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Optimal Tariffs, Tariff Jumping, and Heterogeneous Firms*

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Abstract

The majority of research to date investigating strategic tariffs in the presence of multinationals finds a knife-edge result where, in equilibrium, all foreign firms are either multinationals or exporters. Utilizing a model of heterogeneous firms, we find equilibria in which both pure exporters and multinationals coexist. We utilize this model to study the case of endogenously chosen tariffs. As is standard, Nash equilibrium tariffs are higher than the socially optimal tariffs. Unlike existing models with homogeneous firms, we find that non-cooperative tariffs promote the existence of low-productivity firms relative to the socially optimal tariffs. This highlights a new source of inefficiency from tariff competition not found in models of homogeneous firms. In addition, we find that in many cases the Nash equilibrium tariff when FDI is a potential firm structure is lower than when it is not. As a result, FDI improves welfare by mitigating tariff competition.

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1 Introduction

The optimal tariff literature stems as far back as Bickerdike (1906), which links a country's ability to increase welfare through a tariff to the elasticity of the foreign export supply. With the rise of foreign direct investment (FDI), recent literature has begun to examine the interaction between FDI and tariffs. One such interaction is through what has been coined "tariff-jumping", which refers to a foreign firm investing (either through greenfield FDI or firm acquisition) in the host country to avoid protectionist barriers. There are two primary hypotheses for the motivation behind tariff-jumping; one anticipatory and the other reactional. The former is where a firm uses FDI as a *quid pro quo* for a lower future threat of protection and was formally introduced by Bhagwati (1987).[1] The latter, and what will be focused on here, is where a firm finds it more profitable to operate a foreign subsidiary in a host country in response to erected trade barriers by the importing country. In this paper we offer the first model of endogenously chosen tariffs where heterogeneous firms can choose between exporting and FDI as a foreign market entry mode using a formulation of the Helpman, Melitz, and Yeaple (2004) model. A key consequence of firm heterogeneity is that in equilibrium, unilaterally chosen tariffs result in lower average firm productivity than found at the social planner's optimal tariffs. This highlights a new inefficiency resulting from tariff competition, one that does not exist in models with homogeneous firms. Furthermore, in many cases, when FDI is ruled out as a possible firm structure, these inefficiencies become larger. Therefore, allowing FDI improves welfare by its ability to mitigate tariff competition.

Ellingsen and Wärneryd (1999) (EW) are the first to analyze the preferred level of protection in the presence of (or threat of) tariff-jumping. They find that domestic firms would prefer a tariff just low enough to keep multinationals out of a host country. On the one

[1] Blonigen and Feenstra (1997) find that the threat of protection had a substantial positive effect on greenfield FDI in the U.S. in the 1980s, but the protection variable used is a dummy variable taking on only values of zero and one. Similarly, Blonigen and Figlio (1998) investigate the effect of FDI on U.S. legislators' votes on protectionist policies between 1985 and 1994 and finds that *quid pro quo* FDI has an effect, but not in a systematic way. For instance, legislators who were initially more protectionist in nature tended to increase trade restrictions, where legislators who took a more free trade stance were inclined to lower trade restrictions.

hand, this result is useful in that it illustrates how domestic firms, contrary to intuition, do *not* want full protection. On the other hand, it provides a knife-edge result in which there is no FDI in equilibrium; i.e. there is no occurrence of tariff-jumping.[2] Ludema (2002), who considers preferential trade agreements in an economic geography model where an exogenous number of firms choose FDI to avoid both tariffs and transport costs, also finds this knife-edge result for multinationals. However, this does not coincide with what is seen in the real world, where in many industries there are both multinational and exporting firms (see Halland and Wooton (1998), Blonigen and Ohno (1998), and Blonigen (2002)). This knife-edge result is a side-effect of assuming firms are homogeneous – an assumption abolished in our model.[3]

An alternative approach to that of EW is taken by Blanchard (2006, 2007) which assumes exogenous levels of FDI, eliminating the knife-edge.[4] However, Blanchard (2006, 2007) eliminates the endogenous choice of FDI and, thus, the tariff-jumping consideration is absent. The cost of this assumption is not minor, as ignoring endogenous firm structure eliminates a major focus of the recent trade literature, an issue which is central to the work on heterogeneous firms. In contrast, our modeling of firm heterogeneity dulls the knife-edge result of EW, while still allowing for endogenous firm entry. Larch (2008) also considers endogenous FDI, however, he assumes an exogenously endowed specific factor used by exporters and multinationals that pins down the mass of varieties. Therefore in his model the mass of varieties is invariant to the tariff, a structure which, although simplifying enough to yield tractability, eliminates one of the primary gains from trade in the New Trade theory – an

[2]EW does characterize an equilibrium with FDI under uncertainty.

[3] Another departure from EW is the social welfare function we use. EW cite the literature on the political economy of protection, such as Hillman (1989) and Rodrik (1995), and utilize a welfare function that reflects the preferences of small, but strong, interest groups – hence they maximize domestic firm profits. Blonigen, Tomlin, and Wilson (2004) empirically investigate the effect of U.S. antidumping decisions on domestic firm profits and find that when tariff-jumping FDI occurs, the profit gains from the trade barrier are at least partially mitigated. Though domestic firm profits are an important welfare consideration (particularly in a political economy framework), we take a more classical approach and treat profits as a source of income for a representative consumer and the indirect utility of which policy makers seek to maximize.

[4]Technically, FDI in Blanchard (2006) is modeled as passive claims on foreign output and not majority ownership of a firm. However, given the perfect competition assumption of her model, the two definitions can be interpreted identically.

increase in the mass of varieties. Further, in his model, unlike ours, all firms are either exporters or multinationals.

Since Melitz (2003) and Jean (2002), a great deal of attention has been given to introducing firms that differ in terms of productivity into trade models. Typically in these models, trade restrictions are exogenously given symmetric iceberg transport costs and little is done with regards to optimal trade policy. To our knowledge, no one has studied optimal tariffs in the presence of both heterogeneous firms and the endogenous choice to become a multinational. While Helpman, Melitz and Yeaple (2004) provide a model with heterogeneous firms and the option to become a multinational, their focus is not on optimal trade policy. Instead they focus on industry composition and productivity as a result of symmetric trade restrictions (modeled by iceberg transport costs). Jørgensen and Schröder (2006) investigate the welfare effects of a tariff in a Melitz (2003) type model. However in their model, tariffs are symmetric and exogenous. Though their model describes some interesting welfare effects, it does not characterize the unilateral strategy of a particular country and therefore cannot discuss the welfare implications of tariff competition. Demidova and Rodríguez-Clare (2007) use a Melitz-type model and a small country assumption to show the first best outcome can be achieved through either a consumption subsidy, export tax, or an import tariff. Nevertheless, neither Jørgensen and Schröder (2006) nor Demidova and Rodríguez-Clare (2007) allow for the possibility of FDI.

It is interesting that there is such limited theoretical work on optimal trade policy in which both exporters and multinationals are present in equilibrium, given the empirical evidence of its existence. Exceptions to this include Blonigen and Ohno (1998), who provide a partial equilibrium Cournot model where firms have differing (expected) costs of FDI. In this model, foreign firms who establish a significant production presence try to increase trade barriers in the home country. The authors provide case studies of U.S. antidumping cases in tapered roller bearings and color picture tubes and the escape clause investigation of Japanese autos for empirical evidence. Nevertheless, filling this gap in the theory is critical

as it lays the necessary foundation for studying noncooperative trade policy, the formulation of trade agreements, and the many impacts of international trade policy.

This paper contributes to the literature in several ways. First, as noted above, we provide the first model incorporating both firm heterogeneity and endogenously arising FDI into the optimal tariff decision. Second, we show that the world welfare maximizing tariff is negative, that is, welfare is highest when trade is subsidized. This is entirely a consequence of firm heterogeneity. As is well known in this class of models, when domestic firms are forced to compete with importers the least productive domestic firms exit. This shifts resources towards more productive firms. As a result, at free trade the productivity benefits of additional competition outweigh the costs arising from the distortions in the relative price of imported versus domestically produced goods. Third, we characterize the Nash equilibrium tariffs. Regardless of whether FDI is permitted as a possible firm structure, we find that the Nash tariffs are greater than the world welfare maximizing tariffs. This implies that tariff competition lowers average productivity and highlights a new inefficiency from tariff competition, one which arises only in a model of heterogeneity.[5] Finally, we use numerical examples to compare the Nash tariffs when FDI is an option for firms and when it is not. We find that equilibrium tariffs are lower whenever firms avail themselves of FDI. As a result, FDI mitigates tariff competition and raises Nash equilibrium welfare.

The paper proceeds as follows. Section 2 develops the model and characterizes the equilibrium. Section 3 derives the world welfare maximizing tariffs. Section 4 characterizes the noncooperative Nash tariff set by a country both with and without multinationals. Section 5 contains a comparison of the Nash tariffs and the resulting world welfare both with and without multinationals. Section 6 concludes.

[5]This is similar to the model of Davies and Eckel (forthcoming) in which governments compete in profit taxes for mobile heterogeneous firms. They find that tax competition often results in non-harmonized taxes which then encourages survival of low-productivity firms.

2 The Model

There are two countries labeled k and j.[6] Country k (j) is endowed with $\bar{L}_k$ ($\bar{L}_j$) units of labor which is the sole factor of production. Without loss of generality, let $\bar{L}_k \geq \bar{L}_j$. There are two sectors. Sector 1 is the numeraire and consists of a homogeneous good (y) that is produced under constant returns to scale, freely traded, and sold in a perfectly competitive market. Sector 2 consists of a continuum of differentiated goods, each variety of which is indexed by i. As is standard in the Melitz model, this is produced under increasing returns to scale in a monopolistically competitive market with free entry. Unlike sector 1, this market may face tariff barriers. With the exception of the differing labor endowments and (potentially) tariff rates, countries are identical. Therefore, analyzing the situation for country k informs us of the analogous situation for country j, and we will refer to country k as the domestic country to ease discussion.

The timing of the model is as follows. In stage 1, tariffs are simultaneously set. In stage 2, firms choose whether or not to serve the domestic market and whether to serve the overseas market through FDI (if it is an option), exporting, or not at all. Finally, in stage 3, production takes place, trading commences, and payoffs are realized. We solve for the equilibrium via subgame perfection.

2.1 Sector 1

The price of y is normalized to 1 in each market. Assuming that one unit of labor is needed for production, this normalizes the wage in each country to unity. Finally, we assume that in equilibrium a positive amount of y is produced in each country.

[6] Since the amount of foreign firms active in a country depends only on that country's tariff, expanding our model to include additional countries would expand the interpretation of the mass of foreign exporters and multinationals. While this might affect the margins for optimal tariff setting, it would not qualitatively affect the results. Furthermore, if a country can set different tariffs on different countries' firms the equilibrium between any two countries would be identical to that found here.

2.2 Consumers

The representative consumer in country k has quasi-linear preferences embedded with a Dixit-Stiglitz utility function which displays love for variety over the heterogeneous good:

$$U_k = \mu \ln(X_k) + Y_k, \quad X_k = \left(\int_0^{N_k} x_k(i)^{\alpha} di \right)^{\frac{1}{\alpha}}, \quad \mu > 0 \tag{1}$$

where $\varepsilon = 1/(1-\alpha) > 1$ is the elasticity of substitution, N_k is the total mass of varieties in country k, Y_k denotes aggregate consumption of the numeraire, and X_k can be interpreted as the amount of a composite good comprised of the different varieties of the heterogeneous goods $x_k(i)$. Consumers maximize utility subject to their budget constraint:

$$\int_0^{N_k} p_k(i) x_k(i) di + Y_k \leq I_k \tag{2}$$

where $p_k(i)$ is the price of variety i and I_k is aggregate income in country k. We assume that income in each country is sufficiently large that both goods are consumed. The solution to this problem yields a demand function for the heterogeneous good of variety i in country k:

$$x_k(i) = \frac{p_k(i)^{-\varepsilon} \mu}{\int_0^{N_k} p_k(i)^{1-\varepsilon} di}. \tag{3}$$

Since preferences are identical across both countries, it follows that the total expenditure on the heterogeneous good is equal to μ in both foreign and domestic markets.

2.3 Heterogeneous Firms

There is a continuum of firms, each of which holds a unique position on an index, where each point i represents a unique variety and productivity level.[7, 8] Armed with this index the firm

[7] One interpretation of the model is that firms are owned by entrepreneurs and that firm profits accrue to these entrepreneurs. In our representative agent setting, these profits would simply enter national income in the same way that wages do, therefore we discuss the model in terms of firms to avoid needless jargon.

[8] It is common in heterogeneous firm models to have entrepreneurs draw from a distribution of productivities (often at a cost). The advantage to that approach is that it permits multiple varieties to have the

decides whether to serve the domestic market and/or the overseas market. To serve a given market, the firm must incur a fixed cost. These costs are referred to as 'beachhead' costs and can be interpreted as forming a distribution and servicing network.[9] To serve its domestic market, a firm with index i must hire $f(i)$ units of labor (making the fixed cost of serving this market $f(i)$). If a firm chooses to serve the foreign market, it can do so through exports and pay an *extra* $\gamma f(i)$ or become a multinational and pay an *extra* $\Gamma f(i)$. We assume that $\Gamma > \gamma > 1$; $f'(i) > 0$ and $f''(i) \geq 0$, i.e. the mapping from the index to the labor required for beachhead costs is increasing and convex in the index. Thus, firms requiring fewer workers to cover beachhead costs have a lower index i. These fixed cost differences are the source of firm heterogeneity. A firm, therefore, faces the following menu of fixed costs (measured in units of labor):

Table 1: Fixed Cost Menu

Firm Type	**Fixed Cost**
domestic only	$f(i)$
domestic and exporter	$(1+\gamma)f(i)$
domestic and multinational	$(1+\Gamma)f(i)$

Production exhibits constant returns to scale with labor as the only factor of production. The unit-labor requirement for a firm is normalized to one. Note that given this, firms with a low i require less labor per unit of output. We therefore describe these firms as relatively more productive firms.

Goods that are exported from country k to country j are subject to an *ad valorem* tariff τ_j, where we define $t_j \equiv 1 + \tau_j$. We assume that a government is unable to distinguish

same productivity. The cost, however, is one of added complexity and additional assumptions since modelers are often forced to parameterize this distribution (the Pareto distribution is a common choice). Here, our assumption of unique variety/productivity combinations aids greatly in the presentation of our results in the simplest, most tractable fashion. Nevertheless, were we to pursue the alternative approach, the intuition of our results would remain: that welfare is maximized through trade subsidies, tariff competition leads to excessively high tariffs and lower average productivity, and FDI can benefit welfare by mitigating tariff competition. See Cole (2008) and Jørgensen and Shröder (2009) for a detailed comparison between our current setup and the more traditional approach.

[9]The term 'beachhead' costs was coined by Baldwin (1988).

a particular firm's type, so any tariff is an across-the-board tariff applied to all foreign exporters. Intuitively, this is akin to a country charging the same tariff on all imported automobiles and not different tariffs on specific makes and models.

The decision to become a firm and which market to service depends on the associated profit for each type. Recall that the numeraire yields wages equal to one in both countries, thus the operating profits from serving the domestic market in country k are

$$\pi_D^k(i) = p_k(i)q_k(i) - q_k(i) - f(i). \tag{4}$$

Given the nature of monopolistic competition, the price will be a constant mark-up over marginal cost and be equal to $\frac{1}{\alpha}$. From market clearing, set $q_k(i) = x_k(i)$, and the firm has the following profit function for supplying to the domestic market only:

$$\pi_D^k(i) = B_k - f(i) \tag{5}$$

where

$$B_k = \left(\frac{1}{\varepsilon\alpha^{1-\varepsilon}}\right)\frac{\mu}{\mathcal{P}_k^{1-\varepsilon}}$$

and $\mathcal{P}_k = P_k^{\frac{1}{1-\varepsilon}} = \left(\int_0^{N_k} p_k(i)^{1-\varepsilon}di\right)^{\frac{1}{1-\varepsilon}}$ is the aggregate price index of the heterogeneous good.[10] This can also be interpreted as the price of one unit of the composite good X_k. Recall that N_k is the total mass of *all* varieties in country k, domestic and foreign; with the latter including imported varieties and locally produced varieties through FDI. Thus, the decision for foreign firms to enter the market (either through exports or FDI) affects the aggregate price index which, in turn, affects a domestic firm's variable profit (represented by B_k). This price index effect can be more readily seen by fully writing out P_k:

[10]Recall $\varepsilon = \frac{1}{1-\alpha} \Rightarrow 1 - \alpha = \frac{1}{\varepsilon}$.

$$
\begin{aligned}
P_k &= \int_0^{N_k} p_k(i)^{1-\varepsilon} di = \int_0^{i_{kD}} p_k(i)^{1-\varepsilon} di + \int_0^{i_{jM}} p_k^j(i)^{1-\varepsilon} di + \int_{i_{jM}}^{i_{jX}} \left[t_k p_k^j(i)\right]^{1-\varepsilon} di \\
&= \left[\frac{1}{\alpha^{1-\varepsilon}}\right] \left[i_{kD} + i_{jM} + t_k^{1-\varepsilon} \left(i_{jX} - i_{jM}\right)\right]
\end{aligned}
$$

where i_{kD}, i_{jM}, and i_{jX} are the mass of domestic firms, foreign multinationals, and foreign exporters respectively.[11] These terms will be discussed in greater detail in the following section.

When serving the foreign market the firm can do so by exporting or through FDI. The additional profit from becoming an exporter or multinational, respectively are:

$$
\pi_X^k(i) = \frac{B_j}{t_j^{\varepsilon}} - \gamma f(i) \tag{6}
$$

$$
\pi_M^k(i) = B_j - \Gamma f(i). \tag{7}
$$

Note that since expenditure on the differentiated good is the same in each country (and equal to μ), $\Gamma > \gamma > 1$ is sufficient to guarantee that a firm serving the foreign market (either through exports or FDI) will also serve the domestic market. In addition, the variable profit of a multinational is identical to that of a domestic firm in country j. The variable profit of an exporter is lower (as long as there exists a positive tariff), but the fixed cost is also lower. The difference in variable profits between the two methods of serving the foreign market is the driving force behind the decision to become a multinational. As the tariff rate increases, the variable profit of an exporter decreases while the differences in fixed cost remain the same. When the tariff rate is sufficiently high, the gain from higher variable profit is greater than the higher fixed cost of becoming a multinational, and a firm chooses FDI over exporting. This is then an example of the well known proximity-concentration

[11] In this equation we see the simplicity which our assumption of unique variety/productivity pairs buys us. Note that one method of obtaining this simple formulation of P_k using the traditional approach would be to assume that i is distributed uniform on the interval [0,1].

tradeoff, evidence of which is shown by Brainard (1997) among others.[12]

2.4 Equilibrium for given tariffs

Firms will enter each market as long as the associated profits are greater than the opportunity cost, that is, as long as the expressions in (5) and (6) are greater than zero. Furthermore, a firm will choose to be a multinational as long as the profit in equation (7) is greater than that in equation (6). We define the cutoff firms as the firms whose index solves the following conditions:

$$B_h = f(i_{hD}) \tag{8}$$

$$\frac{B_h}{t_h^{\varepsilon}\gamma} = f(i_{gX}) \tag{9}$$

$$\left(\frac{t_h^{\varepsilon}-1}{(\Gamma-\gamma)t_h^{\varepsilon}}\right) B_h \leq f(i_{gM}) \ (= \text{ if } i_{gM} > 0). \tag{10}$$

where

$$B_h = \frac{\mu}{\varepsilon\left[i_{hD} + i_{gM} + t_h^{1-\varepsilon}\left(i_{gX} - i_{gM}\right)\right]}$$

for $h = j, k$ and $g \neq h$. The index i_{hD} represents the firm that is indifferent between producing the differentiated good and not producing at all (i.e. the least productive domestic producer). The least productive exporting firm is denoted by i_{gX}, and i_{gM} is the firm that is indifferent between serving the foreign market through exports or FDI. Figure 1 illustrates these relative cutoffs by plotting the firm's profit as a function of its index.[13]

[12] It is worth noting that the model in Brainard suffers from precisely the knife-edge problem that our approach resolves.

[13] Note that in Figure 1 the linearity of profits in i stems from the assumption that $f(i) = \eta i + \lambda$. We will make use of this functional form as an illustrative example throughout the paper.

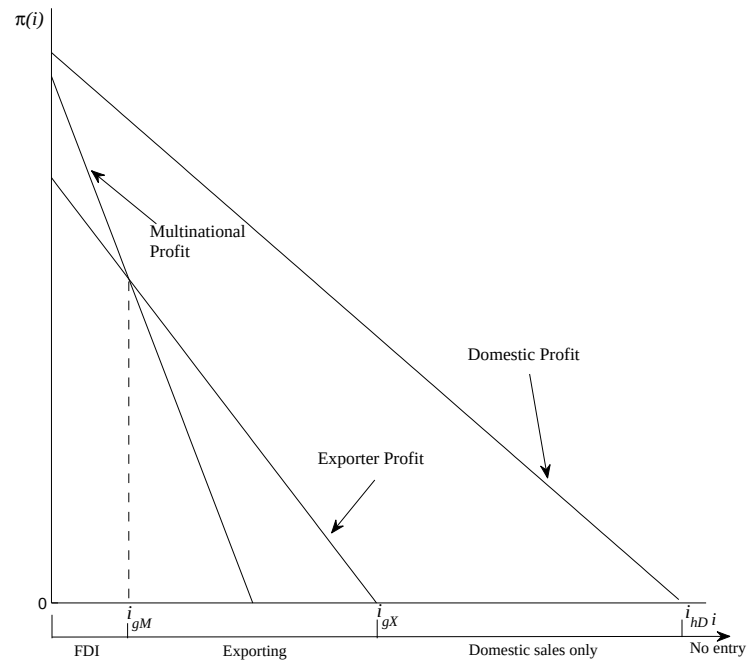

Figure 1: Firm profit as a function of the index i

To derive how the cutoffs move with changes in the tariff, we totally differentiate the equilibrium conditions (8) - (10) and P_h; this yields the following comparative statics:

$$\frac{\partial i_{hD}}{\partial \tau_h} = -\frac{f(i_{hD})}{f'(i_{hD})P_h}\frac{\partial P_h}{\partial \tau_h} \tag{11}$$

$$\frac{\partial i_{gX}}{\partial \tau_h} = -\frac{f(i_{gX})}{f'(i_{gX})}\left[\frac{1}{P_h}\frac{\partial P_h}{\partial \tau_h} + \frac{\varepsilon}{t_h}\right] < 0 \tag{12}$$

$$\frac{\partial i_{gM}}{\partial \tau_h} = \frac{f(i_{gM})}{f'(i_{gM})}\left[\frac{\varepsilon}{t_h(t_h^{\varepsilon}-1)} - \frac{1}{P_h}\frac{\partial P_h}{\partial \tau_h}\right] > 0 \tag{13}$$

$$\frac{\partial P_h}{\partial \tau_h} = \left[\frac{1}{\alpha^{1-\varepsilon}}\right]\left[\frac{\partial i_{hD}}{\partial \tau_h} + (1-t_h^{1-\varepsilon})\frac{\partial i_{gM}}{\partial \tau_h} - \alpha\varepsilon t_h^{-\varepsilon}(i_{gX}-i_{gM}) + t^{1-\varepsilon}\frac{\partial i_{gX}}{\partial \tau_h}\right]. \tag{14}$$

From (12) and (13) (which we can sign regardless of the sign of (14)), we see that a rise in the tariff leads the most productive foreign exporters to become multinationals and the least productive foreign exporters to exit the domestic market entirely. What effect this has on the domestic price index and therefore the mass of domestic firms depends on the how these

two changes balance out. To see this in more detail, reduce (14) to the following:

$$\frac{\partial P_h}{\partial \tau_h} = \frac{\theta_h}{\alpha^{1-\varepsilon} + \phi_h} \tag{15}$$

where

$$\phi_h \equiv \left[\frac{f(i_{hD})}{f'(i_{hD})} + (1 - t_h^{1-\varepsilon})\frac{f(i_{gM})}{f'(i_{gM})} + t^{1-\varepsilon}\frac{f(i_{gX})}{f'(i_{gX})}\right]\frac{1}{P_h} > 0 \tag{16}$$

$$\theta_h \equiv \frac{\varepsilon}{t_h^{\varepsilon}}\left[\frac{f(i_{gM})(t_h^{\varepsilon-1} - 1)}{f'(i_{gM})(t_h^{\varepsilon} - 1)} - \alpha(i_{gX} - i_{gM}) - \frac{f(i_{gX})}{f'(i_{gX})}\right]. \tag{17}$$

This last term relates the increase in domestic competition from additional multinationals to the reduction in competition as low-productivity foreign exporters leave. In order to sign this, we impose an additional assumption that for all tariffs where FDI occurs $\frac{i_{gM}}{\delta(i_{gM})} \leq \frac{i_{gX}}{\delta(i_{gX})}$ where $\delta(i)$ is the elasticity of $f(i)$ with respect to i. Thus, this assumption requires that the elasticity of the fixed cost mapping is not too increasing in the index when evaluated at the relevant cutoffs.[14] Using the equilibrium conditions (9) and (10) and our assumption on the elasticity of $f(i)$, equation (17) can be rewritten as

$$\theta_h = \frac{\varepsilon}{t_h^{\varepsilon}}\left[\frac{i_{gM}}{\delta(i_{gM})}\frac{(t_h^{\varepsilon-1} - 1)}{(t_h^{\varepsilon} - 1)} - \frac{i_{gX}}{\delta(i_{gX})} - \alpha(i_{gX} - i_{gM})\right] < 0. \tag{18}$$

This then implies that as the tariff rises, P_h falls, increasing the aggregate price index and the cutoff for the last domestic firm. Thus, trade protection has the intuitive effect of increasing domestic output. These results are qualitatively identical to those of other similar models in the heterogeneous firm literature, such as Melitz (2003) and Helpman, Melitz, and Yeaple (2004). Where this paper differs and makes its main contribution is by characterizing world welfare maximizing tariffs and countries' noncooperative Nash tariffs. This is the goal

[14]Note that this is weaker than assuming that $\delta(i)$ is not too increasing in all i. Further, note that this is a sufficient, not a necessary condition for (18) to hold. In many of the numerical examples used in the paper, we assume that $f(i) = \eta i + \lambda$, a function where $\delta(i)$ is increasing in i, but not so much as to violate this condition. Another obvious candidate for $f(i)$ which fulfills this assumption is any constant elasticity function.

of the next sections.

Before doing so, however, it is important to note that there is nothing that ensures there will always be positive mass of multinationals. The presence of multinationals depends on both the tariff level and the fixed cost mapping since firms will only choose FDI when the savings from avoiding the tariff are at least as great as the additional fixed costs from setting up a subsidiary. Utilizing a specific parameterization of the fixed cost mapping, such as $f(i) = \eta i + \lambda$, we can illustrate this graphically. In this example, the most productive firm has a fixed cost $f(0) = \lambda$. It follows, then, that there will be no multinationals in equilibrium if

$$\left(\frac{t_h^{\varepsilon} - 1}{(\Gamma - \gamma)t_h^{\varepsilon}}\right) B_h < \lambda. \tag{19}$$

In Figure 2, we illustrate for country k the pairs (λ, τ_k) for which the most productive exporting firm is indifferent between becoming a multinational and staying an exporter (i.e. when (19) holds with equality). For future reference, we refer to these pairs of tariffs and λ as the FF line.

2.5 Welfare

The indirect utility of the representative consumer, and our measure of national welfare, is

$$V_k = \mu \ln(X_k) + I_k - \mu. \tag{20}$$

For a given tariff, income is equal to labor income plus profits from domestically owned firms and tariff revenue:[15]

$$I_k = L_k + \int_{i_{kM}}^{i_{kX}} \pi_X^k(i)di + \int_0^{i_{kM}} \pi_M^k(i)di + \int_0^{i_{kD}} \pi_D^k(i)di + \frac{\tau_k}{\alpha} C_{kX}.$$

[15]Note that profits for multinationals can equal zero, thus maintaining generality.

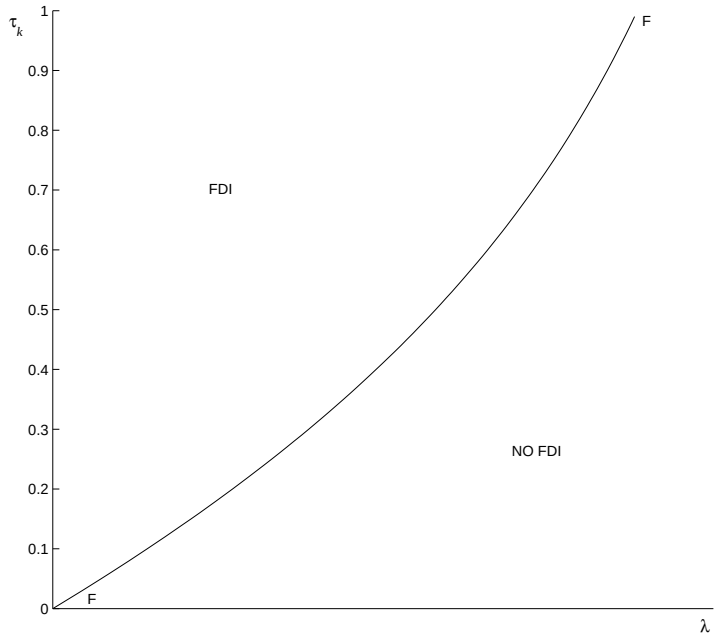

Figure 2: Minimum Tariff Needed to Induce FDI

The term C_{kX} represents country k's aggregate consumption of imported varieties of the differentiated good. For future reference we analogously define C_{kD} as k's aggregate consumption of the domestically produced varieties of the differentiated good which are produced by domestic firms and C_{kM} as k's aggregate consumption of the varieties produced domestically by j's multinational firms.

3 Social Planner's Problem

In this section, we solve for the world welfare maximizing tariffs (which we refer to as the socially optimal tariffs as chosen by a social planner).[16] Noting the analogous nature of the equilibrium across countries, we focus on the socially optimal tariff for country k since a comparable result is found for country j's socially optimal tariff. In doing so, we assume that the social planner puts equal weight on the welfare of each country. The first order

[16]Note that this social optimum is an optimum under the constraint that no firm can be forced to accept negative profits, as discussed by Dixit and Stiglitz (1977).

condition for the social planner is:[17]

$$\frac{\partial V_k}{\partial \tau_k} + \frac{\partial V_j}{\partial \tau_k} = \underbrace{\frac{\mu - \left(C_{kD} + C_{kM} + C_{kX}\right)}{\varepsilon P_k}\left(\frac{\partial P_k}{\partial \tau_k}\right)}_{(-)} + \underbrace{\frac{\tau_k C_{kX}}{t_k}\left[1 + \sigma_{kX}\right]}_{(?)} = 0 \tag{21}$$

where σ_{kX} is the price elasticity of import demand in country k. From here, we can show that the social planner's preferred tariff is negative, i.e. world welfare is maximized by subsidizing trade.

Proposition 1. *Whether or not multinationals are present, the optimal tariff for the social planner is a subsidy.*

Proof. Although it is tempting to simply evaluate (21) at $\tau_k = 0$, without pinning down the magnitude of σ_{kX}, we cannot rule out multiple solutions. Further, the magnitude of σ_{kX} is contingent on the presence of FDI. Thus to find the global maximum it is necessary to consider both the case where FDI occurs and where it does not. If FDI is not present (either because the tariff is too low or FDI is simply not available as an option to firms):

$$\sigma_{kX} = \underbrace{\frac{-(\varepsilon i_{kD} + t_k^{1-\varepsilon} i_{jX})}{i_{kD} + t_k^{1-\varepsilon} i_{jX}}}_{(<-1)} + \underbrace{\frac{i_{kD}}{i_{kD} + t_k^{1-\varepsilon} i_{jX}}\left[\frac{t_k}{i_{jX}}\frac{\partial i_{jX}}{\partial \tau_k} - \frac{t_k}{i_{kD}}\frac{\partial i_{kD}}{\partial \tau_k}\right]}_{(-)} < -1$$

If FDI is present, then:

$$\sigma_{kX} = \frac{t_k}{i_{kD} + i_{jM} + t_k^{1-\varepsilon}(i_{jX} - i_{jM})}\left[\frac{i_{kD} + i_{jM}}{i_{jX}}\frac{\partial i_{jX}}{\partial \tau_k} - \frac{i_{kD} + i_{jX}}{i_{jX} - i_{jM}}\frac{\partial i_{jM}}{\partial \tau_k} - \frac{\partial i_{kD}}{\partial \tau_k}\right] - \frac{\varepsilon(i_{kD} + i_{jM}) + t_k^{1-\varepsilon}(i_{jX} - i_{jM})}{i_{kD} + i_{jM} + t_k^{1-\varepsilon}(i_{jX} - i_{jM})} < -1$$

[17] See the appendix for a more thorough derivation.

To see this, note that $\frac{\partial i_{jX}}{\partial \tau_k} < 0$, $\frac{\partial i_{jM}}{\partial \tau_k} > 0$, $\frac{\partial i_{kD}}{\partial \tau_k} > 0$. Thus, regardless of the presence of FDI, the import demand in country k is elastic. It then follows that the final bracket in (21) is negative, implying that for the first order condition to hold $\tau_k < 0$ at the social optimum. Furthermore, since country size does not impact the social planner's first order condition, we find the same result for τ_j. □

There are two interesting features of this result to point out. First, unlike most models of tariff setting, the social optimum is not free trade. This results from heterogeneity in firm productivity. In this setting, as found in other models of heterogeneity such as Melitz (2003), competition with foreign firms leads the least productive domestic firms to exit the market, a move which shifts resources towards more productive uses. When trade barriers are a choice variable, something not discussed by Melitz, on the margin this productivity boost gives the social planner an additional incentive to promote trade. Thus, world welfare improves by subsidizing imports since this drives out the least productive firms, a change that more than offsets consumption distortions caused by non-zero tariffs. This result would not arise in a model with homogeneous firms. Second, since tariffs are negative, multinationals do not occur at the social planner's optimum. Without transport costs, both firms and the social planner prefer that overseas markets are served through exports rather than FDI since FDI carries a greater fixed cost with no benefits. Since there are no spillovers from FDI in our model, the social planner is content to allow this entry mode to go unutilized. If features such as physical trade costs or productivity spillovers from FDI were introduced into the model, they would provide an incentive for the social planner to not drive out FDI in equilibrium.[18] Nevertheless, these benefits would have to be balanced against the productivity gains from trade promotion that form the driving force in our model. Therefore, in the interest of simplicity we do not consider them here.

[18]Evidence of such productivity spillovers are provided by Javorcik (2004). Chor (2009) considers optimal FDI subsidies when heterogeneous firms face transport costs.

4 Nash Tariff

In this section, we derive the Nash equilibrium in which countries unilaterally choose their tariffs. When country k charges a tariff, there are two standard income effects. The first is an increase in tariff revenue, the second is increased domestic profit from reduced competition. However, as in Larch (2008), there is no terms of trade benefit. This is for two reasons. First, since higher tariff prices are a fixed markup over a constant wage, pre-tariff import prices do not change. Second, quasi-linear utility pushes domestic and overseas income changes onto the numeraire. This leaves overseas consumption of the heterogeneous good, and thus profits from k's exporters or multinationals, unaffected by k's tariff. Note that this means any tariff set by country j will not affect the tariff setting decision of country k, resulting in dominant strategies.

Differentiating national welfare (20) of country k with respect to its tariff, the first order condition is:

$$\frac{\partial V_k}{\partial \tau_k} = \underbrace{\frac{\mu}{X_k}\frac{\partial X_k}{\partial \tau_k}}_{} + \underbrace{\frac{\partial}{\partial \tau_k}\left[\int_0^{i_{kD}} \pi_D^k(i)di\right]}_{} + \underbrace{\frac{C_{kX}}{\alpha} + \frac{\tau_k}{\alpha}\frac{\partial C_{kX}}{\partial \tau_k}}_{} = 0. \tag{22}$$

The first underbrace represents the effect of a tariff on consumers by affecting the total amount of the heterogeneous good they consume. The latter two underbraces represent income changes. More specifically, the second underbrace is the effect of a tariff on the profits of domestic firms producing the heterogeneous good. Finally, the third underbrace is the effect of a tariff on tariff revenue. The first order condition (22) simplifies to[19]

$$\frac{\partial V_k}{\partial \tau_k} = \frac{\mu - C_{kD}}{\varepsilon P_k}\left(\frac{\partial P_k}{\partial \tau_k}\right) + C_{kX} + \tau_k \frac{\partial C_{kX}}{\partial \tau_k}. \tag{23}$$

Our next proposition compares this result with that for the social planner.

[19]See the appendix for detailed derivation and note the comparability of the problems choosing the unilaterally optimal tariff and the world welfare maximizing one.

Proposition 2. *Regardless of whether multinationals are present in equilibrium, Nash tariffs are higher than the world welfare maximizing tariffs.*

Proof. Comparing (23) with the social planner's first order condition (21), the difference is driven by the effect of country k's tariff on country j. Regardless of whether multinationals are present, country j's total exporter profits are decreasing in τ_k. This is clear from two facts. First, a rise in k's tariff leads to a decline in j's exporter cutoff since variable profits are falling in the tariff. Since all of j's exporters earn the same variable profit, this results in a smaller mass of firms earning less each. Country k does not consider this when setting its unilaterally optimal tariff. Therefore, at the tariff which solves (21), (23) is positive, implying that k will set a tariff higher than what the social planner would choose (which by Proposition 1 is negative). Further, if k sets a tariff such that FDI occurs, this requires that $\tau_k > 0$. Therefore regardless of whether FDI arises in the Nash equilibrium or not, Nash tariffs are greater than the world welfare maximizing tariffs.

□

Note that this proposition does not require that FDI occurs in the Nash equilibrium. Evaluating (23) at $\tau_k = 0$, the final term drops out and we are left with a negative effect (the first term, representing changes in productivity and the mass of varieties with respect to tariff changes) and a positive effect (the second term, representing marginal tariff revenues). Unlike the social planner's case, where tariff revenues for one country were canceled out by tariff payments by the other, this second term remains in the unilateral case. Therefore, it is in general ambiguous whether the first effect dominates the unilateral tariff as in the social planner's problem or not.

For qualitative results, we turn to the illustrative example where $f(i) = \eta i + \lambda$ and focus on two main parameters: the elasticity of substitution (ε) and λ (which is inversely related to $\delta(i)$, the elasticity of $f(i)$ with respect to i). In Figure 3, we graph a country's Nash tariff as a function of the elasticity of substitution. It can be seen that for low values of

ε, the Nash tariff is a subsidy.[20] As the elasticity of substitution increases, the Nash tariff increases as well up to a point and then decreases but stays positive. When ε is small, the firm's price markup is higher and, *ceteris paribus*, there are more firms in equilibrium. As a result, encouraging imports creates a large benefit by greatly shifting resources from low productivity domestic firms to high productivity ones. As ε increases, the mass of domestic firms declines, reducing this benefit relative to the tariff's revenue generating properties resulting in a positive tariff. Finally, as ε grows very large, the market approaches perfect competition and foreign exporters become very sensitive to tariffs, resulting in a Nash tariff that asymptotically approaches zero from above.

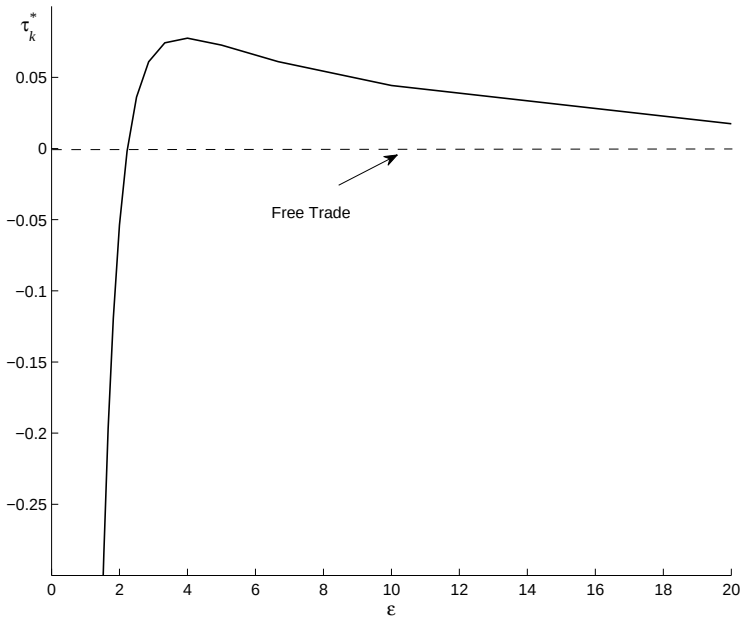

Figure 3: Optimal Tariff as a function of ε

The finding that there exist parameter values resulting in unilateral Nash subsidies is somewhat unusual in the literature. Helpman and Krugman (1989) describe a similar model with monopolistic competition and quasi-linear utility yet find a small across-the-board tar-

[20]Since we are focusing here on the case of negative Nash tariffs, where FDI does not occur, in Figure 3 we set Γ sufficiently high so this is the case to simplify graphical presentation.

iff increases unilateral welfare.[21] In addition, Broda, Limão, and Weinstein (2006) use a similar model and find that this small across-the-board tariff equals the standard inverse of export supply elasticity.[22] However, both of these models assume homogeneous firms and therefore do not have the productivity enhancing effect of a subsidy that our heterogeneous firms model provides. Demidova and Rodríguez-Clare (2007) provide a model with firm-level heterogeneity and find a positive tariff is optimal. Their model, however, does not have a numeraire and wages are a function of tariffs. As a result, a small positive tariff increases the local wage and more than offsets any productivity gain from a subsidy. Another factor complicating comparisons between their results and ours is that in our model, depending on $f(i)$, even a small tariff can induce FDI, a feature absent from their exporter-only model. One paper that does find a result comparable to ours is Chor (2009) who discusses parameterizations of his model where a country unilaterally implements an import subsidy.[23] Note that he does not, however, consider tariff competition or world welfare maximizing tariffs.

Turning to the fixed cost function, Figure 4 shows the relationship between the Nash tariff and λ for two cases, one where FDI is an option for firms and one where it is not. In the no FDI case, the Nash tariff is falling in λ. The reason for this can be traced to the tariff's revenue generating capabilities. As λ rises, low productivity foreign exporters quit the domestic market. This lowers the tax base for the tariff, reducing its marginal benefit and its equilibrium value. When FDI is an option for firms, we see two changes. First, the level of the tariff is lower. This is because the gain from implementing the tariff is smaller due to tariff-jumping multinationals who reduce the tax base (we discuss this in greater detail in the next section). Second, the Nash tariff is increasing in λ. As in the no FDI case, an increase in λ drives low productivity foreign exporters out of the domestic market. However, when FDI is present, it also leads low productivity multinationals to switch to exporting

[21] Their model is a specific example of the more general model described in Flam and Helpman (1987).

[22] Their model is an adaptation of Broda and Weinstein (2006).

[23] Unlike our setting, due to transport costs, even in this case FDI occurs in his model. In addition, since Chor finds this result in a model of heterogeneous unit labor requirements, it reinforces the general applicability of our results.

because the fixed cost savings of doing so are now greater. In this parameterization of the model, the net effect of these is to increase the tax base, which increases the incentive to implement a tariff.

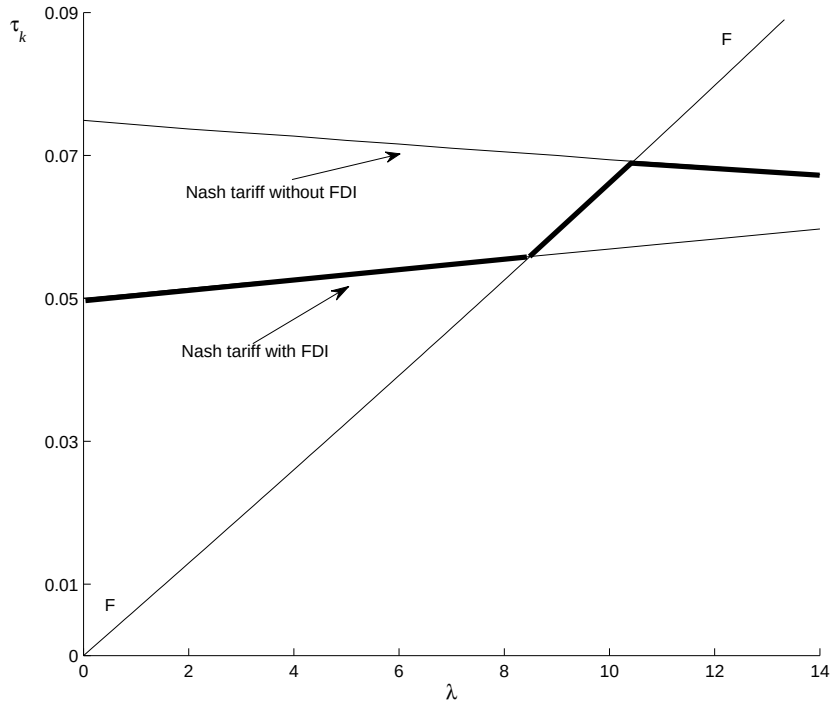

Figure 4: Optimal Tariff as a function of λ (with $\varepsilon = 3.33$)

Figure 4 also serves to illustrate the corner solutions that can arise in a country's choice of Nash tariff which follows the bold line. For low λ, the unilaterally optimal tariff lies above the FF line, i.e. FDI will occur in equilibrium. For high λ, the reverse is true. In the middle range, however, a corner solution is found. At the point where the Nash tariff line with FDI intersects the FF line, no FDI occurs in equilibrium. However, the threat of FDI stops the government from implementing the tariff it would choose were FDI not an option at all (i.e. the one on the Nash tariff without FDI line). Thus, similar to Ellingsen and Wärneryd (1999), the mere threat of FDI can have an effect on a country's tariff.

5 To FDI or not to FDI

In the previous section we found that regardless of whether FDI occurs in equilibrium, Nash tariffs are inefficiently high relative to the world welfare maximizing tariffs. In addition, as illustrated in Figure 4, equilibrium tariffs can differ. Furthermore, even for given tariffs, since multinationals charge different prices than exporters, one would expect this to have an impact on the equilibrium mass of exporters and domestic firms. In this section we investigate this more deeply with an interest in whether permitting FDI as a firm structure serves to benefit world welfare or not.

Since many of our comparative statics hinge on the price level, we begin with the following result.

Lemma 1. *Denote variables with a star * to represent the case* ***without*** *the option to become a multinational. For all tariff levels t_k such that there are multinationals present when they are an option, $P_k^* < P_k$.*

Proof. Suppose this is not the case, that is $P_k^* \geq P_k$. Then

$$\begin{aligned} P_k^* = \left[\frac{1}{\alpha^{1-\varepsilon}}\right]\left[i_{kD}^* + t_k^{1-\varepsilon} i_{jX}^*\right] &\geq \left[\frac{1}{\alpha^{1-\varepsilon}}\right]\left[i_{kD} + i_{jM} + t_k^{1-\varepsilon}(i_{jX} - i_{jM})\right] = P_k \\ \Rightarrow i_{kD}^* + t_k^{1-\varepsilon} i_{jX}^* &\geq i_{kD} + i_{jM} + t_k^{1-\varepsilon}(i_{jX} - i_{jM}). \end{aligned}$$

Furthermore, it follows that

$$(i_{kD}^* - i_{kD}) + t_k^{1-\varepsilon}(i_{jX}^* - i_{jX}) \geq (1 - t_k^{1-\varepsilon}) i_{jM}. \tag{24}$$

From the definition of B_k,

$$B_k = \frac{\mu}{\varepsilon \alpha^{1-\varepsilon} P_k},$$

therefore it must be the case that $B_k^* \leq B_k$. From the equilibrium conditions (8) and (9), it

follows that

$$i_{kD}^* \leq i_{kD} \quad \text{and} \quad i_{jX}^* \leq i_{jX}.$$

But this contradicts condition (24).[24] Therefore, $P_k^* < P_k$ for all t_k such that multinationals are present. □

The next proposition follows from the results in Lemma 1 and compares several key values across the two cases.

Proposition 3. *Denote variables with a star * to represent the case **without** the option to become a multinational. The following inequalities hold for all tariff levels t_k such that there are multinationals present when they are an option.*

$$i_{kD} < i_{kD}^* \tag{25}$$

$$i_{jX} < i_{jX}^* \tag{26}$$

$$P_k^{\frac{1}{1-\varepsilon}} = \mathcal{P}_k < \mathcal{P}_k^* = P^{*\,\frac{1}{1-\varepsilon}}_k \tag{27}$$

$$\frac{\mu\alpha^{\varepsilon} i_{kD}}{P_k} = C_D < C_D^* = \frac{\mu\alpha^{\varepsilon} i_{kD}^*}{P_k^*} \tag{28}$$

$$\frac{\mu\alpha^{\varepsilon}(i_{jX} - i_{jM})}{t_k^{\varepsilon} P_k} = C_X < C_X^* = \frac{\mu\alpha^{\varepsilon} i_{jX}^*}{t_k^{\varepsilon} P_k^*} \tag{29}$$

Proof. Proof by direct calculation.

□

Thus, holding tariffs constant, the entry of multinationals drives low productivity domestic firms and low productivity exporters out of the market, lowers the aggregate price index, and lowers total consumption of both domestically produced and imported varieties. Since multinationals have lower prices than imported varieties for given tariffs, this is an intuitive result. An additional implication of these differences is that the total mass of varieties available to consumers in a given country falls when FDI is introduced since tariff

[24] Recall that $1 < \varepsilon \Rightarrow t_k^{1-\varepsilon} < 1$, where the presence of FDI implies that $t_k > 1$.

jumping varieties were available beforehand but some imported and domestically produced varieties exit the market. National income also changes when FDI is permitted, although the direction is ambiguous. Since both the average profitability of exporting and domestic sales fall and the mass of firms engaged in these activities declines when FDI occurs, these sources of income fall with FDI. Further, the decline in the mass of exporters reduces tariff revenue, further reducing income. This is contrasted with the increase in profits of domestically-owned firms that switch from exporting to tariff-jumping FDI. The net effect depends on the relative size of these changes brought about by changes in the cutoffs.

To compare these discrete changes requires additional assumptions on the functional form of the fixed cost mapping. Therefore we return to our illustrative example where $f(i) = \eta i + \lambda$. In this case, for all relevant values of ε where FDI occurs, income evaluated at the Nash equilibrium when FDI is not permitted is higher than when holding the tariff fixed at that level and allowing FDI to occur. Thus, the increase in profits for firms becoming multinationals is insufficient to outweigh the losses in income from other sources. Indeed, the combined loss in varieties and income implies that welfare is lower when FDI is permitted but the tariff is held constant. Figure 5 illustrates this. In Figure 5, the middle line is welfare evaluated at the Nash equilibrium when FDI is not permitted. The bottom line is welfare using that Nash tariff but allowing firms to undertake FDI.[25] Thus, at least for this specific example, permitting FDI actually lowers welfare because it reduces the mass of varieties available to consumers and lowers national income.

Despite this, it is important to remember that when FDI becomes an option one might well expect tariffs to adjust. Therefore, we now consider how the Nash tariffs compare between the cases when FDI is an option and when it is not. As with the above welfare comparison, we are not analytically able to do so. Although the first order condition (23) remains the same in both cases in its overall form, it is evaluated at different cutoffs for domestic firms, exporters, and (obviously) multinationals. This makes comparisons untractable

[25] In Figure 5, for graphical clarity, we have exaggerated the differences between the welfare levels in a way that preserves the ordinal ranking across regimes where welfare is itself an ordinal ranking.

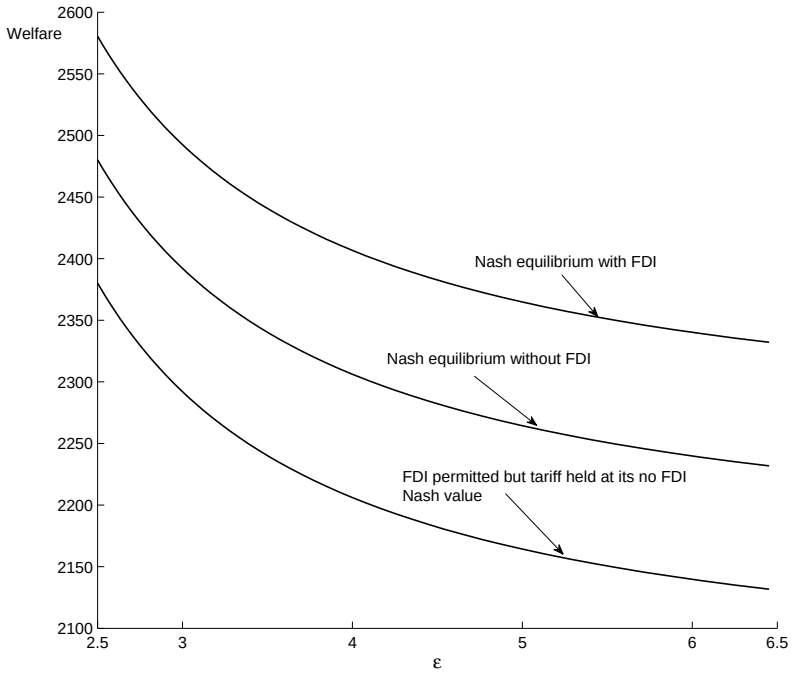

Figure 5: Welfare Comparisons

without additional assumptions on the fixed cost mapping. Despite this, allowing FDI creates two intuitive changes in the optimal tariff decision. In this model, a country gains from a tariff in two ways: (1) tariff revenue (spent on the numeraire) and (2) increased domestic profits. However, in the presence of multinationals both of these gains are dampened. In response to a tariff increase, the least efficient foreign exporters drop out of the market and the most efficient exporters become multinationals. Both actions lower tariff revenue. The latter also lowers the gains to domestic profits from protection. Thus, the benefit of a given tariff falls. At the same time, however, the cost of the tariff falls in the presence of FDI because this lowers the tariff-induced distortions to consumption of the heterogeneous good. This is because a firm that tariff-jumps continues to sell to domestic consumers and does so at a lower price, yielding a positive effect on the consumer's utility. Note that this concerns how the impact of changing the tariff depends on whether FDI is an option and is therefore a distinctly different issue from the impact of making FDI an option but holding the tariff

constant (which was discussed above). Thus, from the demand side of the market, the cost of implementing a tariff is lower when FDI is present.

The net effect of these changes on the desirability of a given tariff is ambiguous. To get additional insight, we again appeal to our illustrative example where $f(i) = \eta i + \lambda$.[26] Figure 6 illustrates a country's Nash tariff both when FDI is present and when FDI is ruled out as a function of the elasticity of substitution, ε. As can be seen, allowing FDI as an entry mode mitigates tariff competition. Intuitively, this occurs because the option of tariff jumping increases the tariff elasticity of export supply which on its own would reduce the chosen tariff. In addition, as discussed above, if the tariff did not change but FDI occurs, there is a loss of varieties. This can be somewhat undone by lowering the tariff and encouraging entry and production by foreign exporters. These two dominate the other effects, resulting in a lower tariff. This is the same intuition provided for Figure 4. Note that this means that allowing FDI pushes tariffs closer to those that would be chosen by the social planner (where, ironically, FDI does not occur in equilibrium).

Blanchard (2006, 2007) have a similar finding, however the mode of FDI in these models differs from that presented here. In Blanchard (2007), domestic firms invest in the host country for purposes of exporting back to the home country, which is a story of vertical FDI. We however consider horizontal FDI, which according to the evidence of Blonigen, Davies, and Head (2003) and Markusen and Maskus (2002) is the dominant form of FDI. Larch (2008) finds a comparable result for horizontal FDI, although he assumes a fixed number of domestic firms. This is a critical assumption because, in our model, FDI results in lost domestic varieties and lower profits from domestic sales. This leads to lower welfare when FDI is introduced and tariffs are held at their no-FDI Nash levels.[27] Blanchard (2006) assumes exogenous foreign equity holdings in both the export and import sector. This supply side integration lowers the Nash tariff because a tariff now decreases the return to domestic

[26]The result that FDI lowers Nash tariffs has been confirmed using other parameterizations of the fixed cost function, including constant elasticity functions for $f(i)$.

[27]This feature would likewise be missing from Ludema (2002) who has an exogenous number of firms.

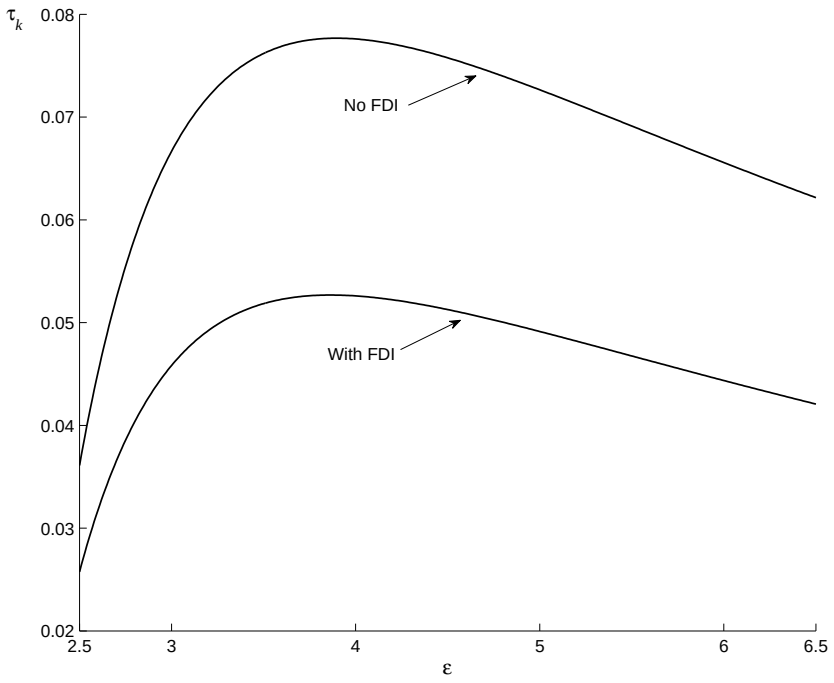

Figure 6: Optimal Tariff as a function of the elasticity of substitution

owners of equity in the foreign export sector. Moreover, there are less gains to domestic producers since a portion is now owned by the foreign country. This latter effect is present in our model, but to a larger extent given that firms are allowed to tariff-jump. In each case, however, it is interesting to note that the rise of FDI has coincided with a general reduction in tariffs (and a proliferation of trade agreements), a correlation matching that found in reality. Thus, declines in barriers to FDI may have played a role in the movement towards freer trade.

The final issue is whether permitting FDI and then allowing an adjustment in tariffs raises welfare. Figure 5 plots welfare in the Nash equilibrium with FDI (the top line) alongside Nash welfare when FDI is not permitted (the middle line). As can be seen, Nash welfare with FDI is strictly greater than Nash welfare without it. The reason for this is because of an increase in the mass of varieties driven by the drop in the equilibrium tariff. When FDI is permitted and the tariff adjusts, income falls due to the introduction of FDI for the

same reasons as discussed in the above thought experiment. This is now exacerbated by the decline in tariffs, which further erodes the profits of domestic firms and tariff revenues.[28] This tariff decline, however, has a second (and dominate) impact on the mass of varieties. When FDI was introduced but tariffs were held constant, the availability of both foreign and domestically owned varieties fell, resulting in an overall drop in welfare. Now, however, the drop in the tariff increases the availability of foreign owned varieties. Although this causes a greater decline in the mass of domestically produced varieties, the net effect is to increase the total mass of varieties relative to the Nash equilibrium without FDI. This engenders a boost to welfare which is sufficient to overwhelm the decline in income. Thus, the welfare gains that come from FDI are driven by their ability to mitigate tariff competition, bringing individual countries' and combined world welfare closer to the levels achievable by coordinated tariff setting.

6 Conclusion

The idea that a country can increase its welfare by charging a positive tariff has been around since Bickerdike (1906) and the idea of tariff-jumping has been around since Bhagwati (1987). Ellingsen and Wärneryd (1997) were the first to marry these two concepts, but resulted in a knife-edge case in which no FDI occurred in equilibrium. We provide a model that dulls this knife-edge through the endogenous entry of heterogeneous firms. This provides an additional insight into the relation between endogenous trade policy and productivity, a link that results in socially optimal import subsidies. We find that a country's unilateral welfare maximizing tariff is greater than the one that maximizes world welfare. Thus the productivity loss

[28]It is worth noting that in our model, domestic producers prefer a higher tariff that creates *more* FDI to this lower tariff with less FDI. This seems to be in contrast to Ellingsen and Wärneryd (1997) where domestic firms prefer a higher tariffs but not so high as to encourage tariff-jumping. The difference in this result is that in our model, FDI and exporters co-exist as a result of firm heterogeneity. Thus the higher tariff encourages some FDI but sufficiently retards exporters so that the net effect benefits domestic producers. Ellingsen and Wärneryd, however, have homogeneous firms. Thus an increase in the tariff that increases FDI does not cause a marginal inflow of FDI, but a large, discrete increase in multinationals which reduces domestic firm profits. This further highlights the contribution of implementing a heterogeneous firm framework.

resulting from tariff competition highlights a new inefficiency of such competition. This result persists regardless of whether or not FDI is an option for firms. Numerical examples indicate that allowing firms to tariff-jump dampens tariff competition and improves Nash equilibrium welfare of each country.

Like all models of heterogeneous firms, we have relied on a variety of assumptions that simplify the model and provide tractability. Nevertheless, the intuitive nature of the results is likely to hold up to many generalizations. Additional testing of the robustness of the model to these assumptions is something we leave to future research. Future work could also incorporate features such as spillovers from FDI, multiple policy instruments (such as domestic subsidies), or intertemporal issues (such as the structure of self-enforcing trade agreements) into the model to yield additional insights. Therefore we hope that this framework provides a useful springboard for examination of such issues in the context of firm heterogeneity.

APPENDIX

The aggregate profit functions are:

$$\int_0^{i_{kD}} \pi_D^k(i)di = \int_0^{i_{kD}} B_k - f(i)di = i_{kD}B_k - \int_0^{i_{kD}} f(i)di \quad \text{(A-1)}$$

$$\int_{i_{jM}}^{i_{jX}} \pi_X^j(i)di = \int_{i_{jM}}^{i_{jX}} \frac{B_k}{t_k^\varepsilon} - \gamma f(i)di = \frac{(i_{jX} - i_{jM})B_k}{t_k^\varepsilon} - \int_{i_{jM}}^{i_{jX}} \gamma f(i)di \quad \text{(A-2)}$$

$$\int_0^{i_{jM}} \pi_M^j(i)di = \int_0^{i_{jM}} B_k - \Gamma f(i)di = i_{jM}B_k - \int_0^{i_{jM}} \Gamma f(i)di. \quad \text{(A-3)}$$

Differentiating (A-1) - (A-3) with respect to τ_k yields:

$$\frac{\partial}{\partial \tau_k}\left[\int_0^{i_{kD}} \pi_D^k(i)di\right] = i_{kD}\frac{\partial B_k}{\partial \tau_k} + [B_k - f(i_{kD})]\frac{\partial i_{kD}}{\partial \tau_k} = \frac{-C_{kD}}{\varepsilon \alpha P_k}\frac{\partial P_k}{\partial \tau_k} \quad \text{(A-4)}$$

$$\frac{\partial}{\partial \tau_k}\left[\int_{i_{jM}}^{i_{jX}} \pi_X^j(i)di\right] = \left[\gamma f(i_{jM}) - \frac{B_k}{t_k^\varepsilon}\right]\frac{\partial i_{jM}}{\partial \tau_k} - \frac{C_{kX}}{t_k \alpha} - \frac{C_{kX}}{\varepsilon \alpha P_k}\frac{\partial P_k}{\partial \tau_k} \quad \text{(A-5)}$$

$$\frac{\partial}{\partial \tau_k}\left[\int_0^{i_{kM}} \pi_M^j(i)di\right] = [B_k - \Gamma f(i_{jM})]\frac{\partial i_{jM}}{\partial \tau_k} - \frac{C_{kM}}{\varepsilon \alpha P_k}\frac{\partial P_k}{\partial \tau_k}. \quad \text{(A-6)}$$

The social planner's first order condition is

$$\frac{\partial V_k}{\partial \tau_k} + \frac{\partial V_j}{\partial \tau_k} = \frac{\mu}{X_k}\frac{\partial X_k}{\partial \tau_k} + \frac{\partial\left[\int_0^{i_{kD}} \pi_D^k(i)di\right]}{\partial \tau_k} + \frac{\partial\left[\int_{i_{jM}}^{i_{jX}} \pi_X^j(i)di\right]}{\partial \tau_k} + \frac{\partial\left[\int_0^{i_{jM}} \pi_M^j(i)di\right]}{\partial \tau_k} + \frac{C_{kX}}{\alpha} + \frac{\tau_k}{\alpha}\frac{\partial C_{kX}}{\partial \tau_k}.$$

Using (A-4) - (A-6) and noting from the equilibrium condition (10) that $B_k - \Gamma f(i_{jM}) = \frac{B_k}{t_k^\varepsilon} - \gamma f(i_{jM})$, this first order condition simplifies to

$$\frac{\partial V_k}{\partial \tau_k} + \frac{\partial V_j}{\partial \tau_k} = \frac{\mu}{X_k}\frac{\partial X_k}{\partial \tau_k} - \left[\frac{C_{kD} + C_{kX} + C_{kM}}{\varepsilon \alpha P_k}\right]\frac{\partial P_k}{\partial \tau_k} + \frac{\tau_k C_{kX}}{t_k \alpha} + \frac{\tau_k}{\alpha}\frac{\partial C_{kX}}{\partial \tau_k} = 0. \quad \text{(A-7)}$$

Furthermore, Dixit and Stiglitz (1977) show that

$$X_k = \frac{I_k s(\mathcal{P}_k)}{\mathcal{P}_k}$$

where $s(\mathcal{P}_k)$ is the propensity to consume the heterogeneous good. Quasilinear utility implies that $I_k s(\mathcal{P}_k) = \mu$. Thus

$$\begin{aligned} \mu &= P_k^{\frac{1}{1-\varepsilon}} X_k \\ \Rightarrow 0 &= \frac{1}{1-\varepsilon} P_k^{\frac{\varepsilon}{1-\varepsilon}} X_k \frac{\partial P_k}{\partial \tau_k} + P_k^{\frac{1}{1-\varepsilon}} \frac{\partial X_k}{\partial \tau_k} \\ \Rightarrow \frac{1}{\varepsilon \alpha P_k} \frac{\partial P_k}{\partial \tau_k} &= \frac{1}{X_k} \frac{\partial X_k}{\partial \tau_k} \end{aligned}$$

This result implies that (A-7) can be written as

$$\frac{\partial V_k}{\partial \tau_k} + \frac{\partial V_j}{\partial \tau_k} = \left[\frac{\mu - (C_{kD} + C_{kX} + C_{kM})}{\varepsilon P_k} \right] \frac{\partial P_k}{\partial \tau_k} + \frac{\tau_k C_{kX}}{t_k} \left[1 + \sigma_{kX} \right] = 0. \tag{A-8}$$

Note that $\frac{\partial C_{kX}}{\partial t_k} = \frac{\partial C_{kX}}{\partial \tau_k}$ and

$$\sigma_{kX} = \frac{t_k}{\alpha C_{kX}} \frac{\partial C_{kX}}{\partial p_{kX}} = \frac{t_k}{C_{kX}} \frac{\partial C_{kX}}{\partial t_k}$$

where $p_{kX} = \frac{t_k}{\alpha}$.

Turning to country k's unilateral Nash tariff, the first order condition mirrors that of the social planner except that it doesn't take into account the impact on the welfare of country j, i.e. the impact on the profits of j's exporters and multinationals:

$$\frac{\partial V_k}{\partial \tau_k} = \frac{\mu}{X_k} \frac{\partial X_k}{\partial \tau_k} + \frac{\partial \left[\int_0^{i_{kD}} \pi_D^k(i) di \right]}{\partial \tau_k} + \frac{C_{kX}}{\alpha} + \frac{\tau_k}{\alpha} \frac{\partial C_{kX}}{\partial \tau_k}. \tag{A-9}$$

Using comparable manipulations, we arrive at equation (23)

$$\frac{\partial V_k}{\partial \tau_k} = \frac{\mu - C_{kD}}{\varepsilon P_k} \left(\frac{\partial P_k}{\partial \tau_k} \right) + C_{kX} + \tau_k \frac{\partial C_{kX}}{\partial \tau_k}. \tag{A-10}$$

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