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Information Matters: A Theoretical Comparison of Some Cross-Border Trade Barriers

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Abstract

There is widespread evidence that geographical borders reduce trade. This paper presents a theoretical model capable of providing a succinct comparison of three broad forms of trade barriers involving i) trade costs, ii) localized tastes, and iii) information frictions. Despite being traditionally under-researched, it provides the stark finding that information frictions often provide the relatively more powerful marginal effect in reducing cross-border trade, and associated levels of welfare. This result remains robust under a number of extensions that further document the roles of product differentiation and alternative forms of trade costs.

Keywords: Information Frictions; Search Costs; Trade Costs; Localized Tastes; Product Differentiation

JEL Codes: F10; L13; D83

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1 Introduction

A vast literature provides widespread evidence that geographical borders reduce trade. This evidence applies across a broad range of markets at both country- and state-level despite suitable controls for region size, distance and other relevant factors. Further empirical findings show that traditional explanations for this phenomenon, such as the effects of tariffs and transportation costs, are unable to fully explain its prevalence. Instead, the findings point to some less conventional trade barriers, including the existence of information frictions or localized tastes (see Grossman 1998, and the surveys by Anderson and van Wincoop 2004 and Head and Mayer 2013). However, an explicit theoretical comparison of these rival explanations remains absent from the literature. Addressing this omission is important to help further understand trade barriers and to guide policymakers towards the most appropriate tools for promoting trade and globalization.

As a first step towards such an aim, this paper presents a succinct model that can compare some theoretical mechanisms for three broad forms of trade barriers, and assess their relative power in determining cross-border trade, and associated levels of welfare. In particular, it compares i) 'trade costs' including cross-border tariffs, transportation costs, and transaction costs, ii) 'localized tastes' where buyers exhibit a (perceived) dis-utility of trading with sellers from outside their home region, and iii) 'information frictions' where buyers incur costs of gathering and interpreting information about sellers from regions other than their own. Despite being traditionally under-researched, our model provides the stark finding that information frictions often provide the relatively larger marginal effect on reducing cross-border trade, and associated welfare.

Among other implications, this suggests that even small information frictions may provide a strong barrier to trade. Moreover, aside from traditional trade policies that aim to reduce tariffs or transportation costs, our results point to the potential merit of less-standard trade policies that aim to reduce information frictions. Such information based policies improve the transparency and accessibility of market information, by for example, improving broadband connections, encouraging online cross-border information sources, or promoting common format/multi-lingual product labeling.

To provide a clean comparison between such broad explanations, we refrain from using a full-scale trade model. Instead, we take an original step by 'importing' a simple version of a

popular information framework by Wolinsky (1986) and Anderson and Renault (1999) that is being used increasingly to explain market phenomena (e.g. Bar-Isaac et al 2012, Haan and Moraga-González 2011, Armstrong et al 2009), and extending it into a trade context. To ease exposition, we present the model within a partial equilibrium setting, although we also show how it can be extended to provide a general equilibrium analysis.

In more detail, we consider a market for a single differentiated good with many potential buyers and sellers, where buyers are distributed over multiple geographic regions. Given sufficiently high entry costs, each region hosts a single seller. We assume that buyers can trade freely with their 'home' seller. However, to trade with a 'foreign' seller, buyers must first incur a cross-border information cost to identify and/or interpret the seller's product and price. This captures the possibility that information about foreign sellers is harder to obtain, and/or harder to interpret as it may be presented in a different format or language. Buyers can gather information about any number of foreign sellers under a sequential search process, incurring the cross-border information cost each time. After having decided to stop searching, a buyer can then exit, trade with its home seller, or trade with a searched foreign seller. However, buying from a foreign seller may i) be less attractive due to the buyer's relative preference for home produce through localized tastes, and ii) require the buyer and/or the foreign seller to further incur a trade cost, as consistent with various cross-border tariffs, transportation costs, or transaction costs.

Sections 3-5 of the paper then derive the equilibrium, and demonstrate the different mechanisms by which each form of trade barrier reduces cross-border trade and welfare. After comparing the effects of buyer trade costs, seller trade costs, information frictions, and localized tastes, we offer the striking result that information frictions often generate the largest marginal effects. This arises because buyers' optimal search behavior is relatively more sensitive to the level of information frictions, which then makes them especially potent in deterring buyers from considering offers from foreign sellers.

In addition, we also show how our findings can help understand a conflict within the literature regarding the interaction between trade barriers and product differentiation. Some evidence finds that the effects of trade barriers are weaker in markets with higher product differentiation. However, other evidence is consistent with an argument made by Rauch (1999) which asserts that markets with higher product differentiation should have larger trade barriers because information search is relatively more costly. To help understand this

debate, our model can illuminate the relevant theoretical mechanisms, and suggest an overarching explanation for the conflicting evidence.

Next, Section 6 considers some empirical implications from our main results and illustrates how our model could be used as the basis for an estimation approach. While there is little direct evidence within the existing literature, a few papers report findings that are consistent with our main prediction. For example, papers such as Lendle et al (2016), Gomez-Herrera (2014), and Fink et al (2005) suggest that information cost proxies, including telecommunication costs or the existence of a common language, are statistically more significant in reducing cross-border trade than some more traditional trade barriers, such as shipping costs and tariff levels.

Finally, Section 7 examines two extensions. First, in contrast to the main model where each seller is able to set different prices to buyers from different regions, we demonstrate how our main results remain robust when sellers are constrained to set only a single 'world' price. Second, and more substantially, we consider our results under an alternative form of trade cost. The main model assumes additive 'per-unit' trade costs that do not vary in the level of a product's price. As argued by Sørensen (2014) and the references therein, such trade costs are common, and important both theoretically and empirically. However, in Section 7.2, we re-examine our results under a more complex case of multiplicative 'iceberg' trade costs that vary in a product's price. Here, we provide conditions under which our main results remain robust, and also show, in contrast to the main model, how seller trade costs can be more powerful than buyer trade costs, and how the effects of buyer trade costs and localized tastes can be separately identified.

Our paper builds most closely on Wilson (2012) who uses a version of Wolinsky (1986) and Anderson and Renault (1999) to examine the relative impact of search costs and switching costs on market power and welfare. Here, we i) adapt and extend his analysis to a qualitatively different multi-region trade context, ii) provide a general re-interpretation of his switching cost variable to capture buyer (additive) trade costs and localized tastes, iii) analyze a new variable to assess the effects of seller trade costs, iv) develop a measure of cross-border trade and show how it, and other measures of welfare, vary with the considered trade barriers, v) assess how these relationships vary with the level of product differentiation, and vi) extend the results to include multiplicative trade costs.

More generally, our paper adds to the emerging theoretical literature on information and

trade (e.g. Steinwender 2015, Allen 2014, Dasgupta and Mondria 2014, Eaton et al 2014 and Alboronoz et al 2012). For instance, Steinwender (2015) presents a partial equilibrium model to show how information frictions reduce average trade levels by delaying agents' access to market information. Closer to our approach are the papers by i) Allen (2014) who provides a multi-region trade model where sellers undergo an optimal search process to find the best regional price, and ii) Dasgupta and Mondria (2014) who consider information frictions in the form of rational buyer inattention in order to provide a micro-foundation for the gravity trade model. In contrast, we consider buyer information frictions in the form of optimal buyer search, and provide a simple model to explicitly compare the power of information frictions in determining cross-border trade and associated welfare relative to other forms of trade barriers.

Our results also complement a number of recent empirical papers that document the role of information in determining cross-border trade. For instance, Fink et al (2005) and Portes and Rey (2005) show how communication costs and communication traffic help explain trade patterns, Allen (2014) finds evidence of substantial information frictions in regional agriculture, and Steinwender (2015) details how improvements to transatlantic information increased the volume and volatility of cotton trade. Other empirical work demonstrates how borders still limit trade in online markets, while documenting the effects of information frictions in the form of language differences or variations in the level of trust (Hortaçsu et al 2009, Gomez-Herrara et al 2014, Lendle et al 2016). Our paper helps underpin this research by demonstrating the relative theoretical significance of information frictions, and by further understanding the channels by which information affects trade.

2 Model

Consider a market for a single differentiated good over n geographic regions.[1] The market has many potential buyers and sellers, where each seller sells a single product or 'brand'. The buyers are symmetrically distributed across regions, and, without loss, the number of buyers per region is normalized to one. Each buyer has quasi-linear preferences and a unit demand.

[1] Like Steinwender (2015), we focus on a partial equilibrium set-up. However, the presented utility function and the later welfare calculations can be micro-founded within a wider general equilibrium framework. See Appendix A for more details.

In particular, excluding other potential trading costs, let buyer m gain an indirect utility, $u_{mi} = \varepsilon_{mi} - p_i$, if it buys from seller i at price p_i, where ε_{mi} is an idiosyncratic, privately-observed match value that reflects how buyer m values seller i's differentiated product. Each match ε_{mi} is drawn independently from a distribution $G(\varepsilon)$ on $[\underline{\varepsilon}, \overline{\varepsilon}]$ where $\underline{\varepsilon} \geq 0$, and where $\mu \equiv (\overline{\varepsilon} - \underline{\varepsilon}) > 0$. Any buyer who chooses not to buy within the market receives a zero outside option utility.

Each potential seller faces a fixed entry cost, F. Sellers can choose whether to enter the market and which region to locate in. Marginal production costs are normalized to zero. Having entered the market, our main model allows each seller to set different prices to buyers from different regions. Under our later assumptions, this implies that each seller i will find it optimal to set a 'home' price, p_{ih}, to buyers from its own region, and a 'foreign' price, p_{if}, to buyers from all other regions. However, in Section 7.1, we relax this assumption by allowing each seller to only set a single 'world' price.

Any trade between a buyer and seller within the same region is unrestricted. Specifically, if buyer m and seller i are located in the same region, buyer m can freely learn i's home price, p_{ih}, and its match at i, ε_{mi}, and then choose to trade with i at zero cost. In contrast, any trade between a buyer and a 'foreign' seller from a different region is open to a number of frictions and barriers. In particular, to trade with a foreign seller j, buyer m must first incur a cross-border information friction or 'search cost', $c > 0$, in order to identify and interpret seller j's foreign price, p_{jf}, and its product match at j, ε_{mj}. In line with a standard sequential search procedure, buyers can search any number of foreign sellers sequentially, incurring a fixed cost of c each time, with the free ability to return to previously searched sellers. Hence, after each search, a buyer can exit the market, keep searching further foreign sellers, trade with a home seller, or trade with any searched foreign seller.

However, to trade with any searched foreign seller, the buyer and/or seller must further incur a trade cost as consistent with various forms of cross-border tariffs, transportation costs, or transaction costs. In our main model, we focus on additive 'per-unit' trade costs and break them down into those borne by the buyer and seller, respectively. Thus, in any foreign transaction, the buyer must incur a 'buyer trade cost' $\gamma_b > 0$ and the seller must incur a 'seller trade cost' $\gamma_s > 0$. In this context, note that the buyer trade cost, γ_b, cannot be separately identified from a buyer's (perceived) dis-utility for foreign trade, as consistent with localized tastes. Therefore, for brevity, we just denote these two explanations as a form

of buyer trade cost, γ_b. However, in Section 7.2, we later extend our results to allow for trade costs with an alternative multiplicative 'iceberg' structure where the effects of buyer trade costs and localized tastes are shown to differ.

We consider a one-shot game. In stage 1, each potential seller decides whether to enter the market and which region to locate in. In stage 2, sellers each choose their prices, while buyers form conjectures about the sellers' prices and select their own strategies. Given the offerings from any sellers within buyer m's home region, buyer m's strategy must prescribe how many and which foreign sellers to search, and which seller, if any, to trade with.

We focus on the symmetric subgame perfect equilibrium where Ψ sellers locate in each region, and where each seller sets a home price, p_h^*, and foreign price, p_f^*. Therefore, all foreign sellers are identical ex ante and so buyers are indifferent over which foreign sellers to search. Hence, after freely observing Ψ home offers, any buyer strategy must only prescribe whether to start searching the foreign sellers, when to stop searching, and which seller to then trade with, if any.

Given the breadth of our model, we then simplify our analysis with three key assumptions. Without these assumptions, the equilibrium and/or the comparative statics quickly become intractable. First, throughout the analysis, we assume that the level of entry costs at, and immediately around, equilibrium, F, is always sufficiently large such that only one seller is able to profitably locate within each region, $\Psi = 1$. Hence, for any considered values of c, γ_b, or γ_s, each region hosts a single monopolist seller in equilibrium.[2] Second, like Allen (2014), we assume that the number of regions is 'large', $n \to \infty$. This is consistent with a global trading environment with many nations or a national market with many geographic regions. With fewer regions, the analysis becomes difficult due to the existence of 'return' buyers who begin searching but then later decide to return to buy from their original home supplier. Related difficulties are well-known in applications of the Wolinsky/Anderson and Renault framework, but these are particularly acute in our broader trade context. Hence, like other papers that seek tractability, such as Bar-Isaac et (2012), we assume $n \to \infty$ to ensure that no searching buyer ever returns to their original (home) seller. Finally, like Wilson (2012) and Armstrong et al (2009), we focus on a uniform match distribution. Given $\mu \equiv (\overline{\varepsilon} - \underline{\varepsilon}) > 0$, this implies $G(\varepsilon) = \left(\frac{\varepsilon - \underline{\varepsilon}}{\mu}\right)$, with density $g(\varepsilon) = \frac{1}{\mu}$.

[2]The model is also tractable under an alternative assumption of low entry costs such that that $\Psi \to \infty$. However, we do not focus on this equilibrium because it exhibits zero cross-border trade.

3 Equilibrium

Given a single seller in each region, we now characterize the stage 2 equilibrium. First, consider the optimal strategy for a buyer with home seller i, home price, p_{ih}, home match value, ε_i, and the expectation that all other sellers set a foreign price, p_f^*:

Lemma 1. *Define the standard reservation utility, $\hat{x}$, as the unique value of x that solves $c = \int_x^{\overline{\varepsilon}} (\varepsilon - x) g(\varepsilon) d\varepsilon$, such that $\hat{x} = \overline{\varepsilon} - \sqrt{2c\mu} < \overline{\varepsilon}$. Then, the optimal buyer strategy involves:*

Step 1: Search any foreign seller and move to Step 2 if $\max\{0, \varepsilon_i - p_{ih}\} < \hat{x} - \gamma_b - p_f^*$. Otherwise, buy from home seller i if $\varepsilon_i - p_{ih} > 0$, and exit if not.

Step 2: After finding a foreign seller j with foreign price, p_{jf}, and match, ε_j, stop searching further foreign sellers only if $\varepsilon_j \geq \hat{x} + p_{jf} - p_f^*$, and then buy from j.

As seller trade costs, γ_s, do not influence optimal buyer behavior for a given set of prices, this result follows as a simple modification and re-interpretation of Lemma 1 in Wilson (2012) and so we omit its proof. However, because the result forms the platform for our remaining analysis, we now provide a detailed account of its intuition.

The full optimal search problem can be condensed to two steps. In Step 1, a buyer decides whether to start searching beyond its home seller. Using standard induction arguments, this optimally reduces to a seemingly myopic comparison between the buyer's effective home offer, $\max\{0, \varepsilon_i - p_{ih}\}$, and the expected gains from searching *one* foreign seller.[3] To calculate these latter expected gains from searching, note that the buyer would only prefer the searched foreign offer (net of buyer trade costs), $\varepsilon_j - p_f^* - \gamma_b$, to its effective home offer if $\varepsilon_j > \max\{0, \varepsilon_i - p_{ih}\} + p_f^* + \gamma_b \equiv x$. Thus, given a cost of search, c, the expected net gains are

$$-c + \int_{\underline{\varepsilon}}^{x} \max\{0, \varepsilon_i - p_{ih}\} g(\varepsilon_j) d\varepsilon_j + \int_{x}^{\overline{\varepsilon}} (\varepsilon_j - p_f^* - \gamma_b) g(\varepsilon_j) d\varepsilon_j \tag{1}$$

Equating this to the effective home offer then implies that the buyer is indifferent over whether to start searching when $c = \int_x^{\overline{\varepsilon}} (\varepsilon - x) g(\varepsilon) d\varepsilon$ which gives the expression for $\hat{x}$ in

[3] In more detail, to show why Step 1 remains optimal when considering the expected gains from searching any number of sellers $\beta \geq 1$, initially suppose $\beta = 2$. First, if search was optimal under the original Step 1, then search must also be optimal when $\beta = 2$. Second, suppose that search was not optimal under the original Step 1. If, instead, the buyer searches, it will be optimal to search only one seller because after making one search, the original Step 1 will apply such that it will be optimal to stop. Hence, as claimed, the decision under $\beta = 2$ is, in fact, only a decision between stopping immediately and making one more search. This argument can then be expanded for higher levels of β.

Lemma 1. As consistent with Step 1, the buyer will then only start searching when $x < \hat{x}$ or equivalently, when $\max\{0, \varepsilon_i - p_{ih}\} < \hat{x} - \gamma_b - p_f^*$. If the buyer decides not to search, then it buys from its home seller if $\varepsilon_i - p_{ih} > 0$ and otherwise exits. If the buyer does decide to start searching the foreign sellers, then it moves to Step 2.

In Step 2, after searching, if the buyer finds a foreign offer that is inferior to that provided by the home seller then clearly it should continue searching. However, on finding a foreign offer from some seller j that exceeds the buyer's home offer, $\varepsilon_j - p_{jf} - \gamma_b > \max\{0, \varepsilon_i - p_{ih}\}$, the buyer then faces a more substantial decision of whether or not to keep searching further foreign sellers. Using similar logic to above, this optimally reduces to a myopic comparison between the current foreign offer $\varepsilon_j - p_{jf} - \gamma_b$ and the expected net benefits of making *one* further search to discover an additional offer from some foreign seller l, $\varepsilon_l - p_f^* - \gamma_b$. To calculate these expected gains, note that the buyer would only prefer the new foreign offer, $\varepsilon_l - p_f^* - \gamma_b$, to its current foreign offer if $\varepsilon_l > \varepsilon_j - (p_{jf} - p_f^*) \equiv x'$. Thus, given a cost of search, c, the expected net gains are

$$-c + \int_{\underline{\varepsilon}}^{x'} (\varepsilon_j - p_{jf} - \gamma_b) g(\varepsilon_l) d\varepsilon_l + \int_{x'}^{\overline{\varepsilon}} (\varepsilon_l - p_f^* - \gamma_b) g(\varepsilon_l) d\varepsilon_l \tag{2}$$

Equating this to the current foreign home offer then implies that the buyer is indifferent over whether to start searching when $c = \int_{x'}^{\overline{\varepsilon}} (\varepsilon - x') g(\varepsilon) d\varepsilon$ which is also consistent with the expression for $\hat{x}$ in Lemma 1. In line with Step 2, the buyer will then only stop searching and buy when $x' \geq \hat{x}$ or equivalently, when $\varepsilon_j \geq \hat{x} + p_{jf} - p_f^*$. Note, this decision is independent of buyer trade costs, γ_b, because the buyer will always buy from either the current foreign seller or another foreign seller and therefore incur γ_b regardless.

Finally, note that if the buyer chooses to start searching in Step 1, then it will always eventually find a better foreign deal and so never return to buy from its home seller because $n \to \infty$.

We now move on to establishing equilibrium prices. First, from Step 1, no buyer will ever search in equilibrium if $\max\{0, \underline{\varepsilon} - p_h^*\} \geq \hat{x} - \gamma_b - p_f^*$. This generates zero foreign trade and so from this point forward, we focus on the more interesting case where the following condition holds in equilibrium:

$$\max\{0, \underline{\varepsilon} - p_h^*\} < \hat{x} - \gamma_b - p_f^* \qquad \text{(Condition 1)}$$

Now consider seller i's residual home demand when all other sellers set a foreign price, p_f^*:

$$D_{ih}(p_{ih}; p_f^*) = 1 - G(\hat{x} - \gamma_b + p_{ih} - p_f^*) \tag{3}$$

This derives from i's home buyers who do not search. To not search, such buyers must have ε_i such that $\max\{0, \varepsilon_i - p_{ih}\} \geq \hat{x} - \gamma_b - p_f^*$. They will then always buy from i rather than exiting because it follows that $\varepsilon_i - p_{ih} > 0$ via Condition 1. Therefore, the probability that a buyer purchases at home is $1 - G(\hat{x} - \gamma_b + p_{ih} - p_f^*)$.

Next, consider i's residual foreign demand when all other sellers set home and foreign prices, p_h^* and p_f^*:

$$D_{if}(p_{if}; p_h^*, p_f^*) = G(\hat{x} - \gamma_b + p_h^* - p_f^*) \cdot \frac{1}{(1 - G(\hat{x}))} \cdot (1 - G(\hat{x} + p_{if} - p_f^*)) \tag{4}$$

To derive this equation, note that any given buyer that is foreign to region i starts searching from their home seller with probability $G(\hat{x}-\gamma_b+p_h^*-p_f^*)$. Hence, when aggregated across all foreign regions, we know that $(n-1)G(\hat{x}-\gamma_b+p_h^*-p_f^*)$ foreign buyers start searching. The probability that any such foreign buyer then searches i at any point during their search process equals $\frac{1}{(n-1)}[1 + G(\hat{x}) + G(\hat{x})^2 + ... + G(\hat{x})^{n-2}] = \frac{1}{(n-1)} \sum_{k=0}^{n-2} G(\hat{x})^k = \frac{1}{(n-1)} \frac{1}{(1-G(\hat{x}))}$ because buyers i) select which sellers to search randomly, and ii) then keep searching beyond any searched seller $k \neq i$ with the probability that $\varepsilon_k < \hat{x}$, $G(\hat{x})$. Then, conditional on searching i, we know a foreign buyer buys at i with the probability that $\varepsilon_i \geq \hat{x} + p_{if} - p_f^*$, which equals $1 - G(\hat{x} + p_{if} - p_f^*)$.

Given these demand functions, each seller then maximizes its total profits, where the revenue from any foreign buyer is also subject to the seller trade cost, γ_s:

$$\text{Max}_{p_{ih}, p_{if}} \qquad \pi_i(.) = p_{ih} D_{ih}(p_{ih}; p_f^*) + (p_{if} - \gamma_s) D_{if}(p_{if}; p_h^*, p_f^*) - F \tag{5}$$

Proposition 1 then follows, where each price reflects the relevant information frictions and trade costs as explained further within the next section. (All proofs are listed in Appendix B unless stated otherwise).

Proposition 1. *The unique symmetric equilibrium prices are:*

$$p_h^* = \sqrt{2c\mu} + \frac{\gamma_s + \gamma_b}{2} \tag{6}$$

$$p_f^* = \sqrt{2c\mu} + \gamma_s \tag{7}$$

4 Cross-Border Trade

The equilibrium proportion of buyers that trade with a foreign seller, $D_{if}(p_f^*; p_h^*, p_f^*)$, forms a natural measure of cross-border trade in our context. Using (4), note that this is equivalent to the proportion of buyers that search in equilibrium, $G(\hat{x} + p_h^* - p_f^* - \gamma_b)$. By re-labeling $D_{if}(p_f^*; p_h^*, p_f^*)$ as T, and expanding, we can then state:

$$T = G(\hat{x} + p_h^* - p_f^* - \gamma_b) = G\Big(\hat{x} - \Big(\frac{\gamma_s + \gamma_b}{2}\Big)\Big) = 1 - \sqrt{\frac{2c}{\mu}} - \Big(\frac{\gamma_s + \gamma_b}{2\mu}\Big) \tag{8}$$

We now consider how marginal changes in the trade barriers, γ_b, γ_s, and c, affect our cross-border trade measure, T. Such changes affect T either directly, and/or indirectly through their effects on prices.

First, with reference to (9) below, consider the effects on T from an increase in buyers' trade costs (or the dis-utility of foreign trade), γ_b. There is no effect on p_f^* because additional foreign search decisions are independent of γ_b, $\partial p_f^*/\partial \gamma_b = 0$. However, an increase in γ_b i) allows sellers to raise p_h^* because trading with a foreign seller is now more costly, $\partial p_h^*/\partial \gamma_b = 0.5$, and ii) produces a larger off-setting direct effect in deterring buyers from starting to search any foreign sellers, such that cross-border trade, T, decreases. (We postpone discussing the role of μ until the next sub-section.)

$$\frac{\partial T}{\partial \gamma_b} = \frac{1}{\mu}\Big[\frac{\partial p_h^*}{\partial \gamma_b} - \frac{\partial p_f^*}{\partial \gamma_b} - 1\Big] = -\frac{1}{2\mu} < 0 \tag{9}$$

Second, consider an increase in sellers' trade costs, γ_s, (10). This produces no direct effect. However, it prompts sellers to raise p_f^* by increasing their costs of foreign transactions, $\partial p_f^*/\partial \gamma_s = 1$. In turn, this softens competition and so also induces a smaller rise in p_h^*, $\partial p_h^*/\partial \gamma_s = 0.5$. This net price change deters buyers from searching and so decreases T.

$$\frac{\partial T}{\partial \gamma_s} = \frac{1}{\mu}\Big[\frac{\partial p_h^*}{\partial \gamma_s} - \frac{\partial p_f^*}{\partial \gamma_s}\Big] = -\frac{1}{2\mu} < 0 \tag{10}$$

While their mechanisms differ, (9) and (10) show that the marginal effects from γ_b and γ_s are equal. Hence, in this context, our measure of cross-border trade is independent of whether trade costs are borne by sellers or buyers. However, as later shown in Section 7.2, this result changes when trade costs have an alternative 'iceberg' structure.

Now consider an increase in information frictions, c, (11). An increase in c deters search in Step 1 and Step 2 in the same way via $\hat{x}$. This prompts sellers to raise p_h^* and p_f^* by an equal amount such that the price effects on T cancel. This leaves only a direct effect in deterring buyers from starting to search, $\frac{\partial \hat{x}}{\partial c} = -\frac{(\bar{\varepsilon}-\underline{\varepsilon})}{(\bar{\varepsilon}-\hat{x})} = -\sqrt{\frac{\mu}{2c}} < -1$, which decreases T.

$$\frac{\partial T}{\partial c} = \frac{1}{\mu}\Big[\frac{\partial \hat{x}}{\partial c} + \frac{\partial p_h^*}{\partial c} - \frac{\partial p_f^*}{\partial c}\Big] = \frac{1}{\mu}\cdot\frac{\partial \hat{x}}{\partial c} = -\frac{1}{\sqrt{2c\mu}} < 0 \tag{11}$$

We can then state:

Proposition 2. *The marginal effect from an increase in information frictions, c, on reducing cross-border trade, T, is always larger than the marginal effect from an increase in buyer trade costs, γ_b, or seller trade costs, γ_s.*

Regardless of the levels of search costs, buyer trade costs or seller trade costs, search costs always have the relatively more powerful marginal effect on the level of cross-border trade. This suggests that a unit reduction in search costs will generate a larger increase in cross-border trade than a unit reduction in buyer or seller trade costs. Hence, while the optimal policy decision will also depend upon the associated resource costs of each intervention and other potential factors, this suggests that an authority seeking to increase cross-border trade may prefer to improve the provision of consumer information at the margin rather than implementing lower trade costs.

As a policy example, consider the European Commission's Digital Agenda which has not yet reached its target for 20% of European citizens to engage in online cross-border transactions (see European Commission 2015 and Gomez-Herrara et al 2014). To encourage cross-border trade, our results suggest that improvements in broadband speed or the promotion of multi-lingual websites may be more effective than the reduction of trade costs associated with cross-border payment systems or delivery costs.

The intuition Proposition 2 is rather subtle, and one must take care to avoid some misleading explanations. For instance, the result does *not* derive from the fact that trade costs can only be incurred once and yet information frictions can be incurred multiple times by searching different sellers. Instead, as shown in (11), information frictions provide a more powerful determinant of the border effect because of their specific effects in discouraging buyers to search foreign sellers via the reservation utility, $\hat{x}$. From Step 1 of Lemma 1, this reservation utility derives from the optimal, yet seemingly-myopic, comparison between a buyer's effective home offer and their expected net gains from searching *one* foreign seller. In particular, when assessing the expected net gains, (1), a buyer views information frictions as a particularly powerful deterrent as they know that c will be incurred with certainty, but that trade costs, γ_b and γ_s (via p_f^*), will only be incurred with the lesser probability that the next search leads to the discovery of a foreign offer that is attractive enough to induce a cross-border transaction.

4.1 The Role of Product Differentiation

At this point, it is useful to consider the role of product differentiation within our results, as captured by the range of possible match values, $\mu \equiv (\overline{\varepsilon} - \underline{\varepsilon})$. In an influential paper, Rauch (1999) asserts that markets with higher product differentiation should have higher barriers to trade because the associated information search is more costly. While some evidence is consistent with this (e.g. Rauch 1999, Lendle 2016), other evidence suggests the opposite result. For instance, Evans (2003) finds that markets with higher levels of product differentiation have lower border effects, while Fink et al (2005) show that such markets are less sensitive to trade barriers and distance. To help better understand the interactions between product differentiation, information search, and cross-border trade, one can use (8)-(11) to show that:

Proposition 3. *An increase in product differentiation, μ, increases cross-border trade, T, and weakens the associated marginal effects from information frictions, c, and trade costs, γ_b and γ_s.*

An increase in product differentiation, μ, generates several subtle effects that are not typically considered within the literature. First, it raises the equilibrium prices, p_h^* and p_f^*. Depending on the net effect on $(p_h^* - p_f^*)$ this could either encourage or discourage cross-

border trade. However, in our model, we see from (6) and (7) that the two prices rise by the same amount and so the net price effect is zero. Second, and increase in μ encourages buyers to begin searching the foreign sellers and to search more foreign sellers by increasing the potential gains from cross-border trade. Hence, while this increases the total number of equilibrium searches, $C = nT \cdot \frac{1}{1-G(\hat{x})} = nT\sqrt{\frac{\mu}{2c}}$, and the total resources spent on search activity, cC, it produces a higher level of cross-border trade, T, and weakens the importance of each trade barrier in (9)-(11).

These results are consistent with evidence, such as Evans (2003) and Fink et al (2005), but inconsistent with the evidence supporting Rauch (1999). To generate results in line with Rauch, one needs to allow the cost of *each individual* search, c, to be sufficiently increasing in the level of product differentiation, μ, as consistent with the possibility that relatively more differentiated products require more time to assess. With this modification, our model can then help provide an over-arching explanation for the conflicting evidence. When $c'(\mu)$ is sufficiently low, an increase in μ increases trade, but when $c'(\mu)$ is sufficiently high, an increase in μ can reduce trade.

5 Welfare

We now extend the spirit of our main result, Proposition 2, to compare how the considered trade barriers affect welfare. However, to avoid any awkward conceptual comparisons, we drop the localized tastes dis-utility interpretation of γ_b.

Proposition 4. *Relative to a marginal increase in seller trade costs, γ_s, or buyer trade costs, γ_b, a marginal increase in information frictions, c, always leads to a greater increase in seller profits, and a larger reduction in buyer surplus and total welfare.*

For any level of c, γ_b, and γ_s, this result suggests that buyer surplus, seller profits, and total welfare are more sensitive to the level of search costs than the level of buyer or seller trade costs. With all else constant, this strengthens the implications of Proposition 2, and further points to the potential policy value of improving buyer information.

To understand the result further, first consider seller profits. Using (5) and (8), a seller's equilibrium profits can be expressed as $\pi_i^* = p_h^*(1-T) + (p_f^* - \gamma_s)T - F$, where it can also be shown that $p_h^* > p_f^* - \gamma_s$. Then relative to the trade costs, γ_s and γ_b, information frictions

always increase profits by a larger amount because they produce a bigger marginal effect in raising p_h^*, p_f^*, and $(1-T)$.

Now consider the effects of a marginal increase in any of the explanatory variables on buyer surplus. These effects are more complex. However, by adapting standard envelope-arguments from Wilson (2012), we know that any *indirect* effects on buyer surplus that result from a change in buyer behavior are only second-order in magnitude. This follows because such buyers must have previously been indifferent between the relevant actions in order for the marginal change to have had any qualitative effect on their behavior. Hence, the only possible first-order *direct* effects on buyer surplus stem from i) any increase in prices, for given levels of existing home and foreign demand, and ii) any increase in the resource costs of existing search activity or existing cross-border transactions. Due to their relative potency in influencing buyers' search decisions, the proof then verifies that information frictions provide the relatively larger marginal effect because they generate larger marginal price effects on p_h^* and p_f^*, and larger marginal resource costs.

Finally, consider total welfare. As all buyers buy in equilibrium, we know that the effects of any increased prices only result in a welfare transfer from buyers to sellers. Therefore, using our previous arguments, the only first-order effects concern the increase in resource costs of existing search activity or existing cross-border transactions. From above, it then follows that information frictions provide the relatively larger marginal effect.

6 Empirical Implications

We now consider some empirical implications from our model. In particular, we illustrate how our measure for cross-border trade, T, could be used as the basis for an estimation approach.

Within a considered product market, h, let the measure of cross-border trade, T_{hr}, denote the proportion of buyers in region r that buy from a foreign seller. If this statistic is not directly available, it can be calculated by using $T_{hr} \equiv \frac{V_{hr}}{p_f^* \cdot N}$, where N is the total number of buyers of product h in region r, V_{hr} is the value of the imports of product h into region r, and p_f^* is the relevant import price. By using the right-hand-side of (8), we can then then write $T_{hr} \equiv \frac{V_{hr}}{p_f^* N} = 1 - \sqrt{\frac{2}{\mu}} \cdot c^{0.5} - \frac{\gamma_s}{2\mu} - \frac{\gamma_b}{2\mu}$. Hence, with the use of suitable proxies for the level of information frictions and trade costs, this suggests the estimation of an equation with form

$T_{hr} \equiv \frac{V_{hr}}{p_f^* N} = \alpha + \beta_1 c^{0.5} + \beta_2 \gamma_s + \beta_3 \gamma_s$ where our past results predict i) $\beta_1 < \beta_2, \beta_3 < 0$, ii) $\beta_2 = \beta_3$ (under additive trade costs), and iii) that each coefficient will be weaker in markets with higher levels of product differentiation, μ.

Some evidence for prediction iii) has already been discussed in Section 4.1. There is little existing empirical work to consider prediction ii). However, some related support for our main prediction i) can be found within the existing literature. Much of the literature employs gravity estimates to explain the value of exports between one country and another as a function of the country size, distance, and relevant trade barriers (see the surveys by Anderson and van Wincoop 2004 and Head and Mayer 2013). While no formal tests are provided to compare our variables of interest, a few papers report that information cost proxies, such as telecommunication costs or the existence of a common language, are statistically more significant in reducing cross-border trade than some more traditional trade costs, such as shipping costs or tariff levels (e.g. Lendle et al 2016, Gomez-Herrera 2014, Fink et al 2005). Future work in this direction would be useful to further test our model and explicitly compare the effects of different forms of trade barriers.

7 Extensions

In this final section, we consider two extensions. First, we show how our main results remain robust in an alternative case where sellers are unable to set different prices to sellers in different regions. Second, and more substantially, we consider an alternative 'iceberg' structure of trade costs. Here, we provide conditions for our main results to remain robust, and highlight two interesting differences to the main model.

7.1 Single Prices

The main model assumed that each seller i could set different prices to buyers from different regions. Here, we now consider an alternative case where each seller i can only set a single 'world' price to all buyers, p_i:

Proposition 5. *When each seller can only set a single price to all buyers, information frictions still exert the relatively larger marginal effect on cross-border trade, and total welfare.*

In the resulting symmetric equilibrium, the sellers set a single price p^*, such that the

cross-border trade measure in (8) now equals $T = D_{if}(p^*; p^*) = G(\hat{x} - \gamma_b)$. This measure is independent of prices, and so the associated price effects in (9)-(11) become neutralized. This leaves only the direct effects, which we know favor information frictions due to their relative power in deterring foreign trade. In terms of welfare, the existence of a single price makes it difficult to explicitly rank the relative comparative statics for seller profits and buyer surplus. However, by applying our previous logic, one can still show that information frictions exert the largest effect on total welfare.

7.2 Alternative Trade Costs

The main model focused on additive 'per-unit' trade costs, γ_b and γ_s. As argued by Sørensen (2014) and the references therein, such trade costs are common, and important both theoretically and empirically. However, we now consider an alternative case with multiplicative 'iceberg' trade costs that are proportional to a product's price.

Here, when a buyer trades with a foreign seller j at foreign price p_{jf}, buyer trade costs are given by $\gamma_{bj} = \phi_b p_{jf}$ and seller trade costs are given by $\gamma_{sj} = \phi_s p_{jf}$, where $\phi_b > 0$ and $\phi_s > 0$ reflect the strength of the relevant buyer and seller trade barriers, respectively. Unlike the main model, marginal production costs, $k \geq 0$, now become important because they affect the equilibrium level of buyer and seller trade costs, $\phi_b p_f^*$ and $\phi_s p_f^*$, via their effects on the equilibrium foreign price, p_f^*.

If information frictions also follow a multiplicative structure, then it is straightforward to show that our results remain robust. However, information frictions are unlikely to have such a structure because the costs of identifying a seller's offer are not dependent upon the actual price charged. This makes the comparison more complex, but we can state the following (where all the derivations and proofs for this sub-section are listed in Appendix C):

Proposition 6. *Under iceberg trade costs, information frictions still exert the relatively larger marginal effect on cross-border trade, buyer surplus, seller profits and total welfare, when marginal production costs, k, are sufficiently small.*

Proposition 5 confirms our main results when k is sufficiently small. When production costs are small, the equilibrium foreign price is relatively low, and so the effects of a marginal change in the strength of buyer trade costs, ϕ_b, or seller trade costs, ϕ_s, remain smaller than the effects from a marginal change in information frictions. However, when production costs

and the resultant equilibrium foreign price are sufficiently large, the effects of a marginal change in the strength of buyer or seller trade costs can dominate the effects of a marginal change in information frictions.

Finally, we note two other interesting features of the 'iceberg' model that differ to the main model. First, the marginal effect from an increase in the strength of seller trade costs, ϕ_s, in reducing cross-border, T, is always larger than the marginal effect from an increase in the strength of buyer trade costs, ϕ_b, when $k > 0$. This differs to the main model where increases in buyer and seller trade costs, γ_s and γ_b, reduced cross-border trade by an equal amount. The intuition is complex. However, because increases in ϕ_s are borne directly by sellers, a marginal increase in ϕ_s prompts a relatively large increase in the equilibrium foreign price, p_f^*. Despite being partially offset by a resulting increase in the equilibrium home price, p_h^*, this ensures that cross-border trade is more sensitive to the strength of seller, rather than buyer, trade costs.

Second, unlike the main model, the iceberg model allows us to separately identify the effects of localized tastes from the effects of buyer trade costs under the assumption that the (preference-based) dis-utility of trading with a foreign seller, γ_b, remains independent of prices. One can then use similar reasoning to Proposition 5, to show that the marginal effect from an increase in localized tastes, γ_b, on reducing cross-border trade, T, is larger than the marginal effect from an increase in the strength of buyer or seller trade costs, ϕ_b and ϕ_s, when marginal production costs, k, are sufficiently small. Hence, at the margin, while still dominated by the effects of information frictions, localized tastes may provide a relatively more powerful barrier to cross-border trade than buyer or seller trade costs in markets for low-value goods.

8 Conclusion

This paper has extended a simple version of a popular information framework (Wolinsky 1986 and Anderson and Renault 1999) into a trade context in order to compare three broad forms of trade barriers. The traditionally under-researched role of information frictions was found to often generate the relatively larger marginal effect in reducing cross-border trade, and associated welfare.

We hope that future research can build on our work in at least three ways. First, further

work should generalize, expand, and test our findings to develop the implication that policymakers may wish to focus more on information-based policy remedies in order to better promote trade and globalization. Second, future work would be useful to widen our comparison to include additional trade barriers, such as an explicit analysis of the information-related 'trust' mechanism recently highlighted empirically by Hortaçsu et al (2009) and Lendle et al (2016). However, the addition of this mechanism is only likely to strengthen our findings about the relative importance of information in determining trade. Finally, and more generally, we hope that future research can build on our framework to analyze further information-related trade questions.

Appendix A: General Equilibrium Foundation

In this appendix, we show how the presented utility function and welfare calculations within the main model can be micro-founded within a wider general equilibrium framework. Suppose there are two sectors: the considered sector, X, together with sector Y which produces an outside numeraire good using labor inputs under perfect competition and constant returns to scale. The real wage therefore equals the level of labor productivity in sector Y, y. Now consider a buyer and seller in sector X. Under our assumption of unit demand, $X \in \{0, 1\}$, and given a price p and buyer match value ε, suppose the buyer has a quasi-linear utility function, $u = \varepsilon X + Y$. The budget constraint, $pX + Y \leq y$ will hold with equality given the marginal utility of Y equals one. Therefore, the consumer optimally buys X if $\varepsilon + y - p > y$ or $\varepsilon > p$, which then implies $u = \varepsilon - p + y$. Hence, one can use $u = \varepsilon - p$ as in the main model without loss because i) all consumers buy in equilibrium and, ii) our results only consider changes in welfare which are independent of the level of real wage, y.

Appendix B: Main Proofs

Proof of Proposition 1: With use of (3) and (4), π_i in (5) is continuous and quasi-concave in both p_{if} and p_{ih} over the relevant range. Hence, when evaluated at equilibrium, i) the FOC with respect to p_{if} gives the unique price; (7), and ii) the FOC with respect to p_{ih} gives $p_h^* = \frac{1}{2}[\overline{\varepsilon} - \hat{x} + p_f^* + \gamma_b]$, which after substituting for p_f^* gives the unique price; (6). □

Proof of Proposition 2: From (9)-(11), we require $\frac{\partial T}{\partial c} = -\frac{1}{\sqrt{2c\mu}} = -\frac{1}{(\bar{\varepsilon}-\hat{x})}$ to be more negative than $\frac{\partial T}{\partial \gamma_s} = \frac{\partial T}{\partial \gamma_s} = -\frac{1}{2\mu}$. This requires $\frac{2(\bar{\varepsilon}-\underline{\varepsilon})}{(\bar{\varepsilon}-\hat{x})} > 1$ and follows because i) $\hat{x} < \bar{\varepsilon}$ from Lemma 1, and ii) $\hat{x} > \underline{\varepsilon} + \frac{(\gamma_s+\gamma_b)}{2} > \underline{\varepsilon}$ from Condition 1 when evaluated with equilibrium prices. □

Proof of Proposition 4: First, consider a seller's profits, $\pi_i^* = p_h^*(1-T)+(p_f^*-\gamma_s)T-F$. Using (6)-(11), we can then state that $\frac{\partial \pi_i^*}{\partial c} = -\frac{\partial \hat{x}}{\partial c}[1 + \frac{\gamma_s+\gamma_b}{2\mu}]$ is strictly larger than $\frac{\partial \pi_i^*}{\partial \gamma_s} = \frac{1}{2}[(1+T)+\frac{\gamma_s+\gamma_b}{2\mu}] > 0$ and $\frac{\partial \pi_i^*}{\partial \gamma_b} = \frac{1}{2}[(1-T)+\frac{\gamma_s+\gamma_b}{2\mu}] > 0$ by using $(1-T) \in (0,1)$ and $-\frac{\partial \hat{x}}{\partial c} > 1$ from past results. Second, consider buyer surplus and denote C as the equilibrium number of searches, and S as the equilibrium number of cross-border transactions. From the text, the only possible first-order effects from a marginal change in an explanatory variable, z, involve the effects on i) increased prices for given levels of demand, $n[\frac{\partial p_h^*}{\partial z}(1-T)+\frac{\partial p_f^*}{\partial z}T]$, ii) increased total resource costs for existing search activity, $C\frac{\partial c}{\partial z}$, and iii) increased total resource costs for existing cross-border transactions, $S\frac{\partial(\gamma_b+\gamma_s)}{\partial z}$. Information frictions, c, then produce the larger total marginal effect. This follows because i) they produce larger marginal effects on both p_h^* in (6) and p_f^* in (7) as $-\frac{\partial \hat{x}}{\partial c} > 1$, and ii) because they produce larger resource effects as the equilibrium number of searches, C, is strictly larger than the equilibrium number of cross-border transactions, S, with $\frac{C}{S} = \frac{G(\hat{x}-\gamma_b+p_h^*-p_f^*)\cdot\frac{1}{(1-G(\hat{x}))}}{G(\hat{x}-\gamma_b+p_h^*-p_f^*)} > 1$. Finally, using the text, the proof for total welfare follows immediately as we need only consider the resource effects in ii) above. □

Proof of Proposition 5: Lemma 1 remains with $p_i = p_{ih} = p_{if}$ and $p^* = p_h^* = p_f^*$. Then, with the assumption that γ_s is not so high that it prevents profitable trade to foreign regions, and under a revised Condition 1: $\max\{0, \underline{\varepsilon}-p^*\} < \hat{x}-\gamma_b-p^*$, each seller i must now maximize $\pi_i(.) = p_i D_{ih}(p_i;p^*) + (p_i-\gamma_s)D_{if}(p_i;p^*) - F$ where $D_{ih}(p_i;p^*) = 1 - G(\hat{x}-\gamma_b+p_i-p^*)$ and $D_{if}(p_i;p^*) = G(\hat{x}-\gamma_b)\cdot\frac{1}{(1-G(\hat{x}))}\cdot(1-G(\hat{x}+p_i-p^*))$. The resulting equilibrium price is $p^* = \frac{\mu(1-G(\hat{x}))+\gamma_s[G(\hat{x}-\gamma_b)]}{1-G(\hat{x})+G(\hat{x}-\gamma_b)}$. The measure for cross-border trade is now independent of prices as $T = D_{if}(p^*;p^*) = G(\hat{x}-\gamma_b)$. Therefore, by modifying the arguments of Proposition 2, we know that $\frac{\partial T}{\partial c} = \frac{1}{\mu}\cdot\frac{\partial \hat{x}}{\partial c}$ is strictly more negative than $\frac{\partial T}{\partial \gamma_b} = -\frac{1}{\mu}$ and $\frac{\partial T}{\partial \gamma_s} = 0$. Finally, for total welfare, using past arguments, we only require the equilibrium ratio of total searches to total cross-border transactions to exceed one. This still follows as $\frac{G(\hat{x}-\gamma_b)\cdot\frac{1}{(1-G(\hat{x}))}}{G(\hat{x}-\gamma_b)} > 1$. □

Appendix C: Derivations for Alternative Trade Costs

This appendix provides a full derivation for the results of Section 7.2 by considering a model with i) information frictions, c, ii) iceberg buyer and seller trade costs, $\gamma_{bj} = \phi_b p_{jf}$ and $\gamma_{sj} = \phi_s p_{jf}$, iii) marginal production costs, $k \geq 0$, and iv) the possibility of localized tastes, $\gamma_b \geq$. First, consider the optimal strategy for a buyer with home seller i, given home price, p_{ih}, home match, ε_i, and the expectation that all other sellers set a foreign price, p_f^*.

Claim 1. *Under iceberg trade costs, the optimal buyer strategy involves:*

Step 1: Search any foreign seller and move to Step 2 if $\max\{0, \varepsilon_i - p_{ih}\} < \hat{x} - p_f^*(1+\phi_b) - \gamma_b$. *Otherwise, buy from home seller i if $\varepsilon_i - p_{ih} > 0$, and exit if not.*

Step 2: After finding a foreign seller j with foreign price, p_{jf}, and match, ε_j, stop searching further foreign sellers only if $\varepsilon_j \geq \hat{x} + (p_{jf} - p_f^*)(1 + \phi_b)$, and then buy from j.

Claim 1 follows a simple adaptation of Lemma 1. In brief, it can be derived as follows. For Step 1, a buyer now expects to discover a first foreign offer of $\varepsilon_j - p_f^* - \phi_b p_f^* - \gamma_b$. By following the steps in the main model, it can be verified that the buyer will start search only if $\max\{0, \varepsilon_i - p_{ih}\} < \hat{x} - p_f^*(1 + \phi_b) - \gamma_b$. For Step 2, a buyer now compares a current foreign offer $\varepsilon_j - p_{jf} - \phi_b p_{jf} - \gamma_b$ with an expected new offer of $\varepsilon_l - p_f^* - \phi_b p_f^* - \gamma_b$. By following the steps in the main model, it can be verified that the buyer will stop and buy if $\varepsilon_j \geq \hat{x} + (p_{jf} - p_f^*)(1 + \phi_b)$. Note in contrast to the main model, buyer trade costs matter in Step 2 if $p_{jf} \neq p_f^*$ because they are now price dependent. However, localized tastes remain irrelevant.

Claim 2. *Under iceberg trade costs, the unique symmetric equilibrium prices are:*

$$p_h^* = \sqrt{2c\mu} + \frac{\gamma_b}{2} + \frac{k}{2}\Big(1 + \frac{1+\phi_b}{1-\phi_s}\Big) \tag{12}$$

$$p_f^* = \Big(\frac{\sqrt{2c\mu}}{1+\phi_b}\Big) + \Big(\frac{k}{1-\phi_s}\Big) \tag{13}$$

To derive this, one can first ensure that some buyers search by stating a new version of Condition 1, $\max\{0, \underline{\varepsilon} - p_h^*\} < \hat{x} - p_f^*(1 + \phi_b) - \gamma_b$. Seller i's residual home demand when all other sellers set a foreign price, p_f^*, now equals $D_{ih}(p_{ih}; p_f^*) = 1 - G(\hat{x} + p_{ih} - p_f^*(1+\phi_b) - \gamma_b)$, and

seller i's residual foreign demand when all other sellers set home and foreign prices, p_h^* and p_f^* is now $D_{if}(p_{if}; p_h^*, p_f^*) = G(\hat{x}+p_h^*-p_f^*(1+\phi_b)-\gamma_b)\cdot\frac{1}{(1-G(\hat{x}))}\cdot(1-G(\hat{x}+(p_{if}-p_f^*)(1+\phi_b)))$. Given these demand functions, each seller then maximizes its total profits, where there is a marginal production cost, $k \geq 0$, and where the revenue from any foreign buyer is subject to the seller iceberg trade cost, $\phi_s p_{if}$: $\pi_i(.) = (p_{ih} - k)D_{ih}(p_{ih}; p_f^*) + (p_{if} - k - \phi_s p_{if})D_{if}(p_{if}; p_h^*, p_f^*) - F$. When evaluated at equilibrium, i) the FOC with respect to p_{if} leads to (13) directly, and ii) the FOC with respect to p_{ih} leads to $2p_h^* = k + (\bar{\varepsilon} - \hat{x}) + (1 + \phi_b)p_f^* + \gamma_b$ which after substitution gives (12).

Claim 3. *Under iceberg trade costs, we can define the cross-border trade measure, T, as*

$$T = D_{if}(p_f^*; p_h^*, p_f^*) = G(\hat{x} + p_h^* - p_f^*(1 + \phi_b) - \gamma_b) = G\Big(\hat{x} - \frac{\gamma_b}{2} - \frac{k}{2}\Big(\frac{\phi_s + \phi_b}{1 - \phi_s}\Big)\Big) \tag{14}$$

We are now ready to state the proof for Proposition 6.

Proof of Proposition 6: First, consider cross-border trade, T. Using (14), it follows that i) $\frac{\partial T}{\partial \phi_b} = -\frac{k}{2\mu(1-\phi_s)} < 0$, ii) $\frac{\partial T}{\partial \phi_s} = -\frac{k(1+\phi_b)}{2\mu(1-\phi_s)^2} < 0$, and iii) $\frac{\partial T}{\partial c} = \frac{1}{\mu} \cdot \frac{\partial \hat{x}}{\partial c} < 0$. Using $\frac{\partial \hat{x}}{\partial c} = -\frac{(\bar{\varepsilon}-\underline{\varepsilon})}{(\bar{\varepsilon}-\hat{x})} < -1$ from past results, it then follows that $\frac{\partial T}{\partial c}$ is more negative than $\frac{\partial T}{\partial \phi_b}$ and $\frac{\partial T}{\partial \phi_s}$ when k is sufficiently small.

Second, consider equilibrium seller profits, which can be rewritten as $\pi_i^* = (p_h^* - k)(1 - T) + (p_f^*(1 - \phi_s) - k)T - F$. One can verify that $p_h^* > p_f^*(1 - \phi_s)$ for small k. Thus, it follows that $\frac{\partial \pi_i^*}{\partial c} > \max\{\frac{\partial \pi_i^*}{\partial \phi_b}, \frac{\partial \pi_i^*}{\partial \phi_s}\}$ if i) $\frac{\partial T}{\partial c} < \min\{\frac{\partial T}{\partial \phi_b}, \frac{T}{\partial \phi_s}\}$, ii) $\frac{\partial p_h^*}{\partial c} > \max\{\frac{\partial p_h^*}{\partial \phi_b}, \frac{\partial p_h^*}{\partial \phi_s}\}$, and iii) $\frac{\partial p_f^*(1-\phi_s)}{\partial c} > \max\{\frac{\partial p_f^*(1-\phi_s)}{\partial \phi_b}, \frac{\partial p_f^*(1-\phi_s)}{\partial \phi_s}\}$. Condition i) follows from above. Condition ii) follows for k sufficiently small with use of (12). Condition iii) follows with use of (13).

Third, consider buyer surplus and denote C as the equilibrium number of searches, and S as the equilibrium number of cross-border transactions. The only possible first-order effects from a marginal change in an explanatory variable, $z = \{c, \phi_s, \phi_b\}$, involve the effects on i) increased prices for given levels of demand, $n[\frac{\partial p_h^*}{\partial z}(1 - T) + \frac{\partial p_f^*}{\partial z}T]$, ii) increased total resource costs for existing search activity, $C\frac{\partial c}{\partial z}$, and iii) increased total resource costs for existing cross-border transactions, which now equals $S\frac{\partial(\phi_b+\phi_s)p_f^*}{\partial z}$. Information frictions, c, then produce the larger total marginal effect when k is sufficiently small. This follows because i) they produce larger marginal effects on both p_h^* in (12) and p_f^* in (13), and ii) because they produce

larger resource effects as the equilibrium number of searches, C, is strictly larger than the equilibrium number of cross-border transactions, S, with $\frac{C}{S} = \frac{G(\hat{x}+p_h^*-p_f^*(1+\phi_b))\cdot\frac{1}{(1-G(\hat{x}))}}{G(\hat{x}+p_h^*-p_f^*(1+\phi_b))} > 1$.

Finally, using the text, the proof for total welfare follows immediately as we need only consider the resource effects in ii) above. □

Finally, we can verify the two results given within the text at the end of Section 7.2.

Claim 4. *Under iceberg trade costs:*

i) The marginal effect from an increase in the strength of seller trade costs, ϕ_s, is always larger in reducing cross-border, T, than the marginal effect from an increase in the strength of buyer trade costs, ϕ_b, when $k > 0$.

ii) The marginal effect from an increase in localized tastes, γ_b, on reducing cross-border trade, T, is larger than the marginal effect from an increase in the strength of buyer or seller trade costs, ϕ_b and ϕ_s, when marginal production costs, k, are sufficiently small.

To derive these, one can use (14), to note that i) $\frac{\partial T}{\partial \phi_s} = -\frac{k(1+\phi_b)}{2\mu(1-\phi_s)^2} < \frac{\partial T}{\partial \phi_b} = -\frac{k}{2\mu(1-\phi_s)} < 0$ given $\phi_s, \phi_b, k > 0$, and ii) $\frac{\partial T}{\partial \gamma_b} = -\frac{1}{2\mu} < \frac{\partial T}{\partial \phi_s} < \frac{\partial T}{\partial \phi_b}$ when k is sufficiently small.

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