VD\}$ may be feasible but it will be more difficult to design a mechanism that makes it possible since D firms will have to be highly compensated by U firms. In the previous case U firms had plenty of resources to do it, while in this case they have just few.

Even though $\{VD; VD\}$ is socially (from the point of view of firms) superior it may be quite difficult to implement.

4.4 Scenario 4: asymmetric size of countries: H large, F small

Here we introduce asymmetric size of countries. H is assumed ten times larger than F. Uncertainty is assumed away and the rest of parameters is as above with home bias of the normal degree ($s = 0.3$). In this case the game in normal form may appear as in Table 4s.

Table 4s: Asymmetric size of countries

		F		
		VI	VI-VD	VD
H	VI	4583; 14790	12970; 2043	13345; 2361
	VI-VD	2043; 12970	12848; 2124	$12700; 2844 - Nash-$
	VD	2361; 13345	2844; 12700	5592; 4778[6050; 1112]

$\{VI; VI\}$ is again the solution since it is the dominant strategy for both firms.

However, if VI is not available the solution of the reduced game is no longer $\{VI - VD; VI - VD\}$, regardless of what U firms do. Indeed for F $\{VI - VD; VI - VD\}$ is no longer dominant.

In this case there seems to be one Nash equilibrium given by $\{VI - VD_H; VD_F\}$ where the two firms adopt different strategies. The firm of the large country prefers to go VI-VD while that of the small country goes VD.

4.5 Scenario 5: joint input production (JIP)

Here we introduce a unique U producer as in (12). D firms own this U firm that carries out JIP. In some sense there a collusion in the U section. However, this sort of collusion is not usually sued since it appears simply, and it is called, a joint venture.

There is a change when firms adopt the VI-VD strategy. In this case we assume that the price of the input is established with the aim of maximizing not the individual profit of the firm producing in the U stage but the sum of profits of the two D firms.

The set of parameters is as in scenario 1.

In this case the game in normal form may appear as in Table 5s.

Table 5s: JIP

		F		
		VI	VI-VD	VD
H	VI	185; 185	117; 257	304; 76
	VI-VD	257; 117	189;189	191;181
	VD	76; 304	181;191	63;63 [207]

In the general game we do not find any more an equilibrium in dominant strategies.

This upsets the general solution of the game and it is not generally possible to find neither an equilibrium in dominant strategies nor a Nash equilibrium.

However, we may examine the partitioned game.

If we consider the game where the strategy VD is deleted it appears that the equilibrium solution is $\{VI - VD; VI - VD\}$ as it is the dominant strategy. Then $\{VI; VI\}$ is no longer the dominant one. This is quite a remarkable result.

However, if we delete the strategy VI the solution is again $\{VI - VD; VI - VD\}$.

Allowing firms to do JIP may change quite a lot the desirability of the vertical arrangement even in the most naive case of linear pricing by the U section. As this form of U production is quite common, it seems that the incentive to go either VD or VI may be quite sensible to the parameters scenario in which firms operate.

5 Conclusions

We have gone through the strategic interactions of two exporting firms which can choose among different vertical arrangements in a stochastic environment with transport costs separating two countries. each firm is based in one country and is required to assemble a final good in its own country. This good is going to be partially exported according to the degree of home bias existing in the foreign country and the transport costs to be born by exporters.

In most cases linear pricing by the input producers leads to a superior performance of the VI arrangement as the classical literature stressed.

Two cases are of extreme interest and worth expanding.

The first concerns the effects of the introduction of a vertical restraint whereby each firm is compelled to buy in the foreign country from the rival or from an independent manufacturer the input needed to produce its exports. This may be the result of a trade policy or simply the need to buy foreign services to sell the good outside the domestic market. In this case the equilibrium solution is the one imposed by the restraint even though in some circumstances firms may switch to other strategies. If the VI strategy is not available, in the case of a small and a large country, the only Nash equilibrium may imply the two firms adopt different strategies: the firm of the large country prefers to go VI-VD while that of the small country goes VD.

The second deals with quite a common scenario where competing firms decide to establish a joint input production (JIP) facility, as it happens in a vein similar to a research joint venture. If that is the case the vertical arrangements to be adopted in a strategic interaction between firms cooperating in the Upstream section of production is going to change fairly radically. In many circumstances there may not be any pure strategy equilibrium. Only if we delete the extreme opportunities, i.e. either VD or VI, we are able to find a solution which tends to be always given by the VI-VD strategy. This strategy alternatively dominates VI and VD. In particular VI-VD dominates VI when VD is not available. This is quite a remarkable result in a linear pricing framework.

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