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Trade liberalization, outsourcing, and the hold-up problem ☆

Emanuel Ornelas [a,b,*], John L. Turner [a,1]

[a] Department of Economics, Terry College of Business, University of Georgia, Brooks Hall Fifth Floor, Athens, GA 30602-6254, United States
[b] Ibmec-RJ, Brazil

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Abstract

This paper shows that, in a bilateral relationship where a foreign supplier has to make a relationship-specific investment but cannot enforce a complete contract, the standard hold-up problem of underinvestment is aggravated when trade incurs a tariff. In this context, we identify two new channels through which trade liberalization enhances international trade. First, lower tariffs increase the incentives of foreign suppliers to undertake cost-reducing investments. Second, lower tariffs may prompt vertical multinational integration. These indirect effects imply that responses of trade volumes to trade liberalization are greater than standard trade models suggest and help explain current trends toward foreign outsourcing and intra-firm trade.

Keywords: International trade; Outsourcing; Hold-up problem; Vertical integration; Investment effect

JEL classification: F13; F23; L22; D23

1. Introduction

World trade has increased significantly in the last fifty years. The conventional view is that this trend results from the systematic reductions in trade barriers during the same period. However, trade barriers have fallen at a much lower pace than trade flows have increased. It is therefore not surprising that conventional trade models can explain only part of the increase in trade flows (Baier and Bergstrand, 2001). Feenstra (1998) suggests that foreign outsourcing may explain the remaining fraction. When goods cross national borders multiple times in the production process, the effects of a

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* Corresponding author. Department of Economics, Terry College of Business, University of Georgia, Brooks Hall Fifth Floor, Athens, GA 30602-6254, United States. Tel.: +1 706 542 2284; fax: +1 706 542 3376.

E-mail addresses: eornelas@uga.edu (E. Ornelas), jlturner@uga.edu (J.L. Turner).

[1] Tel.: +1 706 542 3682; fax: +1 706 542 3376.

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reduction in tariffs on the cost of production of those goods — and thus on the volume of trade — are magnified. Yi (2003) formalizes this reasoning with a dynamic Ricardian model that incorporates the possibility of vertical specialization (defined as production processes in which an exported final good uses imported inputs). Calibrating the model, Yi confirms the importance of vertical specialization in explaining the response of trade flows to trade liberalization. Still, even his model can account for just about half of the growth in trade between 1962 and 1999.[2]

In this paper, we identify additional mechanisms through which trade liberalization affects trade volumes. We begin by arguing that specific assets and incomplete contracts constrain the level of international trade in intermediate goods, then show that trade liberalization loosens that constraint. First, we establish that high tariffs make international outsourcing unattractive not only because of the conventional price effects on which Yi and others concentrate, but because firms have limited incentives to carry out transnational relationship-specific investments.

As tariffs fall, then, we expect to see separate, positive "price" and "investment" effects on trade flows. Second, if lower tariffs prompt vertical integration between domestic buyers and foreign suppliers, the incentives to invest improve further. Thus, there is also a potentially positive "integration" effect on trade flows. The investment and integration effects provide a new rationale for why conventional trade models consistently underestimate the responsiveness of trade flows to trade liberalization.

We make these points using the canonical model of the hold-up problem of underinvestment,[3] with only a few adjustments to adapt it to an international context. A domestic downstream firm and a foreign upstream firm bargain under symmetric information over the terms of trade of a specialized component. Efficiency in the bargaining process ensures *ex post* efficiency in production, but contract incompleteness implies that *ex ante* relationship-specific investments undertaken by the upstream firm will generally be inefficient. We add two dimensions to this basic setting. First, to capture a "foreign *vs.* home" outsourcing decision, we do not impose a pure bilateral monopoly; rather, we allow the downstream firm to purchase either the specialized component from the foreign supplier or a standardized version from a competitive domestic market, while assuming that the buyer cannot commit to buy from one or the other. Second, we assume that the downstream firm pays a tariff if it buys from the foreign supplier.

Despite this simple structure, the model yields entirely novel predictions about how trade costs affect outsourcing, investment and integration decisions, as well as trade flows. These results are consistent with several sets of stylized facts. We find, first, that trade flows tend to be more sensitive to trade costs than conventional trade models indicate, thus helping us to understand the trade flows "puzzle" mentioned above. Second, we find that the responses of trade flows to lower trade costs in bilateral relationships have discontinuities that, when aggregated, would tend to display a non-linear pattern similar to that described by Yi (2003). Our model is consistent also with the work of Hummels, Ishii and Yi (2001), who find that vertical specialization accounts for about one-third of the increase in world trade between 1970 and 1990, and with that of Hanson, Mataloni and Slaughter (2005), who find that trade in intermediate goods within multinational firms is highly sensitive to trade costs. Finally, when trade liberalization prompts vertical integration in our model, investment and trade respond with an unambiguously positive, discrete jump. This result is supported by the empirical results of Arnold and Javorcik (2005), who identify a tendency of acquired foreign upstream firms to experience a permanent surge in productivity and investment upon acquisition.

Situations creating hold-up problems arise in a variety of contexts, but are likely to be particularly common in international transactions involving intermediate goods. The hold-up literature has focused on situations where either complete contracts cannot be written or investment specifications are not verifiable. In some circumstances, firms may alleviate such problems by reassigning property rights,[4] and empirical research has identified situations where firms have vertically integrated to lessen hold-up problems.[5] Several authors have recognized also theoretical situations

[2] In an intra-industry model with firm heterogeneity à la Melitz (2003), Chaney (2005) shows that trade liberalization causes a "productivity overshooting" where the most productive firms get larger while the least productive firms stop production in the short run. Since the firms that export are those with high productivity, this causes a short-run "trade overshooting" as well. Hence, Chaney finds a magnified elasticity of trade flows to trade barriers, too, but one that takes place during the adjustment period toward the new trade steady state, and which arises because of intra-industry heterogeneity and selection into exporting.

[3] See, *e.g.*, Tirole (1988).

[4] See, *e.g.*, Grossman and Hart (1986) and Hart and Moore (1990).

[5] See, *e.g.*, Klein, Crawford and Alchian (1978) and Monteverde and Teece (1982).

where efficiency can be achieved with simple contracts.[6] Yet even if those "remedies" could be costlessly applied, the standard underinvestment problem would remain unaltered if courts did not/could not enforce contracts properly. But poorly functioning legal systems are indeed the rule in many countries,[7] and the evidence suggests that contracts tend to be enforced particularly leniently across international jurisdictions.[8] The contractually-based solutions proposed in the literature therefore seem particularly ill-suited to mitigate hold-up problems in international contexts, even when they are appropriate for improving relationships between firms within national borders.

A burgeoning body of research incorporates contractual incompleteness into international trade models. McLaren (2000) concentrates on how international openness shapes the organization of production. In his model, buyer–supplier pairs located in the same country simultaneously choose between vertical integration and outsourcing and, depending upon this choice, the supplier builds either a specialized or a flexible component. A move from autarky to free trade increases the incidence of outsourcing because it "thickens" the market — *i.e.*, the possibility to engage in relationships with downstream firms from international markets enhances the expected outside option of suppliers. Market thickness affects outsourcing decisions also in the frameworks of Grossman and Helpman (2003, 2005), although the mechanism is distinct. There, it is the expected gain from search efforts that increases with market thickness.[9] Antràs and Helpman (2004) incorporate contract incompleteness into a monopolistically competitive model where firms choose among domestic integration, multinational integration, domestic outsourcing, and foreign outsourcing. When trade costs fall, the incidence of foreign outsourcing increases vis-à-vis multinational formation.[10]

Our setting is distinct from each of these papers in important ways. First, in our model, the (foreign) supplier is fully specialized to the (home) buyer's needs, so its outside option is unaffected by trade liberalization. This effectively shuts down all market-thickening forces. Second, in contrast to McLaren (2000), we consider vertical *multinational* integration and there is international trade in equilibrium (under both outsourcing and integration), so we can measure the impact of trade liberalization on both organizational choice and trade flows. Third, in comparison to the general equilibrium settings of Grossman and Helpman (2003, 2005) and Antràs and Helpman (2004), where modeling specifications are constrained by considerations of tractability, our partial equilibrium framework permits richer investment and sourcing decisions. We treat investment as a continuous choice variable, in contrast to Grossman and Helpman (2003, 2005),[11] and include separate *ex ante* investment and *ex post* sourcing decisions in our model, in contrast to Antràs and Helpman (2004).[12] These features yield the continuous price and investment effects of trade liberalization that form the basis of our contribution.

[6] For example, Rogerson (1992) shows that the hold-up problem may be solved with properly specified initial contracts as long as it is possible to prohibit renegotiation, whereas Spier and Whinston (1995) and Edlin and Reichelstein (1996) show that well-tuned fixed-price contracts may solve the investment problem depending on the breach remedy enforced by courts. Che and Sakovics (2004) show that the underinvestment problem may be mitigated also when the parties' investments and negotiations are dynamic, that is, when bargaining occurs with the prospect of future investment. However, efficiency is obtained in their setting only when discount factors are sufficiently large, *i.e.*, for situations where repeated bargaining carries low transactions costs. When the buyer and seller are located in different countries, as in our setting, such transactions costs are likely to be high.

[7] In fact, Levchenko (in press) shows that if some sectors rely on institutions more than others, then the quality of a country's institutions can be a source of comparative advantage. In a similar vein, Nunn (2007) shows that a country's contracting environment is an important source of comparative advantage in sectors that are intensive in relationship-specific investments.

[8] See Anderson and Marcouiller (2002) and Ranjan and Lee (in press) for strong evidence on the negative effect of poorly enforced contracts on international trade flows.

[9] A market-thickening effect is present also in McLaren (1999), where it makes informal ("handshake") arrangements more attractive relative to formal (fixed-price contracts) arrangements. In a related point, Levchenko (in press) shows that international trade can alleviate hold-up problems by inducing an improvement in the institutional quality of countries.

[10] Chen, Ishikawa and Yu (2004) study as well the effects of trade liberalization on outsourcing decisions. Their focus is, however, entirely different. They consider situations where a downstream firm engages in foreign outsourcing to lower competition on final goods, and find that such "strategic outsourcing" can lead to higher prices in both intermediate and final goods. The work of Schwartz and Van Assche (2006) is also related but distinct — they study the choice of firms between specific and generic inputs, and argue that low productivity firms are more inclined to reduce hold-up problems by favoring generic outsourcing.

[11] Grossman and Helpman (2003, 2005) adopt an "all-or-nothing" specification for the relationship-specific investments. Thus, investments can be optimal even under incomplete contracts. By contrast, in our setup arm's-length arrangements always lead to suboptimal investment; trade costs affect only the intensity of this problem.

[12] Antràs and Helpman (2004) do adopt an incremental specification for investment, but since in their setting there is a one-to-one relationship between investments and production inputs, a decomposition of the effects of trade liberalization on trade flows (into price and investment effects) does not emerge in their model.

We also identify an integration effect due to trade liberalization. As in Hart and Tirole (1990), we assume that, while entailing a fixed cost, vertical integration "permits profit-sharing between upstream and downstream units [so] all conflicts of interest about prices and trading policies are removed" (p. 206). That is, we assume that vertical integration solves the hold-up problem at a fixed cost. It then follows that trade liberalization, by mitigating this problem, reduces the value of vertical integration vis-à-vis the value of arm's-length arrangements. We show, however, that this does not imply that trade liberalization reduces the net gains from vertical integration. The reason is that expected trade volumes are larger when firms are integrated; accordingly, the direct cost of a tariff is higher (and the direct benefits from trade liberalization greater) when the firms are vertically integrated than when they operate under an arm's-length arrangement. This *trade volume effect*, which is not present in the previous literature, creates an ambiguity regarding the net impact of lower tariffs on the firms' incentives to vertically integrate.[13]

Our point here is, however, simply to indicate that lower trade costs do not *necessarily* lead to more outsourcing vis-à-vis vertical integration. That is, as the diverse ways to model vertical integration suggest and our analysis confirms, the *nature* of the enhanced offshoring that accompanies lower trade barriers (*i.e.*, whether it occurs mostly within multinational corporations or under arm's-length) is inherently ambiguous. Still, if at least some multinational firms are formed as a result of lower tariffs, then the resulting effect on trade flows would tend to be even greater.[14]

These results relate to the broader literature on whether trade and foreign direct investment (FDI) are substitutes or complements. In our model, substitute- and complementarity-like effects coexist even though we only consider trade in intermediate goods and the possibility of "vertical" multinationals. On one hand, lower tariffs generate less incentive for integration by mitigating hold-up problems, implying substitutability. On the other hand, lower tariffs make integration more attractive because of the trade volume effect, implying complementarity. While earlier research using industry- and firm-level data lent strong support to the idea that trade and FDI are complements, but not substitutes, these results are consistent with more recent research employing more disaggregated data. For example, Blonigen (2001) finds, using FDI and product-level trade data for Japanese products, that FDI increases Japanese exports of vertically related goods that are used as inputs, but lowers Japanese exports of vertically related goods that are used as inputs.

The rest of the paper is as follows. Section 2 describes the model and the pattern of investment of firms as a function of tariffs. Section 3 studies the decision between foreign outsourcing and multinational vertical integration. Section 4 then identifies the different forces through which lower tariffs influence trade flows. Section 5 concludes.

2. Model

2.1. Basic structure

A firm (B) in Home wants to buy an input that generates private gain V. There is a specific producer whose characteristics are most suitable to provide such an input to firm B. We are interested in circumstances when this "most

[13] The distinction with Grossman and Helpman (2003) and Antràs and Helpman (2004) in this regard arises from differences in the modeling of vertical integration. Grossman and Helpman consider, as we do, that integration eliminates the inefficiencies due to contract incompleteness, but they also assume that integrated firms have higher *marginal* costs of production. Thus, integration can make production possible when outsourcing cannot, but as long as efficient investment decisions takes place also under arm's length—an event with strictly positive probability in their setting-production becomes more efficient under non-integration. Antràs and Helpman model vertical integration following the property rights approach developed by Grossman and Hart (1986) and Hart and Moore (1990). Thus, integration ameliorates inefficiencies related to the investment of the purchasing party (which they assume to be always the downstream firm), but at the cost of aggravating inefficiencies related to the purchased party's investment. Neither paper identifies a clear-cut volume of trade effect such as the one we identify here.

[14] Gatignon and Anderson (1988) and Hennart (1989) find that asset specificity helps to explain why multinationals are formed, and the results of Arnold and Javorcik (2005) provide indirect evidence that the formation of multinational firms promotes cost-reducing investments. Using Indonesian micro data, Arnold and Javorcik find that foreign ownership has a large positive effect on plant productivity and that a substantial part of such gains materializes right after the foreign acquisition. This productivity hike is precisely what our model predicts should occur when integration/ foreign acquisition is motivated by the inefficiency caused by the hold-up problem.

appropriate supplier" is located in another country. However, to avoid locking firm B into a bilateral monopoly by construction, we allow it to outsource the input from other firms as well.

To model such a situation in the simplest possible way, we assume that firm B can purchase either a standardized version of the input from local suppliers or a specialized version from a manufacturer (S) located in Foreign, a different country. The domestic market for the standardized input is competitive. If B buys from that market, it has to pay a price (including adaptation costs) of p_d, where p_d is a random variable distributed over $[0, \infty)$ according to distribution F. The randomness of p_d reflects both productivity shocks to the domestic industry and uncertainty about the true costs of adapting the good to B's needs. In contrast, the foreign supplier S can produce a specialized version of the input at a deterministic cost $c(i)$, where i is S's relationship-specific investment. Neither the asymmetry between the domestic and foreign markets nor the source of the uncertainty is necessary for our results.[15]

All firms are risk neutral and there are no wealth constraints. B and S have also the option to vertically integrate prior to S's investment. If they do, they share profits and the distortion in S's investment incentive is eliminated, but they must also pay a fixed cost of reorganization $K>0$. Since there are no wealth effects, the Coase Theorem implies that B and S will integrate only if the difference between the expected total profit under integration and under arm's length is large enough to cover these reorganization costs.[16]

The assumption that integration eliminates the hold-up problem at a fixed cost follows Hart and Tirole (1990) and McLaren (2000). However, for our results all that matters is that integration attenuates the hold-up problem; complete elimination is assumed only for technical simplicity. The fixed cost K will generally be specific to the firm and the industry in question, yet since we are considering vertical integration in an international context — that is, the formation of a vertical multinational firm — the difficulties of setting up management and operations in a different country suggest that K could be particularly high here. We also note that, since in reality trade liberalization is often accompanied by capital market liberalization, K and the tariff are often reduced together. This is an important consideration that must be taken into account in an empirical evaluation of the paper. However, to focus on the effects of trade liberalization, we take K as a constant unrelated to the tariff.

The timing of the model is as follows. At period 1, B and S decide whether to integrate. At period 2, S chooses its relationship-specific investment i. At period 3, the state of nature (p_d) is revealed. At period 4, B and S decide whether to trade and, under arm's-length trading, negotiate the price if they trade. At period 5, production and trade occur. We first consider the case where B and S are independent firms, then turn to the case where they are integrated, and then compare the two cases to study the first-stage integration decision.

We assume that firm B cannot commit, *ex ante*, to purchase either the generic or the specialized input. Instead, it makes an efficient outsourcing decision *ex post*. To highlight the possibility of hold-up, as well as the difficulties of enforcing contracts in an international context, we assume that the firms cannot write a contract between them — or equivalently, that any such contract is unenforceable. Thus, if B purchases the specialized input from S, the two parties have to bargain over the selling price, p. We assume the generalized Nash bargaining solution applies, with α and $1-\alpha$ denoting S's and B's bargaining powers, respectively, where $\alpha\in[0, 1]$. Under this bargaining solution, S sells to B at a price that splits the two parties' joint surplus by making the transaction. Firm B purchases the specialized input if and only if that surplus is positive.

Let t denote the specific tariff on imports of the specialized input. With the tariff, the firm purchases the input from the foreign manufacturer if and only if $c+t\leq\min\{p_d, V\}$. *Ex post* payoffs when the bargaining is successful are

$$\begin{cases} u_b^1 = V - p - t \\ u_s^1 = p - c \end{cases}.$$

[15] If the seller also had an outside competitive option, its threat point in negotiations with the buyer would reflect that outside option, making the seller stronger in the bargaining process (described below). This would not have any qualitatively important impact on our results, however. Our results would go through also if S's cost $c(i)$ were stochastic, as is the domestic competitive price p_d.

[16] Conditional on integration, the division of surplus in the bargain that implements it does not affect any endogenous variables, so it is unnecessary to model this further. Under integration, both B and S must each earn (including any side payment) at least their expected payoff under arm's-length trading. This is possible only if total profit, net of K, is larger under integration.

If the bargaining breaks down, the foreign manufacturer S does not produce the specialized input. The buyer may then buy the domestic standardized input or nothing at all. It will choose to buy the domestic standardized input in that case if $V \geq p_{\mathrm{d}}$. Hence, the threat point payoffs for S and B are $u_{\mathrm{s}}^0=0$ and $u_{\mathrm{b}}^0=\max\{V-p_{\mathrm{d}}, 0\}$, respectively.

According to the Nash bargaining solution, the price $p(t)$ satisfies

$$p(t) = \arg\max_p (u_{\mathrm{b}}^1 - u_{\mathrm{b}}^1)^{1-\alpha}(u_{\mathrm{s}}^1 - u_{\mathrm{s}}^0)^{\alpha}.$$

Hence,

$$p(t) = \begin{cases} \alpha(p_{\mathrm{d}} - t) + (1-\alpha)c & \text{if } p_{\mathrm{d}} \leq V \\ \alpha(V - t) + (1-\alpha)c & \text{if } p_{\mathrm{d}} > V, \end{cases} \tag{1}$$

so the price received by S when $c+\mathrm{t} \leq \min\{p_{\mathrm{d}}, V\}$ is a weighted average of the surplus that S adds to the transaction and of S's cost of production.[17]

2.2. Investment choice under arm's-length arrangements

The cost of the local manufacturer is deterministic, but can be reduced by an investment $i \in [0, I]$, carried out and paid for by S. The investment costs i and is observed by both B and S, but is not verifiable by an outside observer such as a court; hence, it is non-contractible. We make the standard assumption that $c(i)$ is twice continuously differentiable, decreasing and convex in i. We also assume that $c(0) \leq V$ and that the following conditions hold:

$$\lim_{i \to 0^+} -c'(i) = \infty, \tag{A1}$$

$$\lim_{i \to I^-} -c'(i) < 1. \tag{A2}$$

These assumptions guarantee that the optimal investment is bounded strictly beneath the maximum I. Under free trade (*i.e.*, with $t=0$), they guarantee also that the optimal investment is strictly positive as long as S has some bargaining power ($\alpha > 0$).

Whenever $c(i)+t < \min\{p_{\mathrm{d}}, V\}$, the seller's profit is given by the price $p(t)$ that it receives minus its cost of production $c(i)$ and the cost of its investment. If $c(i)+t > V$, however, S sells to B with probability zero and has no revenue. Thus, using Eq. (1), the seller's expected profit as a function of its investment and the tariff can be represented as[18]

$$u_{\mathrm{s}}(i,t) = \begin{cases} \int_{c(i)+t}^{V} \alpha[p_{\mathrm{d}} - c(i) - t]\mathrm{d}F(p_{\mathrm{d}}) + \alpha[V - c(i) - t][1 - F(V)] - i & \text{if } c(i) + t \leq V \\ -i & \text{if } c(i) + t > V. \end{cases} \tag{2}$$

Clearly, if $c(0)+t > V$, the seller's profit function has a local maximum at $i=0$. It is intuitive that, for a sufficiently large tariff, $i=0$ will also be the global maximum. In general, when $i=0$ is a local maximum, it must be compared to other local maxima. For analytical simplicity, we limit the number of other local maxima to at most one:

$$[c'(i)]^2 f(c(i) + t) < c''(i)[1 - F(c(i) + t)]. \tag{A3}$$

[17] We develop our analysis for the case of a specific tariff, but similar results can be derived also under an *ad valorem* tariff. In that case, there is however also the possibility of manipulation of transfer prices when firms are vertically integrated, an issue that we return to in footnote 18. Since this potential problem is well-known, we bypass it by restricting the analysis to the case of specific tariffs. We note in addition that, since we consider the trade of only one unit, our specific tariff works analogously to a fixed transportation cost.

[18] For convenience, we will henceforth refer to expected profit interchangeably as profit.

Assumption A3 guarantees that $u_s(i, t)$ is strictly concave in i whenever $c(i)+t \leq V$. Intuitively, A3 requires that the productivity of investment falls quickly, relative to the hazard rate of p_d — that is, $c(i)$ needs to be "sufficiently convex" in i.

Given Assumptions A1, A2, A3, there is exactly one local maximum as long as $c(0)+t \leq V$. This maximum satisfies the first-order condition corresponding to the maximization of $u_s(i, t)$ in Eq. (2) with respect to i:

$$-c'(i_a)[1-F(c(i_a)+t)] = \frac{1}{\alpha}, \tag{3}$$

where subscript a denotes "arm's-length."

If $c(0)+t>V$, once a level of investment $\tilde{\imath}$ is reached such that

$$c(\tilde{\imath})+t = V, \tag{4}$$

an additional investment di increases the probability that S will trade with B. At that point, S's profit increases for some additional di whenever

$$-c'(\tilde{\imath})[1-F(c(\tilde{\imath})+t)] > \frac{1}{\alpha}. \tag{5}$$

Under A3, if condition (5) is not satisfied, $u_s(i, t)$ is monotone decreasing in i and $i=0$ is optimal. When condition (5) holds, $\partial u_s(i, t)/\partial i$ is positive at $i=\tilde{\imath}$. Given Assumptions A2–A3, $u_s(i, t)$ will then have a second local maximum satisfying condition (3). Since $i=0$ also yields a local maximum in this case, analysis of the optimal investment requires the comparison between $u_s(i_a(t), t)$ and $u_s(0, t)$, which is nil.

We show below that $u_s(i_a(t), t)$ is decreasing in t. Using that, we show also that there is a certain tariff level $\bar{t}_a$ greater than $V-c(0)$ at which S is indifferent between $i=0$ and $i=i_a(t)$. We define this tariff implicitly by

$$u_s(i_a(\bar{t}_a), \bar{t}_a) = u_s(0, \bar{t}_a) = 0. \tag{6}$$

For all $t>\bar{t}_a$, there is no investment and no trade, so $\bar{t}_a$ is, in effect, Home's prohibitive tariff. For $t<\bar{t}_a$, Eq. (3) implicitly defines the choice of investment as a strictly decreasing function of the tariff, $i_a(t)$. When t increases from $\bar{t}_a-\mathrm{d}t$ to $\bar{t}_a+\mathrm{d}t$, the optimal investment drops to zero. Proposition 1 summarizes these results. See the Appendix for the proof.

Proposition 1. *The supplier's optimal investment $i_a^*(t)$ is non-increasing in t. For all $t<\bar{t}_a$, $i_a^*(t<\bar{t}_a)=i_a(t)$ and is strictly decreasing in t. For all $t>\bar{t}_a$, $i_a^*(t>\bar{t}_a)=0$. For $t=\bar{t}_a$, $i_a^*(\bar{t}_a)\in\{0, i_a(\bar{t}_a)\}$.*

Thus, for non-prohibitive tariffs, trade liberalization unambiguously increases the supplier's choice of investment. This *investment effect* implies that lower tariffs enhance trade in intermediate goods not only because they reduce the cost of acquiring foreign components, but also because they promote relationship-specific investments that lower the cost of producing foreign components.

We illustrate Proposition 1 with an example, to which we will also refer later in the paper.

Example 1. Let p_d be distributed Exponential(λ), so that $F(p_d)=1-e^{-\lambda p_d}$, and let the supplier's cost function be

$$c(i) = \frac{1}{\lambda}(1-i^{\beta}) \text{ for } i\in[0,1].$$

It is straightforward to show that A1 and A3 are satisfied when $\beta\in\left(0,\frac{1}{2}\right)$ and that A2 is satisfied when $\beta<\lambda$.

Under this specification, the seller's cost when $i=0$ equals the expected price of a generic input. When β and λ are chosen so that A1–A3 hold, the seller's profit, for $c(i)+t\leq V$, is given by

$$u_s(i,t) = \frac{\alpha}{\lambda}[e^{\{-(1-i^{\beta})-\lambda t]\}} - e^{-\lambda V}] - i.$$

Using Eq. (3), note that any interior local maximum under non-integration must satisfy

$$i_{\mathrm{a}}^{\beta-1} e^{-(1-i^{\beta})-\lambda t} = \frac{\lambda}{\alpha\beta}.$$

Consider the case of equal bargaining power, $\alpha=.5$, and moderately responsive investment, $\beta=.25$. Assume also that $\lambda=1$, so $E(p_{\mathrm{d}})=1$, and that $V=2$, so that any $t\geq 1$ precludes international trade when there is no investment by the seller. In that case, the optimal investment is represented by the dashed line in Fig. 1. As Proposition 1 indicates, a higher tariff induces the supplier to reduce its relationship-specific investment. Moreover, if the tariff becomes sufficiently high, investment drops to zero abruptly.

2.3. Investment choice of the integrated firm

Under arm's-length arrangements such as the one analyzed in the previous section, the supplier's choice of investment is inefficient because S does not appropriate the full marginal benefits from its investment but bears all costs. That is, in our setting there is a hold-up problem whenever $\alpha<1$. In fact, the smaller is the supplier's bargaining power, the more severe is the underinvestment problem. This can be seen by noting that the local maximum i_{a} is strictly increasing in α. From Eq. (3), we have

$$\frac{\mathrm{d}i_{\mathrm{a}}}{\mathrm{d}\alpha} = -\frac{1}{\alpha \mathrm{SONC}} > 0,$$

where $\mathrm{SONC} \equiv \mathrm{d}^2 u_{\mathrm{s}}(i,t)/\mathrm{d}i^2 < 0$ follows from A3.

Vertical integration between firms B and S eliminates inefficiencies stemming from bilateral monopoly but entails a higher fixed cost that has no bearing on the choice of investment of the integrated firm. To determine how the integrated firm invests, as a function of the tariff, define the expected profit of the integrated multinational firm (gross of reorganization costs) as $U(i,t) \equiv u_{\mathrm{s}}(i,t) + u_{\mathrm{b}}(i,t)$. Note that it will produce the input itself if and only if its

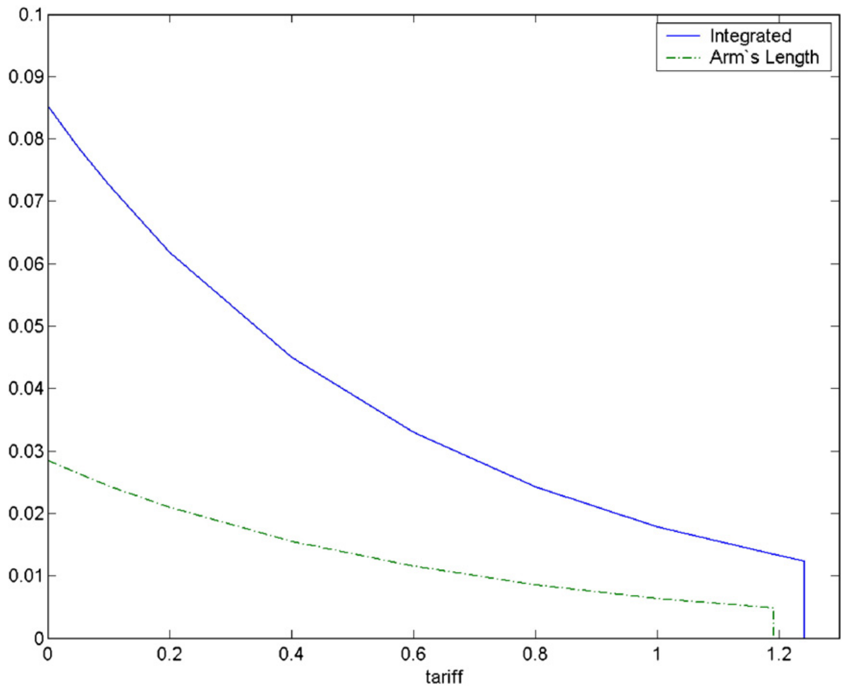

Fig. 1. Optimal investment.

cost, inclusive of the tariff, is not greater than p_{d}, the cost of acquiring the standard input locally and adapting it.[19] When $c(i)+t \leq V$, the profit of the integrated firm with a tariff can therefore be represented as

$$U(i,t) = V - \int_{c(i)+t}^{V} \mathrm{d}F(p_{\mathrm{d}}) - [c(i)+t][1-F(V)] - \int_{0}^{c(i)+t} p_{\mathrm{d}}\mathrm{d}F(p_{\mathrm{d}}) - i. \tag{7}$$

Adding and subtracting $\int_{c(i)+t}^{V} p_{\mathrm{d}}\mathrm{d}F(p_{\mathrm{d}})$ in expression (7) and manipulating, we can rewrite it as

$$U(i,t) = \int_{0}^{V} (V-p_{\mathrm{d}})\mathrm{d}F(p_{\mathrm{d}}) + \int_{c(i)+t}^{V} [p_{\mathrm{d}} - c(i) - t]\mathrm{d}F(p_{\mathrm{d}}) + [V-c(i)-t][1-F(V)] - i. \tag{8}$$

When $c(i)+t>V$, there is no trade, so the integrated firm earns $U(i, t)=\int_0^V (V-p_{\mathrm{d}})\mathrm{d}F(p_{\mathrm{d}})-i$. It is then clear from Eqs. (8) and (2) that $U(i, t)$ is equal to $u_{\mathrm{s}}(i, t)$ when $\alpha=1$, up to a constant. The local maximizer under integration, $i_v(t)$ (we use subscript v to denote "vertically integrated"), satisfies the first-order condition for Eq. (8). Since the proof of Proposition 1 applies for any α, it also applies to the case where $\alpha=1$. Hence, $i_v(t)$ satisfies Eq. (3) for $\alpha=1$ (when t is sufficiently low such that Eq. (3) holds for some i), and the optimal investment of the integrated firm, $i_v^*(t_v)$, corresponds to the special case of $i_{\mathrm{a}}^*(t_{\mathrm{a}})$ when $\alpha=1$.

Proposition 2. *The integrated firm's optimal investment $i_v^*(t)$ is non-increasing in t. For all $t<\bar{t}_v$, $i_v^*(t<\bar{t}_v)=i_v(t)$ and is strictly decreasing in t. For all $t>\bar{t}_v$, $i_v^*(t>\bar{t}_v)=0$. For $t=\bar{t}_v$, $i_v^*(\bar{t}_v)\in\{0, i_v(\bar{t}_v)\}$.*

Thus, there is an investment effect in the integrated case as well. The optimal investment in this case follows a pattern similar to the case without integration. Investment is strictly positive at $t=0$, falls with t, then makes a discrete drop to zero as the tariff reaches $\bar{t}_v$. The thresholds $\bar{t}_{\mathrm{a}}$ and $\bar{t}_v$ are nevertheless different and are ordered unambiguously, as we show in the following lemma. See the Appendix for the proof.

Lemma 1. *The prohibitive tariff is strictly greater under vertical integration than under arm's length whenever $\alpha<1$. When $\alpha=1$, they are equal.*

The intuition for this result is straightforward. The foreign supplier does not consider the impact on the expected profit of the buyer when investing, but the integrated firm does. Accordingly, the expected marginal gain from investment is, at any level, greater for the latter than for the former. As a result, it takes a larger tariff to exhaust the expected gains from a positive amount of investment when the seller is vertically integrated with the buyer than otherwise.

The profit function for the integrated firm in Example 1 is given by

$$U(i,t) = V - \frac{1}{\lambda}\left\{1 - e^{-\lambda \min[V, c(i)+t]}\right\} - i.$$

Optimal investment, for the parameterization used earlier, is represented by the solid line in Fig. 1. Clearly, investment falls with the tariff but is always greater than its level under arm's-length, since the hold-up phenomenon is not present under integration. Moreover, as Lemma 1 indicates, the prohibitive tariff is higher under integration.

3. Integration *vs.* outsourcing

Trade liberalization attenuates the hold-up problem when the firms are not integrated and the initial tariff is non-prohibitive. This may tempt one to argue that trade liberalization is a force toward "industrial disintegration." However,

[19] This may not be the case if the tariff is *ad valorem*, instead of specific. In that case, the issue of manipulation of the transfer price within the integrated firm arises: the firm may attempt to bypass the tariff by announcing the lowest possible transfer price to the customs authority, even though in most countries the arm's-length principle (that the transfer price should be the same as the one charged were the firms not integrated) applies. [See Horst (1971) for an early analysis of transfer prices in the presence of tariffs and profit taxes.] However, to the extent that the customs authority can prevent the firm from announcing a too-low transfer price even if it is unable to enforce the arm's-length principle strictly, our results would remain qualitatively unchanged with an *ad valorem* tariff. In the extreme case when the customs does not have any means to determine what an unrealistic low price is, the tariff (and trade liberalization) would be simply ineffective when the firms are integrated. Such an inability to prevent misrepresentation of the transfer price would, however, be a great incentive for the government to use specific tariffs, since otherwise the tariff would be meaningless.

we show here that this need not be true, since lower tariffs also increase the expected direct gains from becoming a multinational corporation. Indeed, we will see that a move from autarky to free trade unambiguously increases these gains; the same may occur also in the context of less extreme trade liberalization.

Consider the (gross) gains from vertical integration. Without integration, B outsources the input from S if and only if $c+t \le \min\{p_{\mathrm{d}}, V\}$, just as the multinational firm does. Therefore, the total profit under arm's-length is given by $U(i_{\mathrm{a}}^{*}(t), t)$. This makes clear that the difference between the payoffs in the two cases is entirely due to the distinct choices of investment. We also know that total profit (gross of reorganization costs) is at least as large under integration, since investment is chosen in that case to maximize $U(i, t)$.

Let the difference in expected total profit between the two cases be denoted by $\Delta U(t) \equiv U(i_v^{*}(t), t) - U(i_{\mathrm{a}}^{*}(t), t)$. To analyze how ΔU changes with the tariff, we have to consider four distinct cases: (i) $t<\overline{t}_{\mathrm{a}}$; (ii) t in a small neighborhood of $\overline{t}_{\mathrm{a}}$; (iii) $t \in (\overline{t}_{\mathrm{a}}, \overline{t}_v)$; and (iv) $t \ge \overline{t}_v$. The last case is the simplest: when $t \ge \overline{t}_v$, there is no international trade and the firms' joint profit is constant at $\int_0^V (V-p_{\mathrm{d}})\mathrm{d}F(p_{\mathrm{d}})$ regardless of integration, so $\Delta U = 0$ and there is no reason to integrate.

When the tariff is large enough to shut out international trade under arm's length, but there are strictly positive expected trade flows within the integrated multinational firm ($\overline{t}_{\mathrm{a}} < t < \overline{t}_v$), the expected total profit remains $\int_0^V (V-p_{\mathrm{d}})\mathrm{d}F(p_{\mathrm{d}})$ under arm's-length, but the integrated firm implements a strictly positive level of investment and expects a strictly larger profit. Moreover, $U(i_v^{*}(t), t)$ strictly increases as the tariff falls:

$$-\frac{dU(i_v(t),t)}{dt} = -\frac{\partial U(i_v(t),t)}{\partial i}\frac{di_v}{dt} - \frac{\partial U(i_v(t),t)}{\partial t}$$
$$= 1 - F(c(i_v)+t) > 0 \tag{9}$$

for $t \in (\overline{t}_a, \overline{t}_v)$, where we use the envelope theorem to obtain the second equality. Therefore, $\mathrm{d}\Delta U/\mathrm{d}t < 0$ and trade liberalization unambiguously enhances the gains from multinational formation for tariffs in that range. Note that in this case trade liberalization affects the expected gains from integration only through the conventional mechanism of eliminating inefficiencies in the choice of suppliers created by the tariff. This effect is nil under an arm's-length arrangement, however, since there is international trade in this range of tariffs only if the firms are integrated.

When t falls from just above $\overline{t}_{\mathrm{a}}$ to just below it, $U(i_{\mathrm{a}}^{*}(t), t)$ experiences a discrete jump. This is because, for tariff $\overline{t}_{\mathrm{a}}$, when investment jumps from 0 to $i_{\mathrm{a}}(\overline{t}_{\mathrm{a}})$, the seller's profit stays at zero, but the buyer's profit has a discrete positive jump. On the other hand, $U(i_v^{*}(t), t)$ increases continuously. Hence, ΔU necessarily falls for some sufficiently small drop in t from $\overline{t}_{\mathrm{a}}+\mathrm{d}t$ to $\overline{t}_{\mathrm{a}}-\mathrm{d}t$.

Now, when $t<\overline{t}_{\mathrm{a}}$, there is strictly positive investment under both types of arrangements. This makes the analysis subtler, and the effect of a decrease in the tariff on the expected gains from integration becomes ambiguous. The reason is that the tariff produces two effects that exert opposing pressure on ΔU. Consider first the integrated case. The effect of trade liberalization on ΔU is given by expression (9). Thus, just as in that case, the indirect effect of the tariff on the expected total profit through the choice of investment is nil here, too, since the integrated firm always invests efficiently, for a given tariff.

Under the arm's-length arrangement, the effect on the total expected profit due to a change in the tariff is instead

$$-\frac{dU(i_a(t),t)}{dt} = \frac{\partial U(i_a(t),t)}{\partial i}\frac{di_a(t)}{dt} - \frac{\partial U(i_a(t),t)}{\partial t}$$
$$= [1 - F(c(i_a)+t)] - \frac{\partial u_b(i_a(t),t)}{\partial i}\frac{di_a}{dt}, \tag{10}$$

where $\partial U(i_{\mathrm{a}}(t), t)/\partial i = \partial u_{\mathrm{b}}(i_{\mathrm{a}}(t), t)/\partial i + \partial u_{\mathrm{s}}(i_{\mathrm{a}}(t), t)/\partial i = \partial u_{\mathrm{b}}(i_{\mathrm{a}}(t), t)/\partial i$ and the second equality follows from the envelope theorem. Both terms in Eq. (10) are positive. The first corresponds to the reduction of inefficiencies in the choice of suppliers created by the tariff. The second represents the *mitigation of the hold-up problem*. A lower tariff induces the foreign supplier to increase its investment; this extra investment has a first-order positive impact on ΔU, since S disregards the benefits of its investment on B's surplus when the firms are not integrated.

Using Eqs. (9) and (10), we can then compute the effect of trade liberalization on the expected gains from vertical integration when $t<\bar{t}_{\mathrm{a}}$:

$$-\frac{\mathrm{d}\Delta U}{\mathrm{d}t}=[F(c(i_{\mathrm{a}})+t)-F(c(i_{v})+t)]+\frac{\partial u_{\mathrm{b}}(i_{\mathrm{a}}(t),t)}{\partial i}\frac{\mathrm{d}i_{\mathrm{a}}}{\mathrm{d}t}. \tag{11}$$

The second term in Eq. (11) is negative and therefore represents a force against vertical integration. It corresponds to the mitigation of the hold-up problem, and its intuition is straightforward. As the tariff falls, vertical integration becomes less compelling as a device to solve the hold-up problem (for a given level of international transactions), since the inefficiency in investment decisions becomes itself less serious. In contrast, the *trade volume effect* represented by the first term in Eq. (11) is positive, since $c(i_{\mathrm{a}})>c(i_{v})$. The reason is that there is more investment, and therefore a lower supply cost, under integration. This implies that there is also a greater likelihood of international trade under integration, so in that case a tariff is more detrimental (and its elimination more beneficial) to the expected total profit.

The following proposition summarizes the discussion above.

Proposition 3. *For $t\geq\bar{t}_{v}$, B and S gain nothing with integration. For $\bar{t}_{a}<t<\bar{t}_{v}$, the expected gains from integration increase as t falls. For some sufficiently small dt, when t falls from $\bar{t}_{a}+dt$ to $\bar{t}_{a}-dt$, the expected gains from integration decrease. For $t<\bar{t}_{a}$, they may either increase or decrease as t falls.*

The two opposing forces given in Eq. (11), though absent for example from the models of McLaren (2000), Grossman and Helpman (2003) and Antràs and Helpman (2004), are likely to be present in general. The mitigation of the hold-up problem arises from the incomplete contracts assumption, which is present in the models of each of those papers. It corresponds to the extra profit generated by a *marginal* increase in investment under non-integration. The trade volume effect, on the other hand, arises because the *level* of investment is greater under integration ($i_{v}>i_{a}$), implying that a higher level of trade translates into a higher profit when the tariff falls.[20] This latter force renders the net effect of globalization on the expected gains from multinational formation ambiguous once a certain level of trade liberalization has been achieved. Moreover, it is the only effect when a country moves from a very high tariff (above $\bar{t}_{v}$) to a lower but still relatively high tariff (between $\bar{t}_{a}$ and $\bar{t}_{v}$). The effect of a move from a sufficiently large tariff to free trade on ΔU is similarly unambiguous.

Corollary 1. *A move from autarky ($t>\bar{t}_{v}$) to free trade increases the expected gains from vertical integration.*

This simple insight implies that, upon the full opening of a country's borders to trade, the net expected gain from multinational formation is necessarily positive. The reason is that the volume of trade effect trivially dominates in this case, since we start from a situation where there is no relationship-specific investment regardless of the firms' organization.

Fig. 2 plots the expected gains from vertical integration for the parameterization of Example 1 used earlier. Since profit under vertical integration is negatively affected by the tariff, whenever the tariff falls and lies between the two prohibitive tariffs, ΔU must rise. However, when the tariff falls further, to the level just below the prohibitive tariff under non-integration, the expected total profit under arm's length experiences a discrete jump and ΔU falls. For $t\leq\bar{t}_{\mathrm{a}}$, the expected gains from integration decrease monotonically with the tariff, so B and S become more inclined to vertically integrate as t is reduced. This makes clear that, while Proposition 3 indicates that in general either force may prevail, the trade volume effect can dominate the mitigation of the hold-up problem under non-integration. In that case, the level of multinational formation relative to foreign outsourcing increases as the tariff falls, in contrast to the results of Grossman and Helpman (2003) and Antràs and Helpman (2004).

4. Trade liberalization and trade flows

We consider now the impact of trade liberalization on trade flows. A Home tariff on imports from Foreign surely reduces international trade (in expected terms), since it makes purchasing the input from S more expensive for B. A

[20] In our model, this higher profit comes from an increase in the probability of trade, but a completely analogous effect would take place under a downward-sloping demand.

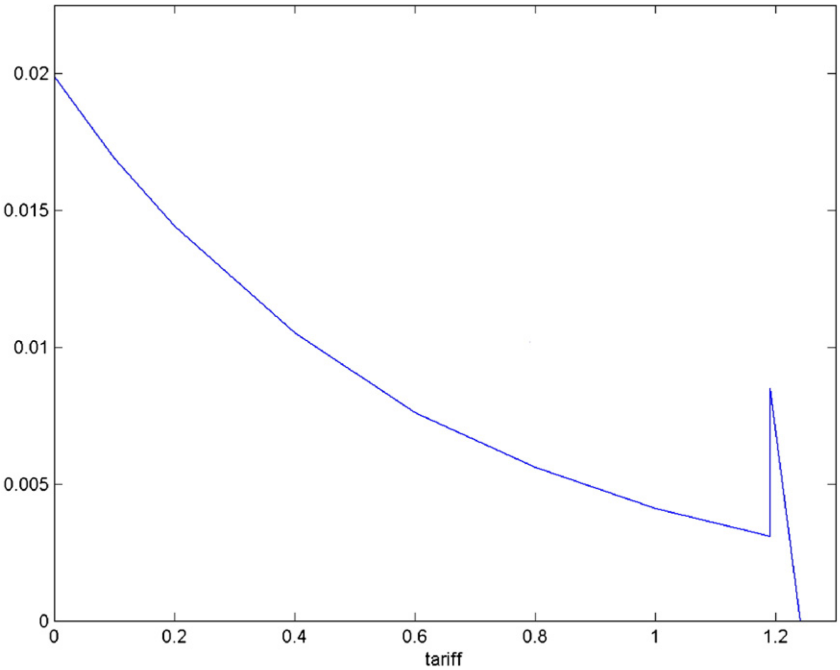

Fig. 2. Expected gross gains to integration.

tariff depresses trade not only through this standard mechanism, however; it also induces S to reduce its investment, regardless of whether it is vertically integrated with B. With less investment being carried out, S's cost increases and the likelihood that it will provide the specialized input to B is further reduced. Finally, protection can depress international trade even further if it affects the organizational choice of a firm. Basically, it may lower the expected gains from integration enough to prevent the formation of a vertical multinational firm that would eliminate hold-up problems. Tariffs, therefore, reduce international trade when firms outsource abroad by making imports more expensive (for given production costs), by lowering suppliers' incentives to undertake cost-reducing investments, and by potentially preventing the formation of vertical multinational firms that would further encourage investment.

To see this, note first that expected trade flows[21] under organizational choice $j \in \{a, v\}$ correspond in this model to

$$T_j(t) = Pr[c(i_j^*(t)) + t \leq \min\{p_{\mathrm{d}}, V\}]$$

$$= 1[c(i_j^*(t)) + t \leq V][1 - F(c(i_j^*(t)) + t)].$$

The effect of a small change in the tariff on trade flows in this case is

$$\frac{\mathrm{d}T_j(t)}{\mathrm{d}t} = \begin{cases} -f(c(i_j^*(t)) + t)\left[1 + c'\left(i_j^*(t)\right)\dfrac{\mathrm{d}i_j^*(t)}{\mathrm{d}t}\right] & \text{if } t < \bar{t}_j \\ 0 & \text{if } t > \bar{t}_j. \end{cases} \tag{12}$$

Naturally, if the initial tariff is prohibitive ($t > \bar{t}_j$), a small reduction in t has no effect on T. On the other hand, the effect of a change in the tariff when $t < \bar{t}_j$ is greater than conventional international trade models suggest. This is represented in the first line of Eq. (12). The first term within the square bracket in that expression corresponds to the standard price effect of tariffs. This effect is amplified by the investment effect represented in the second term: by making trade more likely, a lower tariff increases the supplier's incentives to invest (recall that $c'(i) < 0$). This generates

[21] It is appropriate to consider expected trade flows in this setting because the intermediate input is specified as a single indivisible unit. For convenience, we henceforth refer to expected trade flows interchangeably as simply trade flows.

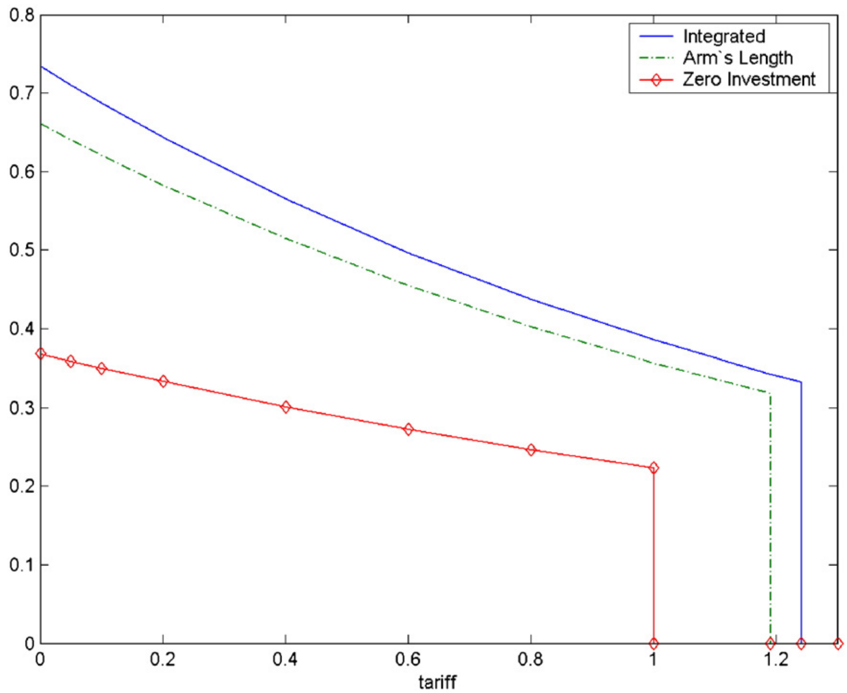

Fig. 3. Expected trade flows.

a lower cost for the supplier that further increases T.[22] Although it is intuitive that, in a setting of incomplete contracts, trade liberalization will have simultaneous price and investment effects on trade flows, our model is the first to identify and separate these effects. Thus, our analysis yields a novel framework for better understanding the observed large and non-linear responses of trade flows to falling trade costs.[23]

In addition to the price and investment effects, a lower tariff may also affect the organizational choice of the firm. In particular, there may be a tariff under which it becomes advantageous for the firms to incur the fixed costs of reorganization and vertically integrate — that is, a tariff t' such that $\Delta U\,(t')>K$. In that case, there is also a discrete jump in trade flows of size $T_v\,(t')-T_a(t')$.

Thus, as the tariff falls, T increases for three different reasons. First, the direct burden of the tariff on imports falls. Second, more relationship-specific investment is carried out by the supplier (regardless of the organizational choice), lowering production costs of foreign inputs. And third, a vertical multinational firm may be formed if reorganization costs are not too high, further increasing investment and reducing the cost of foreign inputs.

This is illustrated for the parameterization considered earlier for Example 1 in Fig. 3. Expected trade flows are $T_j(t) = e^{\{i_j^*(t)^{.25}-1-t\}}$ when $t\leq\overline{t}_j$ and zero otherwise, for $j\in\{a, v\}$. When there is a very high tariff (well above 1.2), there is no trade in either case. As the tariff falls, it first reaches $\overline{t}_v=1.24$, where trade flows would have a discrete jump under integration, to .33, but remain zero under arm's-length trading. As the tariff falls further and reaches $\overline{t}_a=1.19$, trade flows have a discrete jump under arm's-length trading, to .32. Now suppose $K=.01$. Recalling Fig. 2, note that integration becomes optimal once the tariff falls to about .4, at which point trade flows jump from .51 to .56 (from the dashed to the solid line) in Fig. 3. Hence, as the tariff falls, trade flows are non-decreasing everywhere and there are two discontinuities, the first when a positive relationship-specific investment becomes optimal under arm's-length trading, the second when vertical integration (and hence even higher investment) becomes optimal.

[22] When the tariff falls from just above $\overline{t}_j$ to just below it, there is a discrete jump in the supplier's investment that also increases expected trade flows.

[23] An alternative specification with downward-sloping demand for the final good and no uncertainty regarding p_d would yield qualitatively equivalent results. For a tariff low enough to allow international trade, the price effect would stem from a lowering of the effective marginal cost, due to lower tariffs, while the investment effect would stem from a lowering of the marginal production cost, due to greater investment. Moreover, for a sufficiently high tariff, $i=0$ is optimal.

The relative contribution of the investment effect to $dT_j(t)/dt$ is fairly uniform across the range of non-prohibitive tariffs. For the integrated case, as the tariff approaches zero from the right, the total marginal effect is −.49, of which the investment effect accounts for approximately 26%. As the tariff approaches $\bar{t}_v$ from the left, the total marginal effect of the tariff on expected trade flows is about −.21, of which the investment effect accounts for approximately 20%. At $\bar{t}_a + dt$, i_a^* experiences a discrete jump when t falls to $\bar{t}_a - dt$, so the investment effect of a lower tariff is infinite and therefore responsible for 100% of the change in T in that case. Similarly, for a change in the tariff from $t' + dt$ to $t' - dt$, where t' is a tariff that prompts vertical integration, the integration effect accounts for 100% of the increase in T.

Fig. 3 displays also the function $1 - F(c(0) + t) = e^{-(1+t)}$. This curve represents expected trade flows as a function of the tariff when there is no investment, in which case international trade changes solely because of conventional price effects. In that case, there is international trade for a smaller range of tariffs, and the response of trade flows to a reduction in tariffs is far weaker than when some investment takes place. Indeed, the sharp differences in both the level and slope between this curve and the other two curves in Fig. 3 highlight the potentially large importance of investment in shaping the responses of trade flows to trade liberalization.[24]

Naturally, reorganization costs, the competitiveness of the domestic market for inputs, and the technology to reduce production costs all vary by firm and industry. As tariffs start to fall, then, we should expect to see some firms that only outsource domestically forming multinational firms and others beginning to outsource abroad. There should be hikes in investment and productivity in some industries as well. In aggregate, as tariffs drop below the prohibitive level for more bilateral relationships, we should also observe an increase in the intensity of the response of trade flows. Careful empirical research will be necessary to identify how much of the recent increase in trade flows is actually due to investment and integration effects. Our analysis suggests that they may be very significant.

5. Conclusion

Recent research incorporating contractual incompleteness and relationship-specific investments into international trade models has begun to uncover how international trade affects and is affected by the organization of production. We contribute to this literature by focusing on the implications of contract incompleteness for the effectiveness of trade liberalization, an issue that has not yet been fully explored in this nascent line of research. To shed light on these effects, we extend a standard model of the hold-up problem to an international context.

We find that trade liberalization enhances the incentives of foreign upstream firms to carry out cost-reducing investments. This investment effect corresponds to a novel channel through which trade liberalization increases trade flows. We also find an integration effect that can enhance international trade even further. There will be such an effect whenever trade liberalization makes the gains from the internalization of investment decisions greater than the costs of merging and reorganizing previously independent firms as a multinational corporation. The investment and integration effects may help explain why international trade has increased more than twice as fast as world income in the last quarter of a century despite much more modest reductions in world trade barriers.

To highlight the fundamental, qualitative nature of the economics driving our results, we keep our model simple. This leaves some important extensions for future research. For example, while we consider only the benchmark case where a contract between the buyer and the seller has no value, the value of a contract in general depends on the quality of the country's institutions. In light of Nunn's (2007) empirical findings that the strength of a country's contract enforcement is a significant determinant of its comparative advantage, it would be interesting to analyze the impact of the strength of enforcement and of the presence of multiple jurisdictions on transnational specific investments and on trade flows of intermediate goods. Alternatively, embedding our setup into a general equilibrium framework could be helpful to allow one to relate the response of trade flows to lower trade costs to characteristics of the underlying economies. The challenge would be to keep the model tractable while still permitting a decomposition of the forces that lead to the price, investment, and integration effects identified here.

We are optimistic that empirical work incorporating intermediate goods, asset specificity, intra-firm trade, and contract enforcement can identify the investment and integration effects of trade liberalization. To identify the investment effect, controlling simultaneously for intermediate inputs and input specificity are necessary. Controlling

[24] Note that, in this example, trade flows increase faster under vertical integration than under arm's-length. However, this will not hold generally, as the relative size of the price effect depends on the shape of $f(p_d)$ while the relative size of the investment effect depends upon the shapes of $f(p_d)$ and of $c(i)$.

for intra-firm trade would further permit identification of the impact of the mitigation of the hold-up problem on the investment effect. Identification of the integration effect would additionally require observation of cross-border vertical integration caused by changes in trade costs.

The results of Feenstra, Markusen and Rose (2001) provide preliminary support for a significant investment effect, as the coefficients on distance in their gravity equations are of significantly higher magnitude for differentiated goods, which are more likely to require specific investments.[25] However, the estimations do not control for whether the traded goods are intermediate inputs. Hanson et al. (2005) do identify a strong response of intra-firm trade in intermediate goods to changes in trade costs, suggesting a significant investment effect within multinationals. However, they do not control for input specificity. These papers do not control for country-specific contract enforcement either, which, given the findings of Nunn (2007), is likely to be necessary to identify the extent to which the investment effect is influenced by the mitigation of hold-up problems.

Any empirical estimation should allow also for non-linear responses to changes in tariffs. Both the investment and the integration effects derived here are intrinsically non-linear, and the data clearly suggest a non-linear relationship, as Yi (2003) points out. The difficulties of standard trade models in replicating such non-linearities may well be due to the absence of such effects.

We note, however, that our model does not imply that trade liberalization is the only force behind the increase in trade, nor does it require the export elasticity to tariffs to be necessarily very high. The contributions of Feinberg and Keane (2006a,b) highlight this point. Feinberg and Keane (2006b) find that United States–Canada tariff reductions from 1984 to 1995 did not induce a significant increase in intra-firm trade at the extensive margin. This suggests that the jump in trade from zero to a positive level illustrated in Fig. 3 was not particularly important in that case, possibly because the tariffs were already small to start with. Feinberg and Keane (2006a) then study U.S.–Canada multinational trade at the intensive margin. They find that multinational arm's-length trade from 1984 to 1995 was strongly affected by reductions in trade costs, in line with a significant investment effect. On the other hand, Feinberg and Keane (2006a) also find that changes in trade costs account for a relatively small increase in intra-firm trade between those countries, a result that would indicate a small investment effect within multinationals in the context of our model. Instead, they find that the increase in intra-firm trade between the U.S. and Canada was due mainly to increased productivity caused by the adoption of new technologies, such as just-in-time manufacturing.[26]

It is worth noting that, while we frame the analysis as one on the effects of trade liberalization on trade flows, "tariffs" in this paper should be interpreted as a measure of overall trade costs (such as transportation and communication costs) that increase the relative cost of trading internationally instead of within national borders. Anderson and van Wincoop (2004) point out that total trade costs can be very high even in industrialized countries (up to the equivalent of a 170% *ad valorem* tax). Such high trade costs — and the possibility to reduce them — suggest that the significant increases in foreign outsourcing and intra-firm trade observed in recent years may be just the beginning of an enduring process.

Appendix A

Proof of Proposition 1. When $c(0)+t \le V$, $i_a(t)$ is the only local maximum, so $i_a{}^*(t)=i_a(t)$. Implicit differentiation of Eq. (3) then gives us

$$\frac{\mathrm{d}i_a(t)}{\mathrm{d}t} = -\frac{\alpha c'(i_a) f(c(i_a)+t)}{\mathrm{SONC}} < 0,$$

where $\mathrm{SONC} \equiv \mathrm{d}^2 u_s(i,t)/\mathrm{d}i^2 < 0$ follows from A3.

When $c(0)+t>V$, $i=0$ is a local maximum and some minimum investment $\tilde{\imath}$ is necessary for the seller to supply the buyer with a positive probability. Now, note from definition (4) that $\tilde{\imath}$ increases with the tariff. It then follows from the convexity of the cost function $c(\cdot)$ that the marginal gain from investment at $\tilde{\imath}$ is a decreasing function of t. This implies that, for any given α, condition (5) is not satisfied for large enough t. Denote the minimum tariff that violates condition (5) by $\tilde{t}_a$. For any $t \ge \tilde{t}_a$, $i_a{}^*(t)=0$.

[25] This is precisely the approach of Nunn (2007), who employs Rauch's (1999) classification of differentiated goods — that is, those that do not possess "reference prices" — as a proxy for sectors where specificity of inputs matters.

[26] Feinberg and Keane's (2006a) data do not allow them to explain, however, why U.S. multinationals adopted those technologies only in the mid-1980s, since they had already "spread throughout much of Japanese manufacturing in the 70s" (p. 37). Our model suggests that the reduction in tariffs may have been at least partially responsible for such an investment, a possibility that may be worth analyzing in future empirical research.

For $t \in (V-c(0), \tilde{t}_{\mathrm{a}})$, there are two local maxima, $i=0$ and $i=i_{\mathrm{a}}(t)$. We know that $u_{\mathrm{s}}(0, t)=0$ when the tariff is in this range, that $u_{\mathrm{s}}(i_{\mathrm{a}}(V-c(0)), V-c(0))>0$ and that, because of the continuity of $u_{\mathrm{s}}(i, t)$, $\lim_{t \to \tilde{t}_{\mathrm{a}}^{-}} u_{\mathrm{s}}(i_{\mathrm{a}}(\tilde{t}_{\mathrm{a}}), \tilde{t}_{\mathrm{a}})<0$. If we show that $\frac{\mathrm{d}u_{\mathrm{s}}(i_{\mathrm{a}}(t),t)}{\mathrm{d}t}<0$ in this range, then the proof is complete. But by the envelope theorem,

$$\frac{\mathrm{d}u_{\mathrm{s}}(i_{\mathrm{a}}(t),t)}{\mathrm{d}t} = \frac{\partial u_{\mathrm{s}}(i_{\mathrm{a}}(t),t)}{\partial t} = -\alpha[1-F(c(i_{\mathrm{a}})+t)]<0.$$

Hence, there is indeed a tariff level $\bar{t}_{\mathrm{a}}$ satisfying Eq. (6). At that level, $i=0$ is as good for the seller as $i_{\mathrm{a}}(t)$, and the optimal investment is set-valued: $\{0, i_{\mathrm{a}}\}$. For all $t<\bar{t}_{\mathrm{a}}$, $i_{\mathrm{a}}{}^*(t)=i_{\mathrm{a}}(t)$ and is then strictly decreasing in t; for all $t>\bar{t}_{\mathrm{a}}$, $i_{\mathrm{a}}{}^*(t)=0$. □

Proof of Lemma 1. Note that $U(i, t)=u_{\mathrm{s}}(i, t)+u_{\mathrm{b}}(i, t)$, where

$$u_{\mathrm{b}}(i,t) = \int_0^V (V-p_{\mathrm{d}})\mathrm{d}F(p_{\mathrm{d}}) + (1-\alpha)\left\{\int_{c(i)+t}^{V} [p_{\mathrm{d}}-c(i)-t]\mathrm{d}F(p_{\mathrm{d}}) + [V-c(i)-t][1-F(V)]\right\}$$

gives the buyer's expected payoff under an arm's-length arrangement whenever $c(i)+t<V$. Since $c(0)<V$, Assumptions A1, A2, A3 and the results of Proposition 1 guarantee that $u_{\mathrm{s}}(i_{\mathrm{a}}(\bar{t}_{\mathrm{a}}), \bar{t}_{\mathrm{a}})=0$ for some unique, strictly positive $\bar{t}_{\mathrm{a}}$. Since $c(i_{\mathrm{a}})+\bar{t}_{\mathrm{a}}<V$, we have that, for any $\alpha<1$, $u_{\mathrm{b}}(i_{\mathrm{a}}(\bar{t}_{\mathrm{a}}), \bar{t}_{\mathrm{a}})>\int_0^V (V-p_{\mathrm{d}})\mathrm{d}F(p_{\mathrm{d}})$; therefore, $U(i_{\mathrm{a}}(\bar{t}_{\mathrm{a}}), \bar{t}_{\mathrm{a}})>\int_0^V (V-p_{\mathrm{d}})\mathrm{d}F(p_{\mathrm{d}})$. Furthermore, $i_v(t)\neq i_{\mathrm{a}}(t)$ for $\alpha<1$, so it must be true by the definition of i_v that $U(i_v(\bar{t}_{\mathrm{a}}), t_{\mathrm{a}})>U(i_{\mathrm{a}}(\bar{t}_{\mathrm{a}}), \bar{t}_{\mathrm{a}})>\int_0^V (V-p_{\mathrm{d}})\mathrm{d}F(p_{\mathrm{d}})$. Thus, for $\alpha<1$, tariff $\bar{t}_{\mathrm{a}}$ is not prohibitive for the integrated firm. Since $U(i_v(t), t)$ is continuous and strictly decreasing for any tariff t such that $U(i_v(t), t)>0$, it follows that $U(i_v(t'), t')>0$ for some $t'>\bar{t}_{\mathrm{a}}$, and also that there is a $\bar{t}_v>\bar{t}_{\mathrm{a}}$ such that $U(i_v(\bar{t}_v), \bar{t}_v)=\int_0^V (V-p_{\mathrm{d}})\mathrm{d}F(p_{\mathrm{d}})$.

If $\alpha=1$, then $U(i, t)=u_{\mathrm{s}}(i, t)+\int_0^V (V-p_{\mathrm{d}})\mathrm{d}F(p_{\mathrm{d}})$, so the condition $u_{\mathrm{s}}(i, t)=0$ is equivalent to $U(i, t)=\int_0^V (V-p_{\mathrm{d}})\mathrm{d}F(p_{\mathrm{d}})$. Hence, it is trivial that $\bar{t}_{\mathrm{a}}=\bar{t}_v$.

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