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Are Uniform Tariffs Optimal?

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Abstract

This paper analyzes whether uniform tariffs give rise to the highest welfare compared with tariffs that either escalate or de-escalate along the value chain of production. We show that countries may be better off with de-escalating tariffs where tariff rates are higher on intermediate inputs and lower on final goods. The key point is that higher tariffs can encourage agglomeration of intermediate input suppliers and final goods producers in one country. With high tariffs on intermediate inputs, the benefits of close proximity to final goods producers may outweigh the benefits of locating according to comparative advantage, which is more likely when the share of intermediate inputs in producing final goods is high. De-escalating tariffs yield the highest welfare when the benefits of agglomeration are very high. These benefits of agglomeration accrue to both countries in the form of lower prices.

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I. INTRODUCTION

Tariff rates vary widely along the production chain. Most industries are characterized by escalating tariffs where tariffs are lowest on raw materials and increase as one goes up the value chain. Dividing the value chain into first stage, semiprocessed and fully processed, World Bank figures indicate that 48 out of 86 countries had escalating tariffs in their industrial products between 1994 and 2000.[2] For example, in 2000 Mauritius had an average tariff rate of 3.1 percent on the first stage, 4 percent on semiprocessed, and 44.4 percent on the final stage. Some countries had uniform tariff rates, for example Chile had an average tariff rate of 9 percent on all production stages; and other countries had a mix of increasing and then decreasing tariff rates from one stage to the next. Bolivia was the only country to report, on average, de-escalating tariffs with a 10 percent tariff rate on the first stage and semiprocessed, and 9.3 percent on final goods. Given these large disparities in tariff rates, this raises the question of how to proceed with tariff reform.

A guiding principle for tariff reform in developing countries in the 1970s and 1980s has been the "concertina theorem", which involves reducing tariffs on those goods with the highest tariffs first (Michaely, Papageorgiou, and Choski, 1991). This idea dates back to Meade (1955) who concluded that the welfare gains will be larger if tariffs on those goods with the highest tariffs are reduced first. This result was formalized by a number of authors, including Bertrand and Vanek (1971), Lloyd (1974), and Falvey (1988) for a small, open, perfectly competitive economy. However, by introducing pure intermediate inputs that are not produced domestically, Lopez and Panagariya (1992) showed that applying the concertina theorem does not always lead to welfare improvements and may, in fact, be welfare reducing. In general, taking account of vertical structures of production stages complicates the effects of trade liberalization as demonstrated in the effective protection literature (see Corden, 1971).[3]

This paper analyzes whether uniform tariffs do, in fact, give rise to the highest welfare compared with either escalating or de-escalating tariffs. We show that countries may be better off with de-escalating tariffs where tariff rates are higher on intermediate inputs and lower on final goods. The key point is that higher tariffs can encourage agglomeration of intermediate input suppliers and final goods producers in one country. With high tariffs on intermediate inputs, the benefits of close proximity to final goods producers may outweigh the benefits of locating according to comparative advantage, which is more likely when the share of intermediate inputs in producing final goods is high. De-escalating tariffs yield the highest welfare when the benefits of agglomeration are very high and this is the case when varieties of inputs and final goods have a low elasticity of substitution. The lower the substitution, the higher the value of each variety in the production of final goods and the utility of consumers. These benefits of agglomeration accrue to both countries in the form of lower prices.

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[2]Figures for many of the countries were only available for one of the years during this sample period. See *www.worldbank.org/trade*.

[3]Other arguments for uniform tariffs are based on political economy grounds. See Rodrik and Panagariya (1993). There are also many arguments for nonuniform tariffs, such as terms of trade effects and profit shifting reasons. See Tarr (2002) for a survey.

We extend the previous literature by allowing all varieties of inputs to be produced domestically or abroad, rather than only allowing for imported intermediate inputs as in Lopez and Panagariya (1992), and by introducing imperfect competition. We build on the new economic geography literature to analyze piecemeal tariff reform between two countries that differ in relative factor endowments. To date, most new economic geography models have combined upstream and downstream industries into one sector within one-factor models (see Krugman and Venables, 1995). Here, we assume that the manufacturing sector comprises two distinct vertically linked industries that differ in relative factor intensities and are monopolistically competitive, as in Amiti (2004a). There are tariffs on intermediate inputs and final goods, and both industries are also subject to real resource trade costs such as freight costs. Trade liberalization takes the form of symmetric tariff reductions between the two countries.

The rest of the paper is organized as follows. Section II sets out the formal model. Section III solves for equilibrium. Section IV presents the results on industrial location and draws out the welfare implications. Section V concludes.

II. MODEL

The model has two factors of production, labor and capital; and the industries differ in factor intensities. The two factors of production are immobile between two countries that differ in terms of relative factor endowments, where country l is assumed to be labor abundant and country k is capital abundant. Both countries have access to the same technology; and consumers in each country have identical homothetic preferences. There are two imperfectly competitive manufacturing industries, upstream and downstream industries, that are vertically linked through an input-output structure; and a perfectly competitive 'agricultural' industry, with constant returns to scale technology, employing labor and capital.

Upstream firms produce intermediate inputs, using labor and capital, which they sell to firms in the downstream industry. Downstream firms combine intermediate inputs with labor and capital to produce final manufacturing goods, which they sell to consumers. The market structure in each of the vertically linked industries is assumed to be Chamberlinian monopolistic competition: there are many firms in both industries, each employing increasing returns to scale technology and producing differentiated goods. Each firm can choose to locate in either country and it draws on the labor and capital available in the country in which it locates.

Trade costs are modelled as tariffs and real resource costs. Tariff rates can differ between upstream and downstream firms. We include positive real resource costs throughout the analysis for two reasons. One is that production patterns are indeterminate if all trade costs were zero because the number of industries is greater than the number of factors. Two, allowing for real resource costs in transporting goods highlights that even if we can reduce tariff rates to zero we cannot reduce the cost of shipping goods between countries to zero and these real resource costs affect location.

A.   Utility

We present the model for country l and note that symmetric equations hold for country k. All subscripts denote the country and superscripts the industry. The two manufacturing industries are labelled by superscripts $i = u, d$ where u denotes the upstream industry and d denotes the downstream industry. The aggregate utility function, U_l, for the representative consumer in country l is Cobb-Douglas,

$$U_l = \left(C_l^d \right)^s \left(C_l^a \right)^{1-s}, \tag{1}$$

where C_l^d is aggregate consumption of final manufactured goods and C_l^a is consumption of agricultural goods. Aggregate demand for final manufactured goods can be represented by a quantity index or sub-utility function, C_l^d, defined as

$$C_l^d = \left[\sum_{v=1}^{n_l^d} \left(c_{ll}^{dv} \right)^{\frac{\sigma-1}{\sigma}} + \sum_{v=1}^{n_k^d} (c_{lk}^{dv}/\tau)^{\frac{\sigma-1}{\sigma}} \right]^{\frac{\sigma}{\sigma-1}}. \tag{2}$$

We assume that consumers have Dixit-Stiglitz preferences so there is a taste for variety and each variety v enters the utility function symmetrically; preferences are separable and homothetic. The elasticity of substitution between any pair of differentiated goods σ is assumed to be greater than one. A consumer's utility is increasing in the number of varieties. There are n_l^d varieties of final goods produced in country l and n_k^d varieties produced in country k. Domestic demand in country l for each variety v is given by c_{ll}^{dv}, and demand for imported varieties from country k by c_{kl}^{dv}. $\tau > 1$ represents the real resource cost in shipping downstream goods between the two countries.

Dual to the quantity index for final manufactured goods, the price index, P_l^d, is

$$P_l^d = \left[\sum_{v=1}^{n_l^d} \left(p_l^{dv} \right)^{1-\sigma} + \sum_{v=1}^{n_k^d} \left(p_k^{dv} \tau \left(1 + T^d \right) \right)^{1-\sigma} \right]^{\frac{1}{1-\sigma}}, \tag{3}$$

where p_l^d is the producer price of a variety v produced in country l and $p_k^d \tau (1 + T^d)$ is the price of an imported variety from country k to country l, and $T^d \geq 0$ is an ad valorem tariff on final goods.

B.   Manufacturing

The production technology in the manufacturing sector consists of a small fixed cost of setting up a plant, f, to produce each variety. This gives rise to increasing returns technology; and the small size of f ensures that the number of varieties produced is large enough to make oligopolistic interactions negligible.

In the downstream industry, d, the production function for each variety is

$$\left(L_l^d \right)^\delta \left(K_l^d \right)^{1-\delta-\mu} \left(C_l^u \right)^\mu = f + \beta x_l^d.$$

To produce output x_l^d, firms use labor, L_l^d, capital, K_l^d, and many varieties of intermediate inputs.

These intermediate inputs enter the production function through the quantity index, C_l^u, which is defined analogously to C_l^d in equation 2, with the superscript d replaced with u. Hence, industry $u's$ output of intermediate inputs enters the production function of each downstream firm through a CES aggregator as in Ethier (1982) and Venables (1996). The share of intermediate inputs in production, μ, is a key parameter in the model, representing the vertical linkages between the two industries.

Profits of each firm are given by total revenue less total costs. In the downstream industry, profit for each firm, π_l^d, is given by

$$\pi_l^d = p_l^d x_l^d - w_l^\delta r_l^{1-\delta-\mu} \left(P_l^u\right)^\mu \left(f + \beta x_l^d\right),$$

where P_l^u is the price index of intermediate inputs, defined as in equation 3 with the superscript d replaced with u.

In the upstream industry, u, the production function for each intermediate input variety is given by:[4]

$$\left(L_l^u\right)^\alpha \left(K_l^u\right)^{1-\alpha} = f + \beta x_l^u,$$

where L_l^u and K_l^u are the labor and capital amounts employed by each firm to produce output x_l^u. Profits are given by

$$\pi_l^u = p_l^u x_l^u - w_l^\alpha r_l^{1-\alpha} \left(f + \beta x_l^u\right).$$

We assume there is free entry and exit in both upstream and downstream industries, leading to zero profits.

C. Agriculture

The production function for the perfectly competitive agricultural industry is

$$X_l^a = \left(L_l^a\right)^\gamma \left(K_l^a\right)^{1-\gamma},$$

where γ is the share of labor used in production. Agricultural goods are assumed to be freely traded,[5] with the price set equal to 1, $P^a = 1$. Then the profit function can be written as[6]

$$\pi_l^a = X_l^a - w_l^\gamma r_l^{1-\gamma} X_l^a.$$

Factor markets are assumed to be perfectly competitive and factors are fully employed.

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[4]For simplicity, we assume that f and β are the same in both upstream and downstream industries. Allowing them to differ changes the scale of production but does not affect the results.

[5]We assume that agricultural goods are freely traded in order to focus on manufacturing goods.

[6]The constant term in the marginal cost function is suppressed to simplify notation.

III. Equilibrium

We solve for equilibrium in four steps. First, we solve the representative consumer's utility maximization problem to derive the demand for final goods. Second, we solve for each firm's profit maximization problem in each industry i to derive producer prices, and downstream firms' demand for intermediate inputs. Using the free entry and exit condition, we derive the number of units each manufacturing firm must produce to cover fixed cost. Third, we determine product market clearing conditions and fourth, solve the factor market clearing conditions.

A. Consumers

The representative consumer's utility maximizing problem is solved using two-stage budgeting. In stage 1 the consumer allocates expenditure between manufactures and agriculture by maximizing the utility function, equation 1, subject to the budget constraint, which gives

$$C_l^a = (1 - s) Y_l, \tag{4}$$

$$P_l^d C_l^d = s Y_l. \tag{5}$$

The budget constraint is given by $Y_l = w_l L_l + r_l K_l + G_l$, where $G_l = p_k^d T^d c_{kl}^d n_k^d + p_k^u T^u c_{kl}^u n_k^u$ is the tariff revenue collected in country l, which is assumed to be distributed back to consumers. In stage 2 the consumer maximizes the subutility function, C_l^d (equation 2), subject to the budget constraint, sY_l in equation 5, to derive demand functions for each variety of manufactured good produced in country l and each imported variety produced in country k, respectively:

$$c_{ll}^d = \left(p_l^d\right)^{-\sigma} \left(P_l^d\right)^{\sigma-1} s Y_l, \tag{6}$$

$$c_{kl}^d = \tau^{1-\sigma} \left(1 + T^d\right)^{-\sigma} \left(p_k^d\right)^{-\sigma} \left(P_l^d\right)^{\sigma-1} s Y_l. \tag{7}$$

B. Firms

Now we consider firm behavior in the manufacturing sector and in agriculture.

Manufacturing

In the manufacturing sector, upstream and downstream firms choose a variety and pricing so as to maximize profits, taking as given the variety choice and pricing strategy of the other firms in the industry. Each firm will produce a distinct variety since it can always do better by introducing a new product variety than by sharing in the production of an existing type. In the downstream industry, each firm maximizes profits with respect to quantity to derive producer prices:

$$\frac{\partial \pi_l^d}{\partial x_l^d} = 0 \implies p_l^d = w_l^\delta r_l^{1-\delta-\mu} \left(P_l^u\right)^\mu \frac{\beta\sigma}{\sigma - 1}.$$

This gives the usual marginal revenue equals marginal cost condition, with producer price as a constant markup over marginal cost. The producer price, p_l^d, received by a firm in country l is the same whether the good is sold domestically or exported; and the tariff-inclusive

price is $p_{lk}^d = p_l^d \tau \left(1 + T^d\right)$.[7] We choose units of measurement so that $\beta\sigma = \sigma - 1$, then $p_l^d = w_l^\delta r_l^{1-\delta-\mu} (P_l^\mu)^\mu$. A proportion, δ, of downstream industry's revenue is spent on labor, $1 - \delta - \mu$ on capital and μ on intermediate inputs. Hence total expenditure on upstream intermediate inputs is given by $e_l^u = \mu n_l^d p_l^d x_l^d$. The demand functions for each variety of intermediate input produced domestically and abroad are analogous to consumers' demand functions for final manufactured goods:

$$c_{ll}^u = (p_l^u)^{-\sigma} (P_l^u)^{\sigma-1} e_l^u, \tag{8}$$

$$c_{kl}^u = \tau^{1-\sigma} (1 + T^u)^{-\sigma} (p_k^u)^{-\sigma} (P_l^u)^{\sigma-1} e_l^u. \tag{9}$$

Similarly, in the upstream industry, each firm maximizes profit with respect to quantity:

$$\frac{\partial \pi_l^u}{\partial x_l^u} = 0 \ \Rightarrow \ p_l^u = w_l^\alpha r_l^{1-\alpha}. \tag{10}$$

We can derive the number of varieties produced in each industry by imposing the free entry and exit condition, which leads to zero profits. This condition determines the quantity of output required to cover fixed costs. With

$$\pi_l^i = 0, \, x_l^i = \frac{f(\sigma - 1)}{\beta}, \ \ i = u, d. \tag{11}$$

Without loss of generality, firm size is scaled so that profits are equal to zero at size 1, by setting $f = 1/\sigma$. Note that the equilibrium scale of output is independent of price and the number of firms. This is a direct consequence of Dixit-Stiglitz preferences and a constant elasticity of substitution. Then the complementary slack condition implies that at least one of the following equations must hold with equality,

$$x_l^i \leq 1, \ \ n_l^i \geq 0, \ \ i = u, d. \tag{12}$$

For example, if output in industry i, x_l^i, is less than one then firms would earn negative profits so the equilibrium number of firms in that industry, n_l^i, would equal zero.

Agriculture

In the agricultural industry, profit maximization implies price equals marginal cost,

$$1 = w_l^\gamma r_l^{1-\gamma}. \tag{13}$$

Recall that agriculture is the numeraire good.

C. Product Markets and Factor Markets

We are now ready to solve for equilibrium in the product and factor markets. Product market

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[7]In a monopolistically competitive model, segmented and integrated market solutions are equivalent.

equilibrium requires that demand equals supply for each good in each industry,[8]

$$x_l^i = c_{ll}^i + c_{lk}^i, \quad i = u, d. \tag{14}$$

And the factor market clearing conditions are given by

$$L_l = \frac{1}{w_l} \left[\gamma X_l^a + \alpha p_l^u n_l^u + \delta p_l^d n_l^d \right], \tag{15}$$

$$K_l = \frac{1}{r_l} \left[(1 - \gamma) X_l^a + (1 - \alpha) p_l^u n_l^u + (1 - \delta - \mu) p_l^d n_l^d \right]. \tag{16}$$

The factor market clearing conditions (equations 15 and 16) and the product market clearing conditions below (equations 17 and 18), which are derived by substituting equations 3, 6, 7, 8, 9, and 11 into 14), with the analogous equations for country k simultaneously solve for the equilibrium number of firms in each country and factor prices.

$$
\begin{aligned}
x_l^u &= \frac{\mu n_l^d x_l^d w_l^\delta r_l^{1-\delta-\mu}}{(p_l^u)^\sigma \left[n_l^u (p_l^u)^{1-\sigma} + n_k^u (p_k^u \tau (1 + T^u))^{1-\sigma} \right]^{\frac{\sigma-1+\mu}{\sigma-1}}} \\
&\quad + \frac{\mu n_k^d x_k^d w_k^\delta r_k^{1-\delta-\mu}}{\tau^{\sigma-1} (p_l^u (1 + T^u))^\sigma \left[n_l^u (p_l^u \tau (1 + T^u))^{1-\sigma} + n_k^u (p_k^u)^{1-\sigma} \right]^{\frac{\sigma-1+\mu}{\sigma-1}}}
\end{aligned}
\tag{17}
$$

$$
\begin{aligned}
x_l^d &= \frac{s \left(w_l L_l + r_l K_l + T^d c_{kl}^d n_k^d + T^u c_{kl}^u n_k^u \right)}{(p_l^d)^\sigma \left[n_l^d (p_l^d)^{1-\sigma} + n_k^d (p_k^d \tau (1 + T^d))^{1-\sigma} \right]} \\
&\quad + \frac{s \left(w_k L_k + r_k K_k + T^d c_{lk}^d n_l^d + T^u c_{lk}^u n_l^u \right)}{\tau^{\sigma-1} (p_l^d (1 + T^d))^\sigma \left[n_l^d (p_l^d \tau (1 + T^d))^{1-\sigma} + n_k^d (p_k^d)^{1-\sigma} \right]},
\end{aligned}
\tag{18}
$$

$$x_l^i \le 1, \ n_l^i \ge 0, \ i = u, d.$$

These equations will form the basis for analyzing the effects of trade liberalization on industrial location.

IV. RESULTS

We consider three different cases, each with an average tariff rate of 5 percent (i) de-escalating tariffs - 10 percent tariff on intermediates and 0 percent on final goods; (ii) escalating tariffs – 0 percent tariff on intermediates and 10 percent on final goods; (iii) uniform tariffs – 5 percent on

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[8]By Walras' Law, we do not need to specify the equilibrium condition in the agricultural sector.

intermediates and final goods. The results are summarized in Table 1. Throughout the analysis we will assume that agricultural goods are freely traded, in order to focus our attention on the manufacturing sector. The real resource cost on shipping intermediate and final goods will be kept constant at 10 percent, which is based on estimates in Hummels (1999).

For concreteness, we assume that the intermediate inputs are capital intensive ($\alpha = 0.1$), and final goods are labor intensive ($\delta = 0.3$).[9] The two countries are similarly sized in terms of initial factor endowments, with $L_l = 200$, $L_k = 100$, $K_l = 100$, $K_k = 200$. We discuss implications of changing these assumptions below. We assume that the factor intensity of agricultural goods is between the final and intermediate goods ($\gamma = 0.5$). This, combined with the assumption that the share of manufactures in final consumption is less than a half ($s = 0.45$), ensures that both countries always produce agricultural goods, hence equation 13 always holds. This simplifies the analysis by ensuring that trade liberalization cannot lead to an increase in both factor returns within a country.[10] The large differences in factor intensities between intermediate and final goods works against agglomeration, but the high share of intermediate inputs in final goods ($\mu = 0.6$) promotes agglomeration. And the low elasticity of substitution between intermediate varieties and between final goods ($\sigma = 3$) makes the benefits of agglomeration very high.

In general, firms consider two broad factors in deciding where to locate: large markets for their output (market access) and the availability of cheap inputs (production costs). In order to save on fixed costs, each firm prefers to locate in only one country. Other things equal, the preferred country is the one with the largest demand in order to save on trade costs. Hence, downstream firms prefer to locate in a country with many consumers; whereas upstream firms prefer to locate in a country with many downstream firms since they form the market for intermediate inputs. This gives rise to a demand linkage, drawing upstream firms close to downstream firms. In turn, downstream firms benefit from being close to a large number of upstream firms due to the cost linkage: the more upstream firms in a country, the lower the cost of intermediate inputs. We can see this from equation 3 by replacing superscript d with superscript u, the price index, P_l^u, is decreasing in the number of upstream firms.[11] This cost linkage reinforces the demand linkage, giving rise to forces for an agglomeration of all upstream and downstream firms in one country.

There are two forces working against agglomeration. First, with fixed endowments of labor and capital, demand for final goods comes from both countries, encouraging downstream firms to locate in country k and country l. Second, given the differences in factor intensities between upstream and downstream firms the production cost effect pulls them in opposite directions, with upstream firms drawn to the country that offers a relatively lower rental rate and downstream

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[9]Note that the ratio of labour to capital coefficient is $\frac{\delta}{1-\delta-\mu} = 3$, so final goods are assumed to be very labour intensive compared to the other sectors.

[10]Both factor prices can increase in one country if $s > 0.5$. See Amiti (2004a).

[11]The cost linkage would also be present if the upstream industry was a Cournot oligopoly producing a homogeneous good. See Amiti (2001). In that case the larger the number of upstream firms the lower the price of intermediate inputs due to increased competition.

firms to the country that offers a relatively lower wage rate. Whether upstream and downstream firms agglomerate in one country depends on the relative strengths of the agglomeration and diversification forces, which depend on the level of trade costs on intermediate and final goods, and the size of the vertical linkages.

A.   Upstream Firms

The market access effect draws upstream firms to locations with a large number of downstream firms (which forms the market for their output). The production cost effect draws upstream firms to countries with the lowest rental. An upstream firm locates in country k if profits are higher than in country l, which is the case if

$$x_k^u - x_l^u = \frac{\mu n_k^d x_k^d w_k^\delta r_k^{1-\delta-\mu} \left\{ (p_l^u)^\sigma (1+T^u)^\sigma \tau^{\sigma-1} - (p_k^u)^\sigma \right\}}{\tau^{\sigma-1} (p_l^u p_k^u)^\sigma (1+T^u)^\sigma \left[n_l^u (p_l^u \tau (1+T^u))^{1-\sigma} + n_k^u (p_k^u)^{1-\sigma} \right]^{\frac{\sigma-1+\mu}{\sigma-1}}} \quad (19)$$

$$+ \frac{\mu n_l^d x_l^d w_l^\delta r_l^{1-\delta-\mu} \left\{ (p_l^u)^\sigma - (p_k^u)^\sigma (1+T^u)^\sigma (\tau)^{\sigma-1} \right\}}{\tau^{\sigma-1} (p_l^u p_k^u)^\sigma (1+T^u)^\sigma \left[n_l^u (p_l^u)^{1-\sigma} + n_k^u (p_k^u \tau (1+T^u))^{1-\sigma} \right]^{\frac{\sigma-1+\mu}{\sigma-1}}} > 0.$$

A sufficient condition for this to hold is that the difference in the terms in the curly brackets is positive, since all other terms are positive. Whenever the second expression is positive, then this implies the first expression is too. The second expression is positive if

$$\left(\frac{p_l^u}{p_k^u} \right) = \left(\frac{w_l}{w_k} \right)^\alpha \left(\frac{r_l}{r_k} \right)^{1-\alpha} > \tau^{\frac{\sigma-1}{\sigma}} (1+T^u). \quad (20)$$

Upstream firms locate in country k if the production cost advantage outweighs the cost of exporting to country l. Note that the overall sign of equation 19 may still be positive even if the inequality in equation 20 does not hold, for example, if the number of downstream firms in country k is high.

Recall that in our numerical simulations, we have assumed a very high capital intensity in the production of intermediate inputs with $\alpha = 0.1$. Consequently, in all the policy experiments considered in Table 1, the production cost effect arising from a relatively low rental rate in the capital abundant country dominates the market access effect. This leads to all upstream firms to locate in the capital abundant country.

As well as affecting the location of upstream firms, import tariffs on intermediate inputs also affect the location of downstream firms, since downstream firms are drawn to locations with a large number of upstream firms. So by influencing the location of upstream firms, these tariffs also affect the location of downstream firms.

B.   Downstream Firms

The location of downstream firms is also influenced by trade costs on final goods. Lower tariffs on

final goods makes it possible for all downstream firms to locate in one country and serve the other through exports. A downstream firm locates in country k if profits are higher than in country l,

$$x_k^d - x_l^d = \frac{sY_k \left\{ \left(p_l^d\right)^\sigma \left(1+T^d\right)^\sigma \left(\tau\right)^{\sigma-1} - \left(p_k^d\right)^\sigma \right\}}{\left(p_l^d p_k^d\right)^\sigma \left(1+T^d\right)^\sigma \tau^{\sigma-1} \left[n_l^d \left(p_l^d \left(1+T^d\right)\right)^{1-\sigma} + n_k^d \left(p_k^d\right)^{1-\sigma}\right]}$$

$$+ \frac{sY_l \left\{ \left(p_l^d\right)^\sigma - \left(p_k^d\right)^\sigma \left(1+T^d\right)^\sigma \tau^{\sigma-1} \right\}}{\left(p_k^u p_l^u\right)^\sigma \left(1+T^d\right)^\sigma \tau^{\sigma-1} \left[n_l^d \left(p_l^d\right)^{1-\sigma} + n_k^d \left(p_k^d \left(1+T^d\right)\right)^{1-\sigma}\right]} > 0.$$

(21)

A sufficient condition for this to hold is that the difference in the terms in the curly brackets is positive, since all other terms are positive. Whenever the second expression is positive, then this implies the first expression is too. The second expression is positive if

$$\left(\frac{p_l^d}{p_k^d}\right) > \left(1+T^d\right) \tau^{\frac{\sigma-1}{\sigma}}.$$

(22)

Downstream firms locate in country k if the production cost advantage outweighs the cost of exporting to country l. Even if the second expression in equation 21 were negative, the overall sign may still be positive, for example, if the income in country k is high. Whether the inequality in equation 22 holds depends on relative factor prices, the number of upstream firms and tariffs on intermediate inputs, as can be seen by

$$\left(\frac{p_l^d}{p_k^d}\right) = \left[\left(\frac{w_l}{w_k}\right)^\delta \left(\frac{r_l}{r_k}\right)^{1-\delta-\mu}\right] \left[\frac{n_l^u \left(p_l^u \tau \left(1+T^u\right)\right)^{1-\sigma} + n_k^u \left(p_k^u\right)^{1-\sigma}}{n_l^u \left(p_l^u\right)^{1-\sigma} + n_k^u \left(p_k^u \tau \left(1+T^u\right)\right)^{1-\sigma}}\right]^{\frac{\mu}{\sigma-1}}.$$

(23)

The first square bracketed term represents the factor cost advantage of locating in country l, with labor intensive firms putting more weight on lower relative wages. The second square bracketed term represents the cost linkage – the more upstream firms in country k, the lower the price of intermediate inputs there, and the higher is μ, the greater the weight on this term. Whether condition 21 holds will depend on the tariff rates on intermediate and final goods.[12]

C. Trade Liberalization

Reducing tariffs on final goods to zero while keeping tariffs on intermediates as high as 10 percent promotes agglomeration of upstream and downstream firms in the capital abundant country. From Table 1, we see that with $T^u = 10$ percent, $T^d = 0$, the share of upstream and downstream goods produced in the labor abundant country is zero ($sh_l^u = 0$, $sh_l^d = 0$), the labor abundant country produces only agriculture. High tariffs on intermediate inputs increases the benefits of upstream and downstream firms locating in one country; and low tariffs on final goods makes it possible for all downstream firms to locate in one country and export goods to the other. The lower trade

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[12]Note that whether the conditions in equations 19 and 21 hold will be independent of the initial distribution of firms for the parameter values in the simulations. The equilibrium outcome for each tariff combination underlying Table 1 is unique, so the sequence of trade liberalization in these examples are irrelevant. See Amiti (2004b) for examples of path dependence.

costs on final goods reduces the importance of downstream firms locating in country l to be close to consumers. Even though the lower relative wage rate attracts downstream firms to the labor abundant country, the tariff of 10 percent on intermediates makes it too costly for downstream firms to locate in the low wage country and import intermediates.

In contrast, escalating tariffs works against agglomeration. With $T^u = 0$, $T^d = 10$ percent, all intermediate inputs are still produced in the capital abundant country but now the labor abundant country produces 44 percent of final goods. Low trade costs on intermediates means that the lower relative wage cost in the labor abundant country draws downstream firms there and the high tariff on final goods increases the importance of downstream firms locating in both countries close to consumers. As more downstream firms locate in the labor abundant country they bid up the relative wage rate until it no longer becomes profitable for any more downstream firms to locate there.

Interestingly, both countries are better off with the de-escalating tariffs that results in agglomeration than with escalating tariffs. The utility in the capital abundant country is $U_k = 1003.8$ with de-escalating tariffs compared with $U_k = 975.9$ with escalating tariffs. Surprisingly, the labor abundant country is also better off with the agglomeration in the capital abundant country rather than producing 44 percent of final goods. Its utility with de-escalating tariffs is $U_l = 931.6$ compared with $U_l = 923.7$ with escalating tariffs. The basic intuition is that the labor abundant country also shares in the benefits of agglomeration through lower prices of final goods. The benefits are so high in this example because the share of intermediate input is high at $\mu = 0.6$ and the elasticity of substitution is low at $\sigma = 3$. The low elasticity of substitution makes varieties very imperfect substitutes. So the the benefit of differentiated varieties in the production of final goods is very high (see equation 3 with the subscript d replaced with u). A lower elasticity of substitution would reduce the benefits of agglomeration.

With uniform tariff rates at 5 percent, the labor abundant country produces 17 percent of final goods. Given that the capital abundant country produces 83 percent of final goods under uniform tariffs there are still some gains from agglomeration so the utility with uniform tariffs is higher in both countries compared with escalating tariffs, but not as high as with de-escalating tariffs where the full benefits of agglomeration are gained. So in our example, the worst case scenario is that of escalating tariffs.

Reducing tariffs to zero on both intermediate inputs and final goods does not result in complete specialization based on comparative advantage since there is still a 10 percent real resource cost in shipping intermediates and final goods. At zero tariff rates, the labor abundant country produces 41 percent of final goods and achieves the highest utility, however zero tariff rates lead to lower utility in the capital abundant country compared with de-escalating tariffs that results in agglomeration. In this example, aggregate world welfare is highest with agglomeration. Lower shipping costs, τ, could change this result. Recall that we maintained $\tau = 10$ percent on intermediates and final goods to highlight that these costs would still exist even when tariffs have successfully been reduced to zero. Positive shipping costs could prevent complete specialization based on comparative advantage and differential shipping rates on intermediates and final goods

can lead to different patterns of industrial location.

So far we have assumed that intermediate inputs are relatively more capital intensive. If instead intermediate inputs were labor intensive and final goods were capital intensive, there would be a stronger tendency for the agglomeration to locate in the labor abundant country. De-escalating tariffs on the final goods would encourage more capital intensive downstream firms to locate in the labor abundant country to be close to the intermediate input suppliers.

The assumption of similar sized countries ensures that the market access effect is of similar magnitude for downstream firms in both countries. However, if one country is significantly larger than the other country then this will increase its attractiveness for downstream firms. For example, if country l were very large, we see from equation 21 that a high relative income[13] in country l (a high Y_l relative to Y_k) can change the sign of that expression and make it more profitable for downstream firms to locate in country l. With a higher number of downstream firms in country l, we see from equation 19 that this could also increase the profitability of upstream firms locating in country l, hence promoting agglomeration of upstream and downstream firms in the labor abundant country.

V. CONCLUSIONS

This paper has shown that uniform tariffs in an imperfectly competitive world do not always yield the highest welfare. In some cases, a high tariff on intermediate inputs and low tariff on final goods can promote agglomeration of upstream and downstream firms in one country. The benefits of agglomeration give rise to lower prices of final goods, which benefit both countries. So even though the labor abundant country can attract a higher share of the manufacturing industry with escalating or uniform tariff rates, its welfare might be higher if all the manufacturing industry were located in one country – even if the agglomeration is located in another country. In our example, escalating tariffs, which characterize tariff structures in most countries, yield the lowest welfare in the labor abundant and in the capital abundant countries.

The key to the welfare gains arising from de-escalating tariffs is that location of firms is endogenous, and this tariff structure could lead to agglomeration. Indeed, in our model there is free entry and exit, and the fixed cost of setting up a firm is assumed to be very small. In industries that are characterized by high entry and exit costs, lower tariffs on intermediate inputs relative to final goods could give rise to higher welfare as firms benefit from cheaper intermediate inputs.

The benefits of agglomeration are likely to dominate in industries that are highly imperfectly competitive, are subject to high increasing returns to scale, and produce imperfect substitutes. In our model, these characteristics were proxied by a low elasticity of substitution. It should be

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[13]Of course, the relative size of a country not only depends on the size of endowments but also on the endogenous factor returns. But with agriculture produced in both countries, both factors within a country cannot simultaneously experience an increase ie an increase in w_l is associated with a fall in r_l.

noted that the model presented is highly stylized and abstracts from many other important factors, for example there could be additional benefits of agglomeration, such as learning externalities, but there could also be costs, such as congestion and pollution. In practice, it is difficult to identify and properly measure these characteristics. However, further research along these lines could aid the tariff reform process.

Table 1: Results

Labour abundant country

T^u	T^d	sh_l^u	sh_l^d	w_l	r_l	U_l^w	U_l^r	U_l
0.10	0.00	0	0	0.35	0.71	2.33	4.66	**931.60**
0	0.10	0	0.44	0.38	0.65	2.50	4.23	**923.71**
0.05	0.05	0	0.17	0.36	0.69	2.41	4.47	**929.63**
0.00	0.00	0	0.41	0.38	0.66	2.51	4.31	**931.82**

Capital abundant country

T^u	T^d	sh_k^u	sh_k^d	w_k	r_k	U_k^w	U_k^r	U_k	U_l+U_k
0.10	0.00	1	1	0.55	0.46	3.77	3.13	**1003.80**	1935.40
0	0.10	1	0.56	0.51	0.49	3.33	3.21	**975.91**	1899.62
0.05	0.05	1	0.83	0.54	0.47	3.60	3.14	**989.23**	1918.86
0	0.00	1	0.59	0.51	0.49	3.37	3.25	**987.49**	1919.31

Notes:

The real resource cost, τ, is set at 10% in all policy experiments.

T^u – tariff rate on upstream goods (intermediate inputs).

T^d – tariff rate on downstream goods (final goods).

sh_l^u – share of upstream industry located in labour abundant country.

sh_l^d – share of downtream industry located in labour abundant country.

w_l, r_l – factor prices in labour abundant country.

U_l^w – real returns to workers in labour abundant country.

U_l^r – real returns to capitalists in labour abundant country.

U_l – aggregate utility in the labour abundant country.

U_l+U_k – aggregate world utility.

All k subscripted variables refer to the capital abundant country.

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