International Vertical Specialization, Imperfect Competition and Welfare*

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Abstract

This paper looks at the impact of international vertical specialization when the final good industry is imperfectly competitive. Final goods are assembled out of different fragments. In the absence of international vertical specialization all fragments required to produce a given final good must be produced in the same country. International vertical specialization unambiguously reduces the costs of production of all final good producers, albeit not necessarily in the same proportion. If the cost of production of a less efficient producer is reduced to a lesser extent than that of a more efficient producer, vertical specialization may lead to exit in the final good industry. This anti-competitive effect may be strong enough that international vertical specialization leads to a Pareto inferior outcome. On the other hand, we can characterize two sets of policies, which, combined with vertical specialization, are Pareto improving compared to autarky regardless of consumer preferences and of the form of competition in the final good industry.

Key words: fragmentation, vertical specialization, imperfect competition, welfare, anti-competitive effect of trade

JEL Classification: F12

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I) Introduction

One of the most striking trends of the last few decades has been the strong growth of trade driven by the fragmentation, or vertical specialization, of production: Hummels et al. (2001) find that trade in fragments[1] has increased by above 30% during the last 20 years. As a consequence, there has recently been a growing interest for rigorous analyses of the impact of international vertical specialization. Most of the theoretical literature on the topic has so far been cast in general equilibrium trade models with a fixed market structure of the final good industry, assuming either perfect competition or monopolistic competition with constant mark-up and number of firms[2]. The seminal paper of that type is Markusen (1989), who showed in a model with monopolistic competition in the fragment market and perfect competition in the final good market that opening the market for fragments to international trade is welfare improving. More recent work includes Yi (2003) who showed in a Ricardian model that the welfare gains driven by international vertical specialization are significantly larger than those obtained in traditional trade models, and Fujita and Thisse (2002)[3] who showed in a core-periphery economic geography model that lowering costs of fragmentation initially benefits the periphery at the expense of the core before benefiting both regions afterwards, once re-localization of production has taken place.

On the other hand, few papers look at the impact of international vertical specialization when there is imperfect competition in the final good industry. One

[1] Terminology in the literature on fragmentation, or vertical specialization, is still uncertain: the words "fragments", "middle products" and "intermediate inputs" have been used by different authors to describe similar objects. In this paper, we use the word "fragment" throughout, even when describing the work of authors who have adopted a different terminology.
[2] For partial equilibrium analysis focusing on the impact of international vertical specialization on the transfer of technology, see Pack and Saggi, 2001, and Goh, 2003.
[3] See also Peng, Thisse and Wang (2003) for a related model.

exception is Chen, Ishikawa and Yu, 2003 (CIY)[4]. In sharp contrast with the rest of the theoretical literature on vertical specialization, they find that lowering transport costs of fragments may lead to higher prices of the final goods (and thus possibly lower welfare of consumers). However, their result obtains only in a specific set-up, namely one where there are two firms, one of which, the foreign firm, must necessarily be vertically integrated. When transport costs for fragments fall, the home firm is able to purchase fragments from the vertically integrated firm. The vertical relationship between the two firms then provides incentives for tacit collusion in the final good market, thus leading to a higher price paid by the consumer.

The first objective of this paper is to find out how general the result of CIY may be. In particular, we show that international vertical specialization can lead to a Pareto inferior outcome when the market for final goods is imperfectly competitive even in the absence of vertically integrated firms, which are crucial in CIY's argument. The second objective of the paper is to investigate whether there is anything governments can do in terms of policies to ensure that opening the market for fragments will lead to a welfare gain and not a welfare loss.

The model we use is a two-country, two-sector general equilibrium model. Final goods are assembled out of different fragments. Countries differ only in their production function for fragments. Initially, final goods are traded across countries while fragments are not. The market structure of the final good industry is oligopolistic while that of the fragment industry is competitive. Opening up the

[4] See also Spencer and Jones (1991) for an analysis of strategic trade policies in a similar model of imperfect competition with vertically integrated firms.

market for fragments to trade lowers the costs of production of all final good producers, albeit not necessarily in the same proportion. If the cost of production of a less efficient producer is reduced to a lesser extent than that of a more efficient producer vertical specialization may lead to exit in the final good market. We provide an explicit example where this anti-competitive effect of opening up the market for fragments is strong enough that it dominates any other gain from trade in terms of welfare. However, we also characterize two sets of policies which, combined with international vertical specialization, necessarily Pareto improve welfare. Unlike many policy implications in the literature on trade and imperfect competition, this result is robust to different assumptions about preferences and form of competition.

Our paper is, of course, far from providing the only example in the literature whereby trade liberalization leads to a change in market structure. In that respect, the main difference between our paper, looking at international vertical specialization, and the existing literature, looking at trade in final goods, concerns the welfare implications. Indeed, models of imperfect competition and trade in final goods generally lead to the conclusion that trade liberalization has a pro-competitive effect and raises world welfare[5]. We are aware of only two explicit examples in the literature where trade liberalization leads to exit of firms and the *entire world* losing out as a consequence. Eaton and Kierzkowski (1984) and, more recently, François and Van Ypersele (2002) have shown in a model with vertical product differentiation that trade liberalization of the final good market may cause firms to exit, leading to a world welfare loss if the preferences of agents are sufficiently heterogeneous. By contrast, we show that trade liberalization of the fragment market may lead to a welfare loss even if all agents have

[5] See, e.g., Markusen (1981)

the same preferences[6]. Another paper where opening up to trade may cause a loss in world welfare is Amir and Jin (2003). In their model, trade liberalization (of the final good market) may cause average costs of production to go up if the two countries are sufficiently heterogeneous in size and technology. By contrast, we show that even when trade liberalization (of the fragment market) brings down all costs of production welfare may still go down because of exit of firms in the final good market.

The remainder of the paper is as follows: we lay down the model in Section II and analyze the impact of vertical specialization on relative costs of production. We provide an example of welfare reducing trade in fragments in Section III. Section IV is devoted to the normative analysis of some policies while Section V contains a few concluding remarks.

II) The model

We consider a world consisting of two countries, country A and country B. The two countries have the same population size and consumers have the same preferences over three goods, a homogeneous good Z and two differentiated goods, 1 and 2.[7] A representative consumer is assumed to have the following utility function:

$$U(q_1, q_2, z) = u(q_1, q_2) + z \qquad (1)$$

where q_1, q_2 and z are respectively, the quantity consumed of the two differentiated goods and of the homogeneous good. u(.) is assumed to be symmetric (u(x,y) = u(y,x) for any x and y in R_+) and strictly concave.

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[6] As discussed later in the paper, the reason why it is significantly easier to get a Pareto-inferior outcome when opening the market for fragments than it is when opening the market for final products is that opening the market for fragments can lead to the number of producers in the final good industry to go down *strictly* in *every* country, which is not the case when opening the market for final goods.

[7] In what follows and for the sake of conciseness, we shall frequently use the expression "final goods" as a short-cut for "differentiated final goods". We hope no confusion arises as a consequence.

The homogeneous good Z is produced at constant returns to scale. It takes one unit of labor to produce one unit of good Z. Good Z is also freely tradable across the two countries.

The two final goods, 1 and 2, are costlessly assembled from two fragments, fragment S_1 and fragment S_2. The production (or assembly) functions are of the Leontieff type, requiring constant proportions of the two fragments. The production functions for final goods are different across goods (i.e. goods 1 and 2 do not require the same amount of each fragment) but identical across countries (i.e. the amount of fragments required to produce good i is the same whether good i is produced in country A or in country B). Goods 1 and 2 are freely tradable, at zero transport cost, across the two countries.

To finish the description of the production side of the economy, we assume that the sole factor of production for the making of fragments is labor and that returns to scale are constant. Both countries can produce both fragments but differ in their productivity. We choose units so that one unit of labor produces one unit of fragment S_1 in country A and one unit of labor produces one unit of fragment S_2 in country B. In country A, one unit of fragment S_2 requires $\varepsilon_A > 1$ units of labor while in country B, one unit of fragment S_1 requires $\varepsilon_B > 1$ units of labor. The assumption that both ε_A and ε_B are strictly larger than 1 implies that country A has a comparative advantage in the production of fragment S_1 and country B has a comparative advantage in fragment S_2.

We assume the following about the market structure: the homogeneous good Z and the two fragments S_1 and S_2 are produced under perfect competition. On the other hand, the patent for each differentiated final good is assumed to be held by only one firm and patent protection is assumed to be perfect. Consequently, the final good industry is characterized by oligopolistic competition. Property rights of the two firms in the final good industry are assumed to be split equally among all agents in both countries. For the moment, we shall leave the exact form of the game played by the two firms in the final good industry unspecified.

Finally, we assume that the labor force is large enough so that the homogeneous good is always being produced by both countries. The homogeneous good also serves as the numéraire so that wages are equalized across countries and equal to one.

In what follows we first study the impact of opening up trade in fragments on the relative costs of production, starting from a situation where there is free trade in final goods only and comparing it to an economy where markets both for fragments and for final goods are opened. We then proceed to illustrate that in the absence of taxation and transfer policy, welfare can either go up or down when the market for fragments is opened. We finally show that if government is free to impose taxes/subsidies and make lump sum transfers, welfare can always be increased as we move from a world where there is trade in final goods only to a world where there is trade both in fragments and in final goods.

Trade in fragments and relative costs of production

We have assumed free trade and zero transport costs for final goods. An implication of that assumption is that each final good producer chooses to locate its production in the country where the unit cost of production for the good is the lowest and will be able to serve both markets from that one location.

Each variety is assembled from two fragments using a fixed coefficient technology. One unit of final good *i* requires γ_{i1} units of fragment S_1 and γ_{i2} units of fragment S_2 for assembly. Consider first the case where trade in fragments is not possible: then each of the final good producer can only purchase fragments that are manufactured in the country where the producer is located. The cost of production of a good is equal to the sum of the costs of producing the fragments it is made of. It is straightforward to derive the unit cost of production of each final good depending on the country where its production is located, as presented in Table 1 below:

Table 1 Unit costs of production of final goods without vertical specialization

	Country A	Country B
Unit cost of good 1	$\gamma_{11} + \gamma_{12}\varepsilon_A$	$\gamma_{11}\varepsilon_B + \gamma_{12}$
Unit cost of good 2	$\gamma_{21} + \gamma_{22}\varepsilon_A$	$\gamma_{21}\varepsilon_B + \gamma_{22}$

By contrast, if trade in fragments becomes possible, then each final good producer will be able to purchase each fragment from the country which can produce it more cheaply. Given the assumption we made earlier about comparative advantage in the production of fragments, country A will specialize in fragment S_1 production and country B in fragment S_2 production. Thus both firms in the final good industry, wherever they used to locate their production when trade in fragments was impossible, will now purchase fragment S_1 from country A and fragment S_2 from country B. The following unit cost of production obtains:

Table 2 Unit costs of production of final goods with vertical specialization

	Country A	Country B
Unit cost of good 1	$\gamma_{11} + \gamma_{12}$	$\gamma_{11} + \gamma_{12}$
Unit cost of good 2	$\gamma_{21} + \gamma_{22}$	$\gamma_{21} + \gamma_{22}$

Since ε_A and ε_B are strictly greater than 1, all unit costs of production fall once the market for fragments is opened. However, how much each producer gains from trade in fragments in terms of the reduction in their unit cost varies depending upon the proportion in which the two fragments are combined. The following table displays the reduction in unit cost for each producer depending on their location:

Table 3 Reduction in unit costs of production with vertical specialization

	Country A	Country B
Reduction in unit cost of good 1	$\gamma_{12}(\varepsilon_A - 1)$	$\gamma_{11}(\varepsilon_B - 1)$
Reduction in unit cost of good 2	$\gamma_{22}(\varepsilon_A - 1)$	$\gamma_{21}(\varepsilon_B - 1)$

We observe that since in general $\gamma_{11} \neq \gamma_{21} \neq \gamma_{12} \neq \gamma_{22}$, the reduction in unit cost will be different for the two producers. The intuition is that the more intensively the production of a final goods uses a fragment which is cheaper to produce abroad, the larger is the cost reduction brought about by international vertical specialization for that good.

As a consequence, the market share of the two final goods producers changes after the market for fragments has been opened. In particular, it is possible that one producer ends up capturing the entire market. This may happen when the cost of production of the less efficient producer is reduced to a lesser extent than that of the more efficient producer. The resulting market concentration can lead to a Pareto inferior outcome despite the efficiency gains in production. We construct an example to illustrate this possibility in Section III below.

III) An Example of Welfare-Reducing Trade

Our objective in this section is to construct a simple example to illustrate that trade in fragments may cause the exit of some final good producers and reduce welfare despite the gains in production efficiency. We start from a situation where there is trade in final goods only and where the two final goods are being produced in positive quantities. We then allow trade in fragments and we show the existence of parameter values such that one firm exits the market and welfare goes down.

We assume that the utility function is quadratic:

$$U(q_1, q_2, z) = \alpha(q_1 + q_2) - \frac{1}{2}(\beta q_1^{\ 2} + 2\theta q_1 q_2 + \beta q_2^{\ 2}) + z \tag{2}$$

where $\alpha > 0$ and $\beta > \theta > 0$[8].

[8] The case $\beta = \theta$ corresponds to the case of perfect substitutes (see e.g. Vives, 1999)

With quadratic utility, the inverse demand curves of the two firms are simply:

$$\begin{aligned} p_1 &= \alpha - \beta q_1 - \theta q_2 \\ p_2 &= \alpha - \beta q_2 - \theta q_1 \end{aligned} \tag{3}$$

We assume the following about the game played by the two producers: in a first stage of the game, firms decide whether to stay in the market or not. It is assumed that firms will exit unless they can get strictly positive profits in the second stage of the game[9]. In the second stage of the game, firms compete in prices if they are both still in the market. If one firm has exited, then the other one is able to charge the monopoly price.

We assume that it is optimal for both firms to stay in the market in the benchmark economy, where the market for fragments is closed. We derive below the exact condition under which this would be true. Solving the Bertrand competition game using standard arguments, and substituting the optimal price charged by each firm into the demand functions, we obtain the following equilibrium quantities:

$$\begin{aligned} q_1 &= \frac{\beta\left[\alpha(2\beta^2 - \beta\theta - \theta^2) + \theta\beta c_2 - (2\beta^2 - \theta^2)c_1\right]}{\left(4\beta^2 - \theta^2\right)\left(\beta^2 - \theta^2\right)} \\ q_2 &= \frac{\beta\left[\alpha(2\beta^2 - \beta\theta - \theta^2) + \theta\beta c_1 - (2\beta^2 - \theta^2)c_2\right]}{\left(4\beta^2 - \theta^2\right)\left(\beta^2 - \theta^2\right)} \end{aligned} \tag{4}$$

where c_1 and c_2 are the unit costs of production of the two firms respectively.

Profits of the two firms are given by:

[9] This timing could be justified through the introduction of an arbitrarily small fixed cost.

$$\pi_1 = \beta(\beta^2-\theta^2)\left[\frac{\alpha(2\beta^2-\beta\theta-\theta^2)+\theta\beta c_2-(2\beta^2-\theta^2)c_1}{(4\beta^2-\theta^2)(\beta^2-\theta^2)}\right]^2$$
$$\pi_2 = \beta(\beta^2-\theta^2)\left[\frac{\alpha(2\beta^2-\beta\theta-\theta^2)+\theta\beta c_1-(2\beta^2-\theta^2)c_2}{(4\beta^2-\theta^2)(\beta^2-\theta^2)}\right]^2 \qquad (5)$$

The next step is to derive the unit costs c_1 and c_2 from the primitives of the model. For this example we shall assume that good 1 is initially cheaper to produce in country A and good 2 cheaper to produce in country B. From Table 1 on p.7, this amounts to assuming that:

$\gamma_{11} + \gamma_{12}\varepsilon_A < \gamma_{11}\varepsilon_B + \gamma_{12}$

and: (6)

$\gamma_{21} + \gamma_{22}\varepsilon_A > \gamma_{21}\varepsilon_B + \gamma_{22}$

We thus obtain:

$$c_1^{NT} = \gamma_{11} + \gamma_{12}\varepsilon_A$$
$$c_2^{NT} = \gamma_{21}\varepsilon_B + \gamma_{22} \qquad (7)$$

where c_1^{NT}, c_2^{NT} denote the unit costs of firms when there is no trade in fragments.

Substituting (7) into (4) yields the equilibrium quantities. It is straightforward to show that a necessary and sufficient condition for both producers to initially make strictly positive profits, and hence to stay in the market is:

$$\frac{\beta\left[\alpha(2\beta^2-\beta\theta-\theta^2)+\theta\beta(\gamma_{21}\varepsilon_B+\gamma_{22})-(2\beta^2-\theta^2)(\gamma_{11}+\gamma_{12}\varepsilon_A)\right]}{(4\beta^2-\theta^2)(\beta^2-\theta^2)} > 0$$
$$\frac{\beta\left[\alpha(2\beta^2-\beta\theta-\theta^2)+\theta\beta(\gamma_{11}+\gamma_{12}\varepsilon_A)-(2\beta^2-\theta^2)(\gamma_{21}\varepsilon_B+\gamma_{22})\right]}{(4\beta^2-\theta^2)(\beta^2-\theta^2)} > 0 \qquad (8)$$

Given that (8) is satisfied, equilibrium profits are given by equation (9) below:

$$\pi_1 = \beta(\beta^2-\theta^2)\left[\frac{\alpha(2\beta^2-\beta\theta-\theta^2)+\theta\beta(\gamma_{21}\varepsilon_B+\gamma_{22})-(2\beta^2-\theta^2)(\gamma_{11}+\gamma_{12}\varepsilon_A)}{(4\beta^2-\theta^2)(\beta^2-\theta^2)}\right]^2$$

$$\pi_2 = \beta(\beta^2-\theta^2)\left[\frac{\alpha(2\beta^2-\beta\theta-\theta^2)+\theta\beta(\gamma_{11}+\gamma_{12}\varepsilon_A)-(2\beta^2-\theta^2)(\gamma_{21}\varepsilon_B+\gamma_{22})}{(4\beta^2-\theta^2)(\beta^2-\theta^2)}\right]^2$$

and consumer surplus at the equilibrium is given by equation (10) below:

$$CS_c = \frac{1}{2}\beta^3\left[\frac{\alpha(2\beta^2-\beta\theta-\theta^2)+\theta\beta c_2^{NT}-(2\beta^2-\theta^2)c_1^{NT}}{(4\beta^2-\theta^2)(\beta^2-\theta^2)}\right]^2 +$$
$$\frac{1}{2}\beta^3\left[\frac{\alpha(2\beta^2-\beta\theta-\theta^2)+\theta\beta c_1^{NT}-(2\beta^2-\theta^2)c_2^{NT}}{(4\beta^2-\theta^2)(\beta^2-\theta^2)}\right]^2 +$$
$$\theta\beta^2\left[\frac{\alpha(2\beta^2-\beta\theta-\theta^2)+\theta\beta c_2^{NT}-(2\beta^2-\theta^2)c_1^{NT}}{(4\beta^2-\theta^2)(\beta^2-\theta^2)}\right]\left[\frac{\alpha(2\beta^2-\beta\theta-\theta^2)+\theta\beta c_1^{NT}-(2\beta^2-\theta^2)c_2^{NT}}{(4\beta^2-\theta^2)(\beta^2-\theta^2)}\right]$$

where $c_1^{NT} = \gamma_{11}+\gamma_{12}\varepsilon_A$; $c_2^{NT} = \gamma_{21}\varepsilon_B+\gamma_{22}$

We now compare this benchmark economy to another economy, which is identical in all aspects except that the market for fragments is opened. From Table 2 on p.8, we obtain the following costs of productions for the two final goods:

$$\begin{aligned} c_1^T &= \gamma_{11}+\gamma_{12} \\ c_2^T &= \gamma_{21}+\gamma_{22} \end{aligned} \tag{11}$$

where c_1^T, c_2^T denote unit costs of the two firms when there is trade in fragments.

For the sake of exposition, we shall only consider the case where firm 2 is forced to exit the market. Firm 2 exits the market if and only if it would not make strictly positive profits in the second stage of the game if it decided to stay. It is straightforward to check that this will happen when:

$$\frac{\beta\left[\alpha(2\beta^2-\beta\theta-\theta^2)+\theta\beta(\gamma_{11}+\gamma_{12})-(2\beta^2-\theta^2)(\gamma_{21}+\gamma_{22})\right]}{(4\beta^2-\theta^2)(\beta^2-\theta^2)} \leq 0 \tag{12}$$

In that case, only firm 1 stays in the market and charges the monopoly price to its consumers. This yields the following equilibrium quantities and profits:

$$q_m = \frac{\alpha - (\gamma_{11} + \gamma_{12})}{2\beta}$$
$$\pi_m = \beta\left(\frac{\alpha - (\gamma_{11} + \gamma_{12})}{2\beta}\right)^2 \tag{13}$$

Consumer surplus is then given by:

$$CS_m = \frac{1}{2}\beta\left(\frac{\alpha - (\gamma_{11} + \gamma_{12})}{2\beta}\right)^2 \tag{14}$$

We now evaluate the change in welfare between the benchmark economy, where there is no trade in fragments, and the economy where the market for fragments is opened. Since agents in both countries have same labor supply, wages, and property rights of firms in the final good industry, all agents have the same income. Furthermore, since preferences are homogeneous and all final goods are traded, each consumer in each country consumes the same amount of every good and thus has the same level of utility. Finally, with utility being linear in the homogeneous good, the change in welfare is equal to the sum of change in consumer surplus and change in total income. Labor income being constant, and in the absence of taxes and/or transfers, the change in total income is equal to the change in the profits of the two firms. Therefore, welfare of all agents goes down if and only if:

$$CS_c + \pi_1 + \pi_2 > CS_m + \pi_m \tag{15}$$

where CS_c is given by equation (10), π_1, π_2 are given by equation (9), CS_m is given by equation (14), and π_m is given by equation (13).

The last step in our demonstration is to show that all the assumptions we have made along the way to get welfare to go down are not mutually exclusive. In other words, we need to show that there exists parameter values such that equations (6), (8), (12) and (15) hold together. Since the full description of that set of parameters would not provide much intuition, we provide instead in Table 4 below some numerical values such that (6), (8) and (12) are satisfied, along with a numerical estimate of the change in welfare in each case:

Table 4 Numerical estimates of welfare change with trade in fragments

ε_A	ε_B	c_1^A	c_2^A	c_1^T	c_2^T	$CS_c+\pi_1+\pi_1$ (1)	$CS_m+\pi_m$ (2)	Δ Welfare (2)-(1)
1.4	**1.4**	4.1	4.2	3.5	4.0	30.35	30.38	**0.10%**
1.25	**1.25**	3.88	4.13	3.5	4.0	33.48	30.38	**-9.28%**
1.1	**1.1**	3.65	4.05	3.5	4.0	37.34	30.38	**-18.66%**

Note : $\gamma_{11}=2$, $\gamma_{12}=1.5$, $\gamma_{21}=0.5$, $\gamma_{22}=3.5$, $\alpha=8$, $\beta=0.25$, $\theta=0.24$

A few comments are in order about Table 4. The first comment is that equations (6), (8) and (12) do not necessarily imply inequality (15). When the gains in cost efficiency driven by international vertical specialization are large enough, which is the case when the parameters ε_A and ε_B are high, they may dominate the market concentration effect, thus causing welfare to increase. On the other hand, if the fall in the cost of production of firm 1 is moderate then a possibly large welfare loss can occur. We summarize the findings of this section in the following Proposition:

<u>*Proposition 1*</u>:

Opening the market for fragments when the final good market is imperfectly competitive may lead to the exit of a final good producer and to a Pareto inferior outcome.

It may be worthwhile comparing Proposition 1 to what can be obtained in trade models with imperfect competition but without vertical specialization. Eaton and Kierzkowski (1984) have shown that opening the final good market to trade may lead to a Pareto inferior outcome if and only if agents have sufficiently heterogeneous preferences. Proposition 1 shows that when one opens the fragment market the same phenomenon can occur even when consumer preferences are identical. The reason why we get a stronger result with vertical specialization is that opening the market for final goods, as in Eaton and Kierzkowski (1984), can never make the number of firms in the final good industry go down *strictly* in *every* country. By contrast here, we started with an equilibrium with two firms selling two final goods in each country and, after having opened the fragment market, we ended up with an equilibrium with only one firm selling one final good in each country. Thus, the market concentration effect is stronger, and hence potentially more worrisome, for the international vertical specialization case than for traditional trade models.

IV) Government Policies

Having shown that opening the market for fragments can lower welfare despite gains in production efficiency we then ask whether there is any government policy that could be implemented to prevent this welfare loss from occurring. So as to be as general as possible, we ask the question in the same framework as in Section II where, unlike in Section III, consumer preferences and the exact form of competition between the final goods producers are left unspecified. The answer is provided in the following proposition:

Proposition 2:

There exists a policy mix of production tax and lump-sum transfers such that:

i) Opening the market for fragments and implementing the policy mix is Pareto improving compared to the economy where the market for fragments is closed.

ii) The policy mix depends neither on the function $u(q_1,q_2)$ nor on the form of competition in the final good industry.

Proof:

By construction: consider a policy which taxes the production of each unit of final good by an amount exactly equal to the unit cost savings given in Table 3 and redistributes the proceeds to the consumers as lump sum transfers. Note first that the costs of production of the final goods producers after the market for fragments has been opened and the production tax has been implemented are exactly equal to what they were in the economy where the market for fragments is closed. Furthermore, because of the presence of the homogeneous good Z, the demand for goods 1 and 2 is independent of income. Hence, equilibrium prices, quantities and profits in the final good industry are unchanged. However, income has gone up: labor supply and wages are constant, we have shown that profits are unchanged, and strictly positive lump-sum transfers are distributed. Hence consumption of good Z and welfare increase. Note finally that the market for good Z clears because of Walras law (the labor that has been saved in the production of fragments thanks to international vertical specialization is now being used in the production of good Z). □

Proposition 2 begs for a number of comments. First, it is important to point out that the policy constructed above will in general not be the optimal policy from the point of view of a policy maker having full information about the structure of the economy. However, since an optimal policy will do at least as good as a given policy, we have shown that opening the market for fragments and implementing the optimal production tax / transfer policy mix will raise welfare compared to the economy where the market for fragments is closed. Second, it may be argued that the result we obtained in Proposition 2 is in some sense stronger than usual results on optimal policy. Indeed, a common critique of trade models with imperfect competition is that their policy implications are very sensitive to the specific modeling assumptions, for instance about the game played by producers (see e.g. Krugman, 1990), which is not the case here since we left that game entirely unspecified. In this light, a possible interpretation of our result is that even if policy makers have very little information about the structure of the economy, including preferences and form of competition in the final goods industry, and even if they are very risk-averse regarding the outcome of policies, they will still be able to implement a welfare improving policy in combination with opening the market for fragments.

Note that the key ingredient behind the policy in Proposition 2 is the ability of the policy-maker to "undo" the impact of opening the market for fragments on the relative production costs of final goods producers. This is the reason why only knowledge of technology is required and knowledge of preferences or form of competition in the final good industry is irrelevant. It also suggests that the policy mix described in the proof of Proposition 2 is not the only way for the policy maker to ensure that opening the market for fragments will lead to a welfare gain. In particular, if one is willing to impose a bit more structure on the game in the final goods industry, namely assuming that equilibrium allocations are continuous with respect to the costs of productions of final goods, and following the proof of Proposition 2 step by step, one can show that a policy mix composed of an almost prohibitive tariff on fragments (so as to give incentives to fragment producers to delocalize while keeping costs of production and, by the continuity assumption, equilibrium quantities of final goods arbitrarily close to those in the benchmark economy) redistributed as lump-sum transfer also leads to a Pareto improvement compared to the economy with no trade in fragments.

This last result has some interesting normative implications for international vertical specialization: what it says is that, regardless of preferences of agents and form of competition in the final good industry, a marginal liberalization of the market for fragments (going from prohibitive to almost prohibitive tariffs) generates a discrete positive jump in welfare. However, as shown in Proposition 1, going afterwards all the way from almost prohibitive tariffs to free trade in fragments can bring welfare either up or down, and even possibly to a level lower than under autarky. These welfare implications of international vertical specialization under imperfect competition are in sharp contrast with those obtained in the existing literature: Markusen (1989) and Yi (2003) find that opening the market for fragments raises world welfare. Fujita and Thisse (2002) find that going from autarky to a world with large transport costs has an ambiguous impact on welfare, one region necessarily gaining at the expense of the other, but that further decreases in transport costs raise welfare in both regions. What this comparison suggests is that ignoring imperfect competition may have a significant impact on the welfare conclusions, and hence the policy implications, that can be drawn from an analysis of international vertical specialization.

V) Concluding Remarks

At a general level, it is not surprising that different policy objectives can be contradictory in a "second best" world, where welfare theorems do not hold. This is what happens here, where opening the fragment market improves production efficiency but may at the same time bring down the level of competition in the final good industry. However, to abstract away from this possibility can lead to misleading conclusions regarding the welfare implications of international vertical specialization, even at a qualitative level. It may also, and maybe more worryingly, lead to poor design of international institutions. We have indeed characterized some policies which, combined with international vertical specialization, necessarily improve world welfare. Unlike many policy implications in the literature on trade and imperfect competition, our result is robust to different assumptions about preferences and form of competition. Yet, any country or set of countries that would try to implement such a policy would run afoul of current WTO rules...

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