UCD CENTRE FOR ECONOMIC RESEARCH

WORKING PAPER SERIES

2010

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WP10/09

April 2010

UCD SCHOOL OF ECONOMICS
UNIVERSITY COLLEGE DUBLIN
BELFIELD DUBLIN 4

Not All Trade Restrictions are Created Equally*

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March 30, 2010

Abstract

There has been great focus in the recent trade theory literature on the introduction of firm heterogeneity into trade models. This introduction has highlighted the importance of the entry/exit decision of firms in response to changes in trade barriers. However, it is typical in many of these models to use iceberg transport costs as a general form of trade barriers that can be interchangeable with *ad valorem* tariffs. I show that this is not always an appropriate conclusion. Specifically, I illustrate that profit for an exporter is more elastic in response to tariffs than iceberg transport costs, which has implications for total product variety. One such implication is the possibility for there to be an *anti*-variety effect associated with lower transport costs while there also being a *pro*-variety effect associated with lower tariffs.

JEL classification: F10; F13; F15

Keywords: Intra-industry Trade; Trade policy; Firm heterogeneity; Monopolistic competition

*I would like to thank Ron Davies, Bruce Blonigen, Peter Lambert, and participants at the 2008 Midwest International Economics meeting (Urbana-Champaign, IL) and NUI Maynooth for helpful discussions and comments. This draft has benefited a great deal from comments by two anonymous referees. All remaining errors are my own.

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1 Introduction

There has been great focus in the recent trade theory literature on the introduction of firm heterogeneity into trade models. Beginning with Jean (2002) and Melitz (2003), one of the literature's key results is that increased trade restrictions lead to increases in average productivity for exporters and decreases in average productivity for domestic firms. These models, among many others, have provided a significant advancement in the literature on intra-industry trade since its conception with Krugman (1979, 1980). This comes, in part, from highlighting the entry and exit mechanism of firms, as this has direct ramifications for the number (or mass) of varieties in equilibrium. Since consumers in these models show a love of variety, this has important welfare implications; if more low productivity domestic firms exit in response to lower trade barriers than foreign exporting firms enter, the domestic country actually loses varieties from freer trade. This is indeed interesting since all the gains from trade in the "New Trade Theory" stemmed purely from gains in variety.

The more recent trade theory still finds gains from trade. However, the effect on product variety has less consensus. In Melitz (2003), the effect on the total mass of varieties in a particular country is left ambiguous. Baldwin and Forslid (forthcoming) address this issue and find that decreased trade restrictions, in fact, have a counterintuitive anti-variety effect for the importing country. However, Melitz and Ottaviano (2008) find that decreased trade restrictions have an pro-variety effect. In all three models (as in most models dealing with such issues), trade restrictions are modeled as the standard iceberg transportation cost.[1] Although iceberg trade costs are equivalent to *ad valorem* tariffs in some settings, they are not equivalent in the case of monopolistic competition. Therefore one cannot take the lessons learned from the existing literature and blindly apply them to changes in tariffs, which is important if one is interested in strategic trade policy.[2] A key contribution of this paper is

[1] "Iceberg" transport costs are defined as a firm needing to ship more than one unit of good in order for one unit to arrive; the additional units "melt" away.

[2] Similarly, it may not be appropriate to simply "waste" tariff revenue in order to model iceberg transport costs as Jørgensen and Schroöder (2008) does.

to show iceberg transport costs affect firm profits and consequently the entry/exit decision differently than *ad valorem* tariffs in a monopolistic competition setting. This has direct implications for product variety.

To accomplish this, I provide a highly tractable model of heterogeneous firms that allows for asymmetric changes in three types of trade barriers; iceberg transport costs, *ad valorem* tariffs, and the additional fixed cost to become an exporter. Chaney (2008) uses a model with asymmetric iceberg transport costs and country sizes to investigate the effects of the elasticity of substitution on both the intensive and extensive margins of trade. He finds that the elasticity of substitution always dampens the impact of iceberg transport costs on trade flows. In particular, the decreased sensitivity of the extensive margin outweighs the increased sensitivity of the intensive margin. In addition to modeling methods, this paper differs from Chaney (2008) in other ways. First, though I focus on the extensive margin, I am primarily concerned with the number (mass) of total varieties (both foreign and domestic), where he focuses only on exports. Second, I'm interested in how different trade barriers, not specifically the elasticity of substitution, affect this margin. Thus, in this regard, my paper complements Chaney (2008) as it illustrates how the elasticity of the extensive margin is different depending on whether one models trade barriers as iceberg transport costs or *ad valorem* tariffs.

In order to provide the most tractable baseline model, I make various key assumptions that greatly ease the analysis of a situation with heterogeneous firms and endogenous entry. First, I assume firms are heterogeneous across fixed cost. Though the majority of these recent models assume firms are heterogeneous across marginal cost, there is a growing literature that assumes firms differ across fixed cost, e.g. Schmitt and Yu (2001), Jørgensen and Schröder (2006, 2008), and Davies and Eckel (2007).[3] Jørgensen and Schröder (2008) provide a very nice motivation for the use of fixed cost heterogeneity. For instance, they point out that fixed

[3] A key difference between Jøgensen and Schröder (2006, 2008) and my model is that all firms, purely domestic and those who export, are heterogeneous across fixed cost, where Jørgensen and Schröder (2006, 2008) only allow the fixed cost to *export* to differ.

cost heterogeneity is more appropriate with so-called "original brand name manufacturers" that differ in the power of their brand name – a result of marketing and other fixed cost activities. Arkolakis (2008) also incorporates marketing into a model with heterogeneous firms. Though firms can differ in expenditures on marketing, the main source of heterogeneity is from marginal cost in this model. This coincides well with recent empirical results that suggest there is heterogeneity fixed as well as marginal cost. For instance, Cole, Elliott, and Virakul (2009) find that sunk costs (which are identical to fixed costs in my static model) and firm characteristics are important factors in explaining Thai manufacturing firm's decision to export.[4] I have chosen to use fixed cost heterogeneity for three reasons: using marginal cost heterogeneity will not change the qualitative results; marginal cost heterogeneity will complicate the comparative statics significantly; and there is evidence that firms do differ across fixed costs.[5]

Second, I assume the representative consumer has Dixit-Stiglitz preferences embedded in a quasi-linear utility function. The cost of this assumption is the income elasticity of demand for the heterogeneous good is zero (which could be inferred as not being general equilibrium). Despite the cost, this assumption is not entirely uncommon in the literature. Chor (2009) uses a similar technique to investigate the merits of subsidizing foreign direct investment (FDI) in a model with heterogeneous firms.[6] Moreover, some models use more general utility functions, but then make other simplifying assumptions that mitigate income effects. Demidova and Rodríguez-Clare (2009) utilize a small country assumption to eliminate any income feedback effects. Similarly, Chaney (2008) makes a small country assumption to ensure changes in transport and fixed costs have no significant impact on the general equilibrium.[7] In this paper, quasi-linear preferences prove useful beyond the sim-

[4] See also Eaton, Kortum, and Kramarz (2008) who use a Melitz-type model calibrated to a French data set, and Lawless and Whelan (2008) who explain trade flows for Irish owned firms.

[5] The use of fixed cost heterogeneity results in all firms of the same "type" (either pure domestic or exporting) to charge the same price. This obviously affects firm demand and profits which in turn affects the entry and exit decision. However, this does not eliminate the differences between iceberg transport costs and *ad valorem* tariffs as trade barriers.

[6] See also Becker (2009).

[7] Chaney (2008) points out that relaxing this assumption would reinforce his results.

plifications they provide. My goal is to compare the differences between iceberg transport costs and *ad valorem* tariffs. Tariffs generate income and though transport costs are often assumed to be lost. Thus, tariffs would create an income effect whereas iceberg transport costs would not, clouding the difference I focus on. Alternatively I could model a transport sector that generates income. I would need to take a stance on which country the transport sector resides in as the income would affect demand.[8]

Despite the perceived cost of these simplifications, the benefit is the model's parsimony, which allows it to be used to investigate asymmetric changes in trade barriers. Symmetric trade barriers seem reasonable when dealing with transport costs since the distance between countries is the same regardless of the country of origin. Furthermore, one might expect that differences in fueling and other miscellaneous shipping costs would be minor. However, while symmetric changes in tariffs might be reasonable between members of the World Trade Organization by rules of reciprocity, this does not necessarily apply to trade policy changes between members and non-members. Thus, the model is useful for undertaking a detailed analysis of changes in trade barriers, including asymmetric changes. In order to analyze strategic trade policy, it is necessary to derive best responses, a task which requires analysis of asymmetric tariffs. Though this is certainly a nice feature of the model, it is beyond the scope of this particular paper. However, Cole and Davies (2009) use an extension of this model to incorporate the additional option for a firm to become a multinational. They find that a country's Nash tariff is higher than the global optimum (which is a subsidy) and that FDI mitigates this difference.[9]

Finally, in addition to the typical barriers to trade (tariffs and transport costs), I consider the effect of "foreign beachhead costs", that is, those fixed costs necessary to switch to engage

[8]It should be noted that income does change in response to changes in trade barriers and this income change affects welfare. However, it will all be through changes in consumption/production of the numeraire and not affect the heterogeneous goods sector.

[9]Jørgensen and Schröder (2008) shows that many of the qualitative results of the Melitz (2003) model holds true with a model of fixed cost heterogeneity and *ad valorem* tariffs. Given this and Cole and Davies (2009), these aspects are omitted.

in exporting.[10] This is often a minor consideration, but with the rapid technological growth and service industries being created to facilitate business operations, these beachhead costs are becoming increasingly important. Friedman (2007) explains, "...UPS also has a financing arm – UPS Capital – that will put up the money for the transformation of your supply chain, particularly if you are a small business and don't have the capital...UPS is creating enabling platforms for anyone to take his or her business global or vastly improve the efficiency of his or her global supply chain" (p. 173). This has direct implications for these particular beachhead costs and needs to be considered in conjunction with investigating changes in other trade restrictions, as they may have conflicting results.

The paper proceeds as follows. Section 2 sets up the model and characterizes the equilibrium. Section 3 analyzes the results including a discussion of the results under alternative modeling assumptions including marginal cost heterogeneity. Section 4 concludes.

2 The Model

There are two countries labeled k and j. 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 both transportation costs and 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 I will refer to country k as the domestic country to ease discussion.

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

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 will normalize the wage in each country to unity. Finally, I assume that in equilibrium a positive amount of y is produced in each country.

2.2 Consumers

The representative consumer in country k has quasi-linear preferences with an embedded 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 $x_k(i)$. Quasi-linear utility will isolate the decision whether to become an exporter or not without any income feedback effects; providing a model that allows for asymmetric changes in trade restrictions (e.g. unilateral tariff policy) to be easily analyzed.[11] Moreover, this specification allows me to compare the differences between an *ad valorem* tariff and iceberg trade costs on productivity and variety without having to account for the income effects of the tariff or the "wasteful" costs of iceberg transport costs. Finally, I assume that income in each country is sufficiently large that both y and x goods are consumed.

[11] Demidova and Rodríguez-Clare (2009) use a small country assumption to eliminate the income feedback effects. However, this assumption would only be appropriate when investigating strategic trade policy between two countries of asymmetric size. I too can allow for asymmetric country sizes in my model. This could be done in two ways. One is by increasing the labor of one country. However, since μ is the same, the expenditure on the heterogeneous good is still identical and this would be a trivial change. A second way would be to have different μs. In this scenario, one would need to be careful that the other parameters were such to ensure a firm in country k didn't export to country j without also supplying to its domestic market.

Consumers maximize utility subject to their budget constraint:

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

where $p_k^c(i)$ is the price of variety i *paid* by consumers and I_k is aggregate income in country k.[12, 13] The solution to this problem yields a demand function for the heterogeneous good of variety i in country k:

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

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 are 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.[14, 15] Armed with this index the firm 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. 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* $\gamma f(i)$. I assume that $\gamma > 1$; $f'(i) > 0$ and $f''(i) \geq 0$, i.e. the

[12]Note that if tariffs are set to zero or the firm is domestic the prices, $p_k(i) = p_k^c(i)$, are equivalent.

[13]Recall that under perfect competition, the price of y is equal to one.

[14]One interpretation of the model is that firms are owned by entrepreneurs and that firm profits accrue to these entrepreneurs. In my representative agent setting, these profits would simply enter national income in the same way that wages do, therefore I discuss the model in terms of firms to avoid needless jargon. This interpretation is similar to that of Yu (2002).

[15]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 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, my assumption of unique variety/productivity combinations aids greatly in the presentation of my results in the simplest, most tractable fashion.

mapping from the index to the labor required for beachhead costs is increasing and convex in the index.[16] 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	$(1+\gamma)f(i)$

Goods that are exported from country k to country j are subject to melting-iceberg transport costs, $\sigma = 1 + s \geq 1$, where a firm must ship σ units in order for one unit to arrive at its destination. I assume that transport costs are symmetric and thus omit country subscripts.[17] I do not investigate the effect of a per-unit transport cost; since marginal costs are normalized to one, this would have the same effect as iceberg transport costs.[18] Additionally, an exporting firm from country k is subject to an *ad valorem* tariff τ_j, where I define $t_j \equiv 1 + \tau_j$. Furthermore, I assume that a government is unable to distinguish a particular firm's type, so any tariff is an across-the-board tariff applied to all exporters. Note that tariffs can differ across countries.

The decision to become a firm and which market(s) 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 are

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

[16] The assumption that $\gamma > 1$ is fairly standard (e.g. Melitz (2003)) and important. It is rarely seen that a firm (particularly not a multinational) that sells abroad but not at home and as long as expenditure on the heterogeneous good are not *too* different, this ensures that will never happen. Moreover, it does so by allowing profits in both countries to be additively separable, which is quite attractive. Relaxing this assumption, but restricting the firm to sell at home before exporting would only complicate the model without changing the qualitative results.

[17] This assumption is only done for notational ease. In order to investigate asymmetric changes in transport costs, one need only add a country subscript to σ.

[18] This is not the case when firms differ across marginal costs.

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 $\mathcal{P}_k = P_k^{\frac{1}{1-\varepsilon}} = \left(\int_0^{N_k} p_k^c(i)^{1-\varepsilon}di\right)^{\frac{1}{1-\varepsilon}}$ is the aggregate price index of the heterogeneous good.

The decision to become an exporter stems purely from the *additional* profits from serving the foreign market.[19] The main contribution of this paper is to illustrate that there is an important distinction between modeling trade restrictions as iceberg transport costs or *ad valorem* tariffs. Consequently, I will explicitly derive the additional profit function from exports for the firm in country k exporting to country j. This function is:

$$\pi_X^k(i) = t_j p_j(i)x_j(i) - \tau_j p_j(i)x_j(i) - \sigma x_j(i) - \gamma f(i). \tag{6}$$

It can easily be seen by $t_j p_j(i)x_j(i) - \tau_j p_j(i)x_j(i) = p_j(i)x_j(i)$, that imposing a tariff on the firm is analogous to imposing it on the consumer. Recalling that $p_j^c(i)$ is the price consumers pay, the demand for variety i is

$$x_j(i) = \frac{p_j^c(i)^{-\varepsilon}\mu}{\int_0^{N_j} p_j^c(i)^{1-\varepsilon}di} = \frac{[t_j p_j(i)]^{-\varepsilon}\mu}{\int_0^{N_j} p_j^c(i)^{1-\varepsilon}di}. \tag{7}$$

[19]Since preferences are identical across both countries, it follows that the total expenditure on the heterogeneous good is equal to μ in both markets. Furthermore, recall that technologies and the mass of entrepreneurs are also identical across countries. This, along with $\gamma > 1$, is sufficient to ensure that a firm that exports will always serve the domestic market.

Thus (6) can be written as

$$\pi_X^k(i) = [p_j(i) - \sigma] \frac{[t_j p_j(i)]^{-\varepsilon}\mu}{\int_0^{N_j} p_j^c(i)^{1-\varepsilon} di} - \gamma f(i) \tag{8}$$

Note that the presence of a tariff is just a monotonic transformation of the profit function, so the firm's optimal price setting rule is unaffected by the tariff (it is still a constant markup over marginal cost). However, the price paid by the consumer, p^c, is affected. Therefore, the exporting firm's optimal price is

$$p_j(i) = -\frac{\varepsilon\sigma}{1-\varepsilon} = \frac{\sigma}{\alpha} \tag{9}$$

and the price consumers pay for exported variety (imported from their perspective) is

$$p_j^c(i) = \frac{t_j\sigma}{\alpha}. \tag{10}$$

Thus, regardless of whether one chooses to model trade restrictions as iceberg transport costs, *ad valorem* tariffs, or some more general term encompassing them both, $\varsigma = \tau\sigma$, the affect on the price consumers pay is the same – the restriction is completely passed through onto them. *However*, the effect on firm profits are, in fact, different and this is important when dealing with a general equilibrium model and firm entry. To see this, input the price, (9), into the firm profit function (8)

$$\pi_X^k(i) = \underbrace{\left[\frac{\sigma}{\alpha} - \sigma\right]}\left(\frac{t_j\sigma}{\alpha}\right)^{-\varepsilon}\frac{\mu}{P_j} - \gamma f(i). \tag{11}$$

The underbraced term is the key here. Due to the monopolistic nature of the model, firms charge a markup over marginal cost and transport costs are included in marginal cost.[20] Recall $\sigma = 1 + s$. If a firm ships one unit, it loses s units in transport, but gains $\frac{s}{\alpha}$ from it's

[20]Note that, in perfect competition, price equals marginal cost and the standard result of iceberg costs having the same effect as an ad valorem tariff still holds.

ability charge a price higher than marginal cost, for a net gain (excluding demand effects) of $\frac{s}{\alpha\varepsilon} > 0$. Conversely, a tariff results only in decreased demand, which as seen by (10) is identical to that of iceberg transport cost. Thus, not only are profits higher with iceberg transport costs compared to an identical *ad valorem* tariff, but the sensitivity of profits to changes in these two different forms of trade restrictions differs as well; i.e. the variable profit will be more elastic with respect to tariffs than iceberg transport costs.[21] Essentially, through monopolistic power, the firm is able to recoup a portion of its losses in transport; whereas tariff revenue is completely captured by the domestic government. The markup over marginal cost drives a wedge between the effect of iceberg transport costs and an *ad valorem* tariff.

The effect of trade restrictions on product variety is an important welfare consideration and is determined by the extent domestic varieties enter to replace imported foreign varieties. Since the choice of trade restrictions affects the variable profit elasticity and consequently the foreign firm's decision to enter or exit, this has implications with regard to product variety. For notational ease, I will write profits from exports as:

$$\pi_X^k(i) = t_j^{-\varepsilon}\sigma^{1-\varepsilon}B_j - \gamma f(i). \tag{12}$$

Again, note the different exponents on tariffs (t_j) and transport costs (σ), a difference at the heart of the differing variety effects.

2.3.1 Relaxing Modeling Assumptions

In this section, I briefly describe the affects of two specific assumptions on the generality of results. To begin, suppose firms were additionally heterogeneous across marginal costs, $a(i)$. This means that firms charge a different price, $\frac{t_j\sigma a(i)}{\alpha}$ for an exporter.[22] Additionally, let $M_j(\mathbf{p}_j^c, I_j(\cdot))$ be the expenditure on the heterogeneous good in country j, which a function

[21]This will be shown later.
[22]Recall equation (10).

of the vector of prices and income. Therefore, an exporting firm is faced with the following general profit function:

$$\pi_X^k(i) = \underbrace{\left[t_j^{-\varepsilon}\sigma^{1-\varepsilon}\right]}\frac{a(i)^{1-\varepsilon}M_j}{\varepsilon\left[\int_0^{i_{jD}} a(i)^{1-\varepsilon}di + \int_0^{i_{kX}} \left(t_j\sigma a(i)\right)^{1-\varepsilon}di\right]} - \gamma f(i) \tag{13}$$

i.e. the B_j term becomes more complex.

For a baseline model, I assume that $a(i) = 1$ for all i, and $M_j = \mu$. It can be seen that allowing marginal cost to differ across firms will have an affect on the results. However, since the t_j is raised to a different exponent than σ in the underbraced, term differences still arise for different trade barriers. Furthermore, using a different utility function will obviously affect $M_j(\mathbf{p}_j^c, I_j(\cdot))$.[23] In particular, tariffs generate income where iceberg transport costs are generally assumed to be wasted. There are two points to be made with regard to this: One, in order for tariffs to have the same affect on exporting firm profits as iceberg transport costs, the utility function would have to result in $M_j(\mathbf{p}_j^c, I_j(t_j,\cdot)) \equiv t_j M_j(\mathbf{p}_j^c, I_j(\cdot))$, which is more restrictive than assuming quasi-linear preferences; and two, as mentioned in the introduction, there *is* a transportation sector that *does* generate income. To be completely rigorous, I would need to model this sector. However, it would seem to be a very special case, in which tariffs and transport costs affect income in the such a way to offset the differences highlighted by the underbraced term in equation (13). Therefore, the result that *ad valorem* tariffs affect exporting profits differently than iceberg transport costs is not driven by my simple baseline model.

2.4 Equilibrium

Firms will enter each market as long as there are positive profits, that is, until equations (5) and (12) are driven to zero. Thus, define the cut-off firms as the firms that draw the values

[23]Note though, that t_j and σ affect $\mathbf{p}_j^c$ in the exact same way, as shown by equation (10).

in the index (i) that solves the following equalities:

$$B_k = f(i_{kD}) \tag{14}$$

$$\frac{B_j}{\gamma t_j^{\varepsilon} \sigma^{\varepsilon-1}} = f(i_{kX}) \tag{15}$$

$$B_j = f(i_{jD}) \tag{16}$$

$$\frac{B_k}{\gamma t_k^{\varepsilon} \sigma^{\varepsilon-1}} = f(i_{jX}) \tag{17}$$

The indices i_{kD} and i_{jD} represent the firms that are indifferent between producing the heterogeneous good and not producing at all in country k and j respectively. The indices i_{kX} and i_{jX} represent the firms that are indifferent between serving both the domestic and foreign markets and serving only the domestic market. Furthermore, the terms on the left-hand side of the equalities represent the variable profit for a particular firm and are functions of the total mass of firms (domestic and foreign).

Figure 1 illustrates the profits, with zero variable trade costs, of firms in country k including those who export and those who only sell domestically.[24] It can be seen that the greater the index i, the greater the fixed cost to enter a market, and thus the lower the profits. The intersection with the horizontal axis represents the index in which profits are zero for operating in that particular market. Note that the line representing export profits defines the profits from exporting in addition to serving the domestic market. In other words, firms with an index $i \in [0, i_{kX}]$ make profits from exporting *and* serving the domestic market, and firms with an index $i \in (i_{kX}, i_{kD}]$ make profits from only serving the domestic market. Firms with an index $i > i_{kD}$ do not produce.

After careful inspection of the equilibrium conditions, it can be seen that this is, in fact, two systems of two equations and two unknowns: equations (14) and (17) and equations (15) and (16).[25] Moreover, due to the symmetry it is sufficient to only focus on one country. I will focus on the output market in country k, and thus equations (14) and (17). For future

[24]For numerical simulations, I assume that the function $f(i)$ is linear.
[25]This nice simplification stems from the utility specification used.

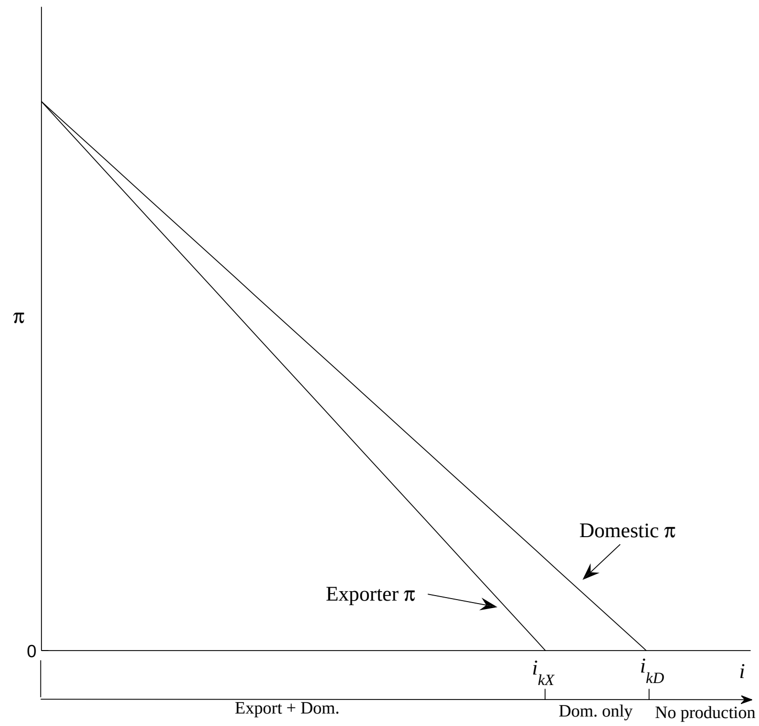

Figure 1: Profits from production in country k with free trade

use, it will be helpful to rewrite the equilibrium conditions, (14) and (17), in the following manner:

$$f(i_{kD}) = \frac{\mu}{\varepsilon(i_{kD} + (t_k\sigma)^{1-\varepsilon} i_{jX})} \tag{18}$$

$$f(i_{kD}) = \gamma t_k^{\varepsilon} \sigma^{\varepsilon-1} f(i_{jX}). \tag{19}$$

3 Changes in Equilibrium

Although, I cannot explicitly solve for the cutoff values without assuming a functional form of the fixed cost mapping $f(i)$, I am still able to characterize the comparative statics. Totally differentiating this system of equations (18) and (19) yields the following comparative statics:

$$\frac{\partial i_{jX}}{\partial t_k} = -\frac{1}{t_k\psi}\left[\varepsilon f(i_{kD})[1+\delta(i_{kD})] + \frac{i_{jX}f'(i_{kD})}{(t_k\sigma)^{\varepsilon-1}}\right] < 0 \tag{20}$$

$$\frac{\partial i_{jX}}{\partial \sigma} = \frac{(1-\varepsilon)f(i_{kD})}{\sigma\psi}[1+\delta(i_{kD})] < 0 \tag{21}$$

$$\frac{\partial i_{jX}}{\partial \gamma} = -\frac{f'(i_{kD})}{f(i_{kD})\psi\gamma}\left[\frac{\mu}{\varepsilon} + \frac{f(i_{kD})^2}{f'(i_{kD})}\right] < 0 \tag{22}$$

$$\frac{\partial i_{kD}}{\partial t_k} = \frac{\varepsilon\gamma f(i_{jX})}{\psi}\big[1+\alpha\delta(i_{jX})\big] > 0 \tag{23}$$

$$\frac{\partial i_{kD}}{\partial \sigma} = \frac{(\varepsilon-1)\gamma t_k f(i_{jX})}{\sigma\psi}\big[1+\delta(i_{jX})\big] > 0 \tag{24}$$

$$\frac{\partial i_{kD}}{\partial \gamma} = \frac{t_k f(i_{jX})}{\psi} > 0 \tag{25}$$

where

$$\psi \equiv \frac{f'(i_{kD})}{f(i_{kD})}\left[\frac{f(i_{jX})}{f'(i_{jX})}\left(\frac{\mu}{\varepsilon} + \frac{f(i_{kD})^2}{f'(i_{kD})}\right) + \gamma t_k f(i_{jX})\right], \text{ and}$$

$$\delta(z) = \frac{zf'(z)}{f(z)} > 0.$$

The term $\delta(z)$ represents the elasticity of fixed costs with respect to the index i, evaluated at z. Equations (20) through (22) represent the effect of changes in trade restrictions (either through a tariff, transport cost, or foreign beachhead cost) on the cutoff firm serving the foreign market. It follows that increases in trade restrictions decreases this cutoff, or in other words the mass of exporting firms has decreased. By decreasing the mass of exporting firms and the foreign firms still producing now charging a higher price relative to domestic producers, there is less competition in the domestic market. This decreased competition makes being a domestic firm more profitable, thereby increasing the mass of domestic firms – illustrated by equations (23) through (25). The fact that increased trade restrictions, in general, have these results is not surprising. What is important is that different trade restrictions correspond to different magnitudes in firm cutoff changes.

There does exist a (t_k, σ) pair that equates the comparative statics (20) with (21) and

(23) with (24). This pair solves the following equality, respectively:

$$\begin{aligned}\frac{\alpha t_k}{\sigma} &= 1+\frac{(t_k\sigma)^{1-\varepsilon} i_{jX} f'(i_{kD})}{\varepsilon f(i_{kD})[1+\delta(i_{kD})]} > 1 \qquad (26)\\ \frac{\alpha t_k}{\sigma} &= \frac{1+\alpha\delta(i_{jX})}{1+\delta(i_{jX})} < 1 \qquad (27)\end{aligned}$$

As can be seen, the (t_k, σ) pair that equates (20) with (21) is not the same pair that equates (23) with (24). This reinforces the fact that iceberg transport costs are not isomorphic to *ad valorem* tariffs.

3.1 Variety Effect

As just shown, different trade barriers affect the entry and exit decision by firms in different ways. This is important for two main reasons; the effect on total variety is part of welfare and if two or more barriers are changing at the same time, it is critical to understand these differences to know if these changes will amplify or negate each other. Therefore, I now investigate how each trade barrier affects the equilibrium mass of varieties. The corresponding effects on the mass of varieties in country k are as follows:[26]

$$\begin{aligned}\frac{\partial N_k}{\partial t_k} &= \frac{\varepsilon\gamma f(i_{jX})}{\psi}\left\{1+\alpha\delta(i_{jX})-(t_k\sigma)^{\varepsilon-1}[1+\delta(i_{kD})]-\frac{i_{jX}}{\varepsilon i_{kD}}\delta(i_{kD})\right\} \qquad (28)\\ \frac{\partial N_k}{\partial \sigma} &= \frac{(\varepsilon-1)\gamma t_k f(i_{jX})}{\sigma\psi}\left\{\left[1+\delta(i_{jX})\right]-(t_k\sigma)^{\varepsilon-1}\left[1+\delta(i_{kD})\right]\right\} \qquad (29)\\ \frac{\partial N_k}{\partial \gamma} &= \frac{1}{\psi\gamma}\left[\left(\frac{1}{(t_k\sigma)^{\varepsilon-1}}-1\right)f(i_{kD})-\frac{f'(i_{kD})}{f(i_{kD})}\frac{\mu}{\varepsilon}\right] < 0 \qquad (30)\end{aligned}$$

It can be seen from equations (28) and (29) that the effect of tariffs and iceberg transport costs have an ambiguous effect on equilibrium total variety. The following proposition pins down the condition that ensures a pro-variety effect associated with decreases in iceberg

[26]Note that $N_k = i_{kD} + i_{jX}$.

transport costs.[27]

Proposition 1. *There is a pro-variety effect associated with decreases in iceberg transport costs if and only if*

$$\frac{1}{(t_k\sigma)^{\varepsilon-1}} < \frac{1+\delta(i_{kD})}{1+\delta(i_{jX})}.$$

Proof. Proof is by direct calculation. □

This is a sufficient and necessary condition. A more restrictive condition for a pro-variety effect, although one that is perhaps more intuitive, is if the elasticity of $f(i)$ with respect to the index is nondecreasing in i. Examples would include both linear, exponential, and power functions of i.

It is difficult to compare the magnitudes of the variety effects from changes in iceberg transport costs and *ad valorem* tariffs because these magnitudes depend on the actual values of t_k and σ.[28] However, I can comment about the direction of these variety effects.

Corollary 1. *If* $\frac{\partial N_k}{\partial \sigma} \leq 0$ *then* $\frac{\partial N_k}{\partial t_k} < 0$.

Proof. Let $\frac{\partial N_k}{\partial \sigma} = 0$, then

$$(t_k\sigma)^{\varepsilon-1}[1+\delta(i_{kD})] = 1+\delta(i_{jX}).$$

Plugging this into (28) yields:

$$\begin{aligned} \frac{\partial N_k}{\partial t_k} &= \frac{\varepsilon\gamma f(i_{jX})}{\psi}\left\{1+\alpha\delta(i_{jX}) - 1 - \delta(i_{jX}) - \frac{i_{jX}}{\varepsilon i_{kD}}\delta(i_{kD})\right\} \\ &= \frac{-\gamma f(i_{jX})}{\psi}\left\{\delta(i_{jX}) + \frac{i_{jX}}{i_{kD}}\delta(i_{kD})\right\} < 0. \end{aligned}$$

[27]Note that this is the case when $\partial N_k/\partial\sigma < 0$.

[28]For purposes of comparison, one logical choice would be to evaluate the comparative statics when the trade restrictions are equal. Let $\sigma = t_k = \rho \geq 1$, then

$$\left.\frac{\partial N_k}{\partial t_k}\right|_{\sigma=t_k=\rho} = \left.\frac{\partial N_k}{\partial \sigma}\right|_{\sigma=t_k=\rho} + \left(\frac{\gamma}{\rho}\right)\left.\frac{\partial N_k}{\partial \gamma}\right|_{\sigma=t_k=\rho}.$$

It is straightforward that $\frac{\partial N_k}{\partial \sigma} < 0 \Rightarrow \frac{\partial N_k}{\partial t_k} < 0$. $\square$

It is obvious that the contrapositive to Corollary 1 is also true, that is $\frac{\partial N_k}{\partial t_k} \geq 0 \Rightarrow \frac{\partial N_k}{\partial \sigma} > 0$. The fact that trade restrictions can have an ambiguous effect on total product variety in a country is not surprising or new. What is surprising and new is that it is possible for there to be an anti-variety effect associated with lower transport costs while there also being a pro-variety effect associated with lower tariffs. Thus, under certain specifications a reduction in both trade barriers could lead to no change in total product variety. Again, these differences are driven by how iceberg transport costs affect profit differently than an *ad valorem* tariff. Changes in a firm's variable profit ($\upsilon\pi$) is the reason for entry and exit and the variable profit is more elastic with respect to tariffs than iceberg transport costs:

$$\frac{t_k}{\upsilon\pi}\frac{\partial \upsilon\pi}{\partial t_k} - \frac{\sigma}{\upsilon\pi}\frac{\partial \upsilon\pi}{\partial \sigma} = \frac{-f'(i_{jX})\left[f'(i_{kD})\mu + \varepsilon f(i_{kD})^2\right]}{f'(i_{jX})\left[f'(i_{kD})\mu + \varepsilon f(i_{kD})^2\right] + \varepsilon\gamma t_k f(i_{jX})^2 f'(i_{kD})} < 0.$$

This, in turn, affects the elasticity of the firm cutoffs – the cutoffs for an exporting and a purely domestic firm are more elastic in response to a change in an *ad valorem* tariff than iceberg transport costs. Turning now to the elasticity of total variety, N_k, which I define as ϱ_{t_k} and ϱ_σ for tariffs and transport cost respectively:

$$\begin{aligned}
\varrho_{t_k} &= \frac{\varepsilon\gamma t_k f(i_{jX})}{N_k\psi}\left\{1 + \alpha\delta(i_{jX}) - (t_k\sigma)^{\varepsilon-1}[1+\delta(i_{kD})] - \frac{i_{jX}}{\varepsilon i_{kD}}\delta(i_{kD})\right\} \\
\varrho_{\sigma} &= \frac{(\varepsilon-1)\gamma t_k f(i_{jX})}{N_k\psi}\left\{1 + \delta(i_{jX}) - (t_k\sigma)^{\varepsilon-1}[1+\delta(i_{kD})]\right\}.
\end{aligned}$$

Comparing the two elasticities yields:

$$\varrho_{t_k} - \varrho_\sigma = \frac{t_k\gamma f(i_{jX})}{N_k\psi}\left\{1 - (t_k\sigma)^{\varepsilon-1}[1+\delta(i_{kD})] - \frac{i_{jX}}{i_{kD}}\delta(i_{kD})\right\} < 0.$$

One has to be careful in interpreting this result given the results of Corollary 1. If there is a pro-variety effect associated with a decrease in iceberg transport costs, then the total product variety is *more* elastic (but is negative) with respect to tariffs. If there is an anti-variety effect associated with a decrease in *ad valorem* tariffs, then the total product variety is *less* elastic (but is positive) with respect to tariffs. Finally, there are scenarios in which the two trade barriers have opposite effects on variety resulting in ambiguity as to the relative elasticities.

4 Conclusion

It is common in the recent trade literature to simply assume iceberg transport costs as a general proxy for many types of trade restrictions (in particular *ad valorem* tariffs). When perfect competition is assumed the two trade barriers are analogous. However, in the often used model of monopolistic competition, this is no longer the case. I have provided a simple model of trade with monopolistic competition and heterogeneous firms that illustrates how changes in iceberg transport costs affect profit differently then *ad valorem* tariffs. This, in turn, affects the elasticity of entry and exit differently. Since the equilibrium number of total varieties is determined by how many new foreign varieties replace exiting domestic varieties or vice versa (depending on the direction the trade barriers are going), this elasticity of entry and exit matters. Furthermore, I have shown that although iceberg transport costs and *ad valorem* tariffs have an ambiguous effect on total variety, they do not necessary have the same effect; i.e. it is possible for there to be an anti-variety effect associated with lower transport costs while there also being a pro-variety effect associated with lower tariffs. Thus, there are consequences in how one chooses to model trade restrictions. The severity of these consequences depends on the particular research question, but the consequences are there nonetheless.

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