Intransparent Prices: A Model of Intra-Industry Trade due to Incomplete Information*

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February 2009
Preliminary version.

Abstract:

Buyers are typically unaware of the full set of offers when making a purchase. This paper examines how international trade interacts with this problem of incomplete information. Sellers must communicate their offers through costly price posting, but cannot reach all buyers. Consequently, no market clearing price exists, and sellers randomize over an equilibrium price distribution. Letting sellers communicate their offers abroad leads to international trade, which would not take place under perfect information. Buyers then receive more offers, leading to (stochastically) lower prices and welfare gains. Sellers in the model are identical, but appear heterogeneous due to their price randomization.

Keywords: price dispersion, advertising, intra-industry trade, firm heterogeneity

JEL-codes: F12, D83

* I thank Philipp Schröder, Jørgen Ulff-Møller Nielsen, Bruno Versaevel, Richard Ruble, Stéphane Robin and Izabela Jelovac. I acknowledge financial support from the Danish Social Sciences Research Council (grant no. 275-06-0025).

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1 Introduction

The IT revolution of the last two decades has greatly facilitated access to, and diffusion of, information, and made instant communication across the globe possible. Recent research in international trade, with Antras, Garicano and Rossi-Hansberg (2006) and Grossman and Rossi-Hansberg (2008) as prominent examples, has highlighted how improved information technology enable firms to internationalize organization and production processes. So far, however, studies of information technology has focused on the internal organization of the firm, markets for final products have been neglected. This paper examines how the ease of transmitting and receiving information affects markets and trade flows of final goods.

I construct a model with two types of agents, buyers, who demand a good, and sellers, who produce it. Buyers are initially unaware of the characteristics of offers, and sellers must spend resources on advertising their offers to buyers. The setup for the closed economy is adapted from the wage posting model of Mortensen.(2003). For expositional clarity, I focus on homogeneous goods, where advertisement reduces to price posting. The approach, however, generalizes directly to quality-adjusted prices of non-homogeneous goods, where advertisement may require other information than price.

Sellers' price posting technology is similar to the advertisement model of Butters (1977). Advertisement is non-rival in its form, one can think of sellers posting offers in mass media or in the public space. That these forms of advertisement hit potential buyers at random, seems like a good approximation. A seller is therefore unable to distinguish whether buyers have already received offers from other sellers, and the seller's price posting campaign may reach the same buyer multiple times. As a consequence, if there are many buyers, it becomes prohibitively expensive for the individual seller to reach them all.

In this setting, there is no equilibrium price on the market: sellers will either want to price lower than other sellers, or to price higher, hoping that the buyer gets no better offer. The equilibrium outcome is a price distribution with no mass points, over which sellers randomize their price. Each seller thus charges a different price, although the good is homogeneous. Price dispersion, even for homogeneous goods or within specific brands, has been documented empirically by Stigler (1961) and Pratt, Wire and Zeckhauser (1979), and Clay et al. (2001) documents that the phenomenon has not disappeared in the internet age. A rich theoretical literature has demonstrated different explanations for how price dispersion may occur, Butters (1977) and Burdett and Judd (1983) are seminal papers..

Buyers in the present model can either be thought of as consumers, or as firms wishing to buy an intermediate input. The model may also be given a spatial interpretation, translating price posting costs into costs of setting up retailers or buying presence in an existing retail system. If some buyers frequent more than one retailer, retail presence expenditure would be subject to the same forms of crowding out, with resources spent on serving the same buyer multiple times.

When sellers are able to contact buyers abroad, there will be two-way international trade in the model. The export market presents an entirely new set of buyers to sellers, and initially there is no risk of reaching the same buyer twice with the price posting campaign. The net implication of international trade is an increase in the average number of prices that a buyer learns about and a downward shift in the price distribution. International trade pushes the model towards the Bertrand equilibrium, to the benefit of buyers. Were it not for the information frictions, there would be no reason for international trade to occur, as both countries would be in a Bertrand equilibrium already.

That incomplete information or uncertainty may lead to intra-industry trade in a Bertrand model has been demonstrated in a different setting by Cukrowski and Aksen (2003). Here, risk averse firms face uncertain demand at their domestic and potential export market, and engage in export with the purpose of diversifying risk. In relation to other explanations of intra-industry trade, the present model and the one of Cukrowski and Aksen (2003) can be viewed as Bertrand counterparts of the Cournot model of Brander and Krugman (1981).

International price posting is likely to be easier between countries that share languages. Lower costs of export price posting will enable sellers to export more, the model thus presents an explicit channel for the well-known result that countries with shared languages trade more.

The internet allows a cheap form of price posting that is completely independent of physical distance. Improved IT technology is very likely to have reduced the costs of export price posting, leading to an increase in international trade in final products.

In addition to the above findings the present approach has further somewhat surprising implications:.Since sellers randomize their price, they will appear heterogeneous, when examining prices and output: Some sellers sell few units at a high price, and some sell many, cheaper units. This pattern is similar to the one generated in for example Melitz (2003) by differences in efficiencies among firms. Moreover, in accordance with the predictions of Melitz and Ottaviano (2008), larger markets attract more sellers and sellers earn lower mark-ups.

The next section sets up the model for the closed economy.

2 The Closed Economy

There are n buyers wishing to buy one unit of a good, they have reservation price of $\bar{p}$. The m sellers produce the good at constant marginal cost c, $c < \bar{p}$. Initially, buyers are unaware of the individual seller's existence and the price of her good. Sellers inform buyers of their offers through price posting.

The costs of price posting fall into two parts. There is a fixed costs, f_v of employing the relevant people and have them design the price posting campaign. Thereafter, the cost of reaching k distinct buyers with the campaign and thereby inform them of the price of the product is described by the function $v(k/n)$.Price posting hits buyers at random, so the seller is unable to take into account if a buyer has already received offers from other sellers. Moreover, the campaign may hit the same buyer multiple times, and this leads to convexity of $v(k/n)$: The larger the fraction of the population reached by the campaign, the higher the probability that resources will be spent on reaching the same buyer twice, $v'(k/n) > 0$ and $v''(k/n) > 0$. In the end, reaching the last buyer if all other buyers have been reached becomes impossible: $v'(k/n) \to \infty$ *as* $k/n \to 1$.

The timing of the game is as follows: In the first stage, each seller chooses the scope of her price posting campaign, k, and her price p. In the second stage, each buyer picks the best among the offers he learns about. If a buyer only receives one offer, he buys the good if its price is lower than the maximum willingness to pay; if there are more than one offer, the buyer will accept the cheapest offer. In case there are several offers with the lowest price, the buyer selects randomly among these.

The expected profit earnt by seller j, $j = 1, 2, ...m$, is:

$$\pi_j(p, k_j) = Q(p)\,(p - c)\,k_j - v(k_j/n) - f_v, \tag{1}$$

where $Q(p)$ denotes the probability that a buyer purchases the good when the seller charges price p. Given the form demand has in the model, the price and scope decisions are effectively separate, prices are chosen to maximize the expected markup $Q(p)\,(p - c)$, and the price posting expenditures determines how many times this markup is earnt. It is most convenient to first examine how sellers price in equilibrium.

2.1 Price randomization

As buyers are targeted at random, the number of offers X that a buyer receives is binomially distributed. The base probability is $1/n$ and "sample size" is $\sum_{j=1}^{m} k_j$, where k_j is the number of buyers contacted by seller j. When $\sum_{j=1}^{m} k_j$ and n are large, the distribution of X can be well approximated by the poisson distribution:

$$\Pr(X = x) = \frac{e^{-\lambda}\lambda^x}{x!}, \qquad \text{where } \lambda = \frac{\sum_{j=1}^{m} k_j}{n}. \tag{2}$$

λ is the poisson parameter, equal to the expected number of offers a buyer receives; it will hereafter be called the contact frequency.

Let $F(p)$ denote the distribution of prices offered by sellers. Some characteristics of the equilibrium price offer distribution is summarized in proposition 1:

> **Proposition 1,** adapted from Mortensen (2003): Any equilibrium distribution of price offers, represented by the c.d.f. $F(p)$ is continuous and has connected support with upper support $\bar{p}$ and lower support no less than c.

A formal proof is given in appendix A. Continuity of $F(p)$ implies that there is no equilibria where sellers set the same price. The intuition for this is quite straightforward: If a buyer receives several offers with the same price, a seller will always want to reduce her price slightly and be sure that the buyer accepts her offer rather than selects an offer at random. This undercutting does not continue, though: If all sellers were to price at c, a seller can earn positive profits by setting $p = \bar{p}$, as the probability that the buyer gets no other offer is $\Pr(X = 0) = e^{-\lambda} > 0$.

For a given price offer distribution, the probability that price p is the lowest among x other offers is $[1 - F(p)]^x$. Using this, the purchase probability $Q(p)$ can be computed as

$$Q(p) = \sum_{x=0}^{\infty} [1 - F(p)]^x \frac{e^{-\lambda}\lambda^x}{x!} = e^{-\lambda F(p)} \sum_{x=0}^{\infty} \frac{e^{-\lambda[1-F(p)]}\,(\lambda\,[1 - F(p)])^x}{x!} = e^{-\lambda F(p)}. \tag{3}$$

Since all price offers on the support of $F(p)$ must be profit maximizing, and since $\bar{p}$ is on the support of $F(p)$, any price offered must give the same expected profit as offering $\bar{p}$: $\pi(p, k_j) = \pi(\bar{p}, k_j)$. From this condition, the equilibrium price offer distribution can be derived:

$$e^{-\lambda F(p)}(p-c)k_j - v(k_j/n) - f_v = e^{-\lambda}(\bar{p}-c)k_j - v(k_j/n) - f_v$$
$$\Longleftrightarrow F(p) = 1 - \frac{1}{\lambda}\ln\left(\frac{\bar{p}-c}{p-c}\right) \tag{4}$$

with lower support $e^{-\lambda}\bar{p} + \left(1-e^{-\lambda}\right)c$ and upper support $\bar{p}$. In equilibrium, sellers randomize their price over $[e^{-\lambda}\bar{p} + \left(1-e^{-\lambda}\right)c, \bar{p}]$ in such a manner that prices offered will follow the distribution $F(p)$. If the contact frequency λ tends to infinity, such that each buyer observes all prices offered, the prices will approach the Bertrand equilibrium: The lower support tends to c, and $F(p) = 1$ for all $p > c$, all sellers would price at marginal cost.

2.2 The price posting decision

Sellers choose their price posting scope k_j without taking into account their individual effect on the contact frequency λ, as the sum of all sellers' price posting scopes is large enough to make this effect negligible. Inserting the equilibrium price offer distribution (4) and purchase probability (3) into seller j's expected profits (1)[1] and maximizing with respect to k_j gives

$$e^{-\lambda}(\bar{p}-c) = \frac{v'(k_j/n)}{n}. \tag{5}$$

All sellers will choose the same price posting scope, $k_j = k$ for $j = 1, 2, ..m$, because any price on the support of $F(p)$ gives the same expected markup, making the value of reaching an additional buyer identical for all sellers. The contact frequency simplifies to $\lambda = km/n$.

2.3 The free entry condition

New sellers will enter until each seller has expected profit of zero. Entry increases the contact frequency λ, lowering the expected markup and forcing each seller to reduce her price posting campaign. The process continues until the average cost of price posting equals expected markup. Setting expected profits (1) to zero gives exactly this condition:

$$e^{-\lambda}(\bar{p}-c)k = v(k/n) + f_v. \tag{6}$$

Combining this zero profit condition with the optimality condition for k (5), one gets

Lemma 1: Price posting scope under free entry

$$k/n = \frac{v(k/n) + f_v}{v'(k/n)} \tag{7}$$

Under free entry, (k/n) must be at the level where average cost of price posting is minimized, this happens where marginal price posting costs equals average price posting costs. The

[1] $Q(p)(p-c) = e^{-\lambda F(p)}(p-c) = e^{-\lambda}(\bar{p}-c)$

fraction of buyers reached by the individual seller is therefore determined uniquely by price posting technology.

With the price posting scope determined in Lemma 1, the contact frequency λ that prevails under free entry may be found from (5) as

$$\lambda = \ln \left(\frac{n(\bar{p} - c)}{v'(k/n)} \right). \tag{8}$$

and since $\lambda = mk/n$, the number of sellers under free entry is

$$m = \frac{n}{k} \ln \left(\frac{n(\bar{p} - c)}{v'(k/n)} \right). \tag{9}$$

In markets with more buyers, the contact frequency will be higher. As each seller has a lower risk of hitting the same buyer twice with the price posting campaign, she is able to reach more buyers at the same cost when the market is larger. Larger markets will also attract more sellers.

The contact frequency will be higher the less price posting the individual seller does. The reason is the convexity of $v(k/n)$: One seller spending a given amount of advertising will reach fewer buyers than two sellers spending the same amount. From (7), k/n will be lower with a lower fixed cost of price posting.

The benefit to buyers from a lower contact frequency is twofold: Each buyer has on average more offers to select among, and the proposed prices are stochastically lower. Welfare in the economy consists of the consumer surplus (or "buyer surplus") accruing to buyers that pay less than their reservation price $\bar{p}$; sellers earn no profits. Buyers receiving no offers are equivalent to buyers paying $\bar{p}$. By the law of large numbers, welfare, W, will be:

$$W = n[\bar{p} - E_b(p)],$$

where $E_b(p)$ is the price each buyer can expect to pay ex ante, before any price posting takes place.

In appendix A, it is shown that $E_b(p) = c + e^{-\lambda}(\bar{p} - c)(\lambda + 1)$.

Propostition 2: Welfare and the intransparency loss

$$W = n(\bar{p} - c)\left(1 - e^{-\lambda}(\lambda + 1)\right). \tag{10}$$

Welfare is the Bertrand welfare level $n(\bar{p} - c)$ scaled down by an "intransparency loss" $\left(1 - e^{-\lambda}(\lambda + 1)\right) \in (0, 1)$, representing how much revenue sellers can earn on buyers' lack of information. An increase in the contact frequency will push welfare towards the Bertrand benchmark.

Before opening the economy, two remarks to the closed economy model are worth making. The first concerns arbitrage: Even though there is price dispersion in the economy, there is no room for arbitrage: A third party, buying the good at a price $p' > c$ with the purpose of resale would face the same information problem as the sellers and would have to perform price posting on his own. This third party would effectively correspond to a seller producing at higher marginal cost, thus being unprofitable relative to entering as a seller.

The second remark is the model's strong resemblance to the predictions of Melitz and Ottaviano (2008), although the mechanisms are rather different: The model generates a pseudo-heterogeneity among sellers which is observationally equivalent to firms having different marginal costs and thus different price/quantity choices: As sellers in the present model randomize their prices, they appear different, although they share excactly the same characteristics. In one extreme, a seller sets a price of $\bar{p}$ and sells an expected quantity of $e^{-\lambda}k$, the other extreme is a seller setting a price of $e^{-\lambda}\bar{p} + \left(1 - e^{-\lambda}\right) c$ selling expected quantity of k. Moreover, larger markets attract more sellers, and mark-ups are (stochastically) lower.

I now proceed to opening the economy.

3 Opening the Economy

The main insights of the model are more clearly exposed in a two-country world, but the model can be generalized to any number of countries. Consider two countries Home (H) and Foreign (F), each country having an industry with sellers and buyers of the type described in section 2. A country has n^l buyers, $l = H, F$, all with common reservation price $\bar{p}$.

In addition to communicating their offers to domestic buyers, the m^l sellers may now choose to contact buyers abroad as well. The cost of posting prices abroad for a seller located in country l is described by the function $v_x(k_x^l/n^h)$, where k_x^l is the number of foreign buyers in country h reached by the campaign (superscript h indicates "the other country", $h = L, F$ and $h \neq l$. Subscript x signifies the foreign market from the seller's perspective, "export variables"). As for domestic price posting costs, $v_x'(k_x^l/n^h) > 0$, $v_x''(k_x/n^h) > 0$ and $v_x(k_x^l/n^h) \to \infty$ as $k_x^l \to n^h$.

Cultural and language barriers, along with geographic distance make price posting abroad relatively more expensive: for any k/n, $v_x(k/n) > v(k/n)$. Because a given campaign costs more on the export market, but faces a similar risk of reaching the same buyer several times, export price posting costs rise faster than their domestic counterpart: $v_x'(k/n) > v'(k/n)$ for any k/n. However, a seller can use some common resources for the common and domestic price posting campaigns, any fixed cost of launching price posting abroad is lower than f_v, $v_x(1/n^h) < f_v$.

A seller in country l has expected profit of:

$$\pi(p, k^l, p_x, k_x^l) = Q^l\left(p\right)\left(p - c\right)k^l + Q^h\left(p_x\right)\left(p_x - c\right)k_x^l - v(k^l/n^l) - v_x(k_x^l/n^h) - f_v \tag{11}$$

The pricing behavior of sellers carries over from the closed economy:

Proposition 3: Pricing in the open economy

All sellers making offers in country l, both domestic and exporters from country h, will randomize over the same price offer distribution, $F^l(p)$, given by

$$F^l(p) = 1 - \frac{1}{\lambda^l}\ln\left(\frac{\bar{p} - c}{p - c}\right). \tag{12}$$

with support $\left[\left(\exp\left(-\lambda^l\right)\bar{p}+\left(1-\exp\left(-\lambda^l\right)\right)c\right),\bar{p}\right]$.

The proof goes as follows: The purchase probability for a given price is the same whether the good is offered by an exporter or a domestic seller, and the upper bound on the equilibrium price offer distribution is equal to $\bar{p}$ for both domestic sellers and exporters. The condition that any price on the support of the equilibrium price offer distribution must give the same profit as offering $\bar{p}$, reduces to

$$\exp\left(-\lambda^h F^h\left(p_x\right)\right)\left(p_x-c\right)k_x^l=\exp\left(-\lambda^h\right)\left(\bar{p}-c\right)k_x^l \tag{13}$$

for exporters from h, and to

$$\exp\left(-\lambda^h F^h\left(p\right)\right)\left(p-c\right)k^h=\exp\left(-\lambda^h\right)\left(\bar{p}-c\right)k^h$$

for domestic sellers in l. These two conditions both lead to (12).

The domestic and export price posting scopes are set to maximize (11). A seller in l thus sets her domestic price posting scope k^l to satisfy

$$\frac{v'(k^l/n^l)}{n^l}=\exp\left(-\lambda^l\right)\left(\bar{p}-c\right), \tag{14}$$

whereas the export price posting scope k_x^l satisfies

$$\frac{v_x'(k_x^l/n^h)}{n^h}=\exp\left(-\lambda^h\right)\left(\bar{p}-c\right); \tag{15}$$

the expected markups have been inserted in both expressions. It follows that all sellers in l choose the same values for k^l and k_x^l. The two equations hold for each country, using this one gets

$$v'\left(k^l/n^l\right)=v_x'\left(k_x^h/n^l\right), \tag{16}$$

which implies that $k^l>k_x^h$: A domestic seller reaches more consumers with her price posting campaign than a foreign seller.

With price posting scopes being equal across sellers, the contact frequency λ^l for the open economy can be expressed as:

$$\lambda^l=\frac{k^l m^l+k_x^h m^h}{n^l}. \tag{17}$$

Comparing with the closed economy contact frequency of $\lambda=km/n$, it is not yet clear whether opening the economy will increase λ. It may be that the import competition causes domestic sellers to contract their price posting expenditures or exit to such a degree that the net effect on λ is a decrease.

3.1 The free entry equilibrium

As for the closed economy, free entry implies that sellers must have expected profits equal to zero:

$$\exp(-\lambda^l)\left(\bar{p}-c\right)k^l+\exp(-\lambda^h)\left(\bar{p}-c\right)k_x^l=v(k^l)+v_x(k_x^l)+f_v \tag{18}$$

The zero profit condition, combined with the optimality conditions for price posting scopes, (14) and (15), gives a relation between a seller's domestic and export price posting scopes:

$$\left(k^l/n^l\right)=\frac{v(k^l/n^l)+f_v+\left(v_x(k_x^l/n^h)-v_x'(k_x^l/n^h)\left(k_x^l/n^h\right)\right)}{v'(k^l/n^l)}. \tag{19}$$

By the convexity of $v_x(k_x^l/n^h)$, the term $v_x(k_x^l/n^h) - v_x'(k_x^l/n^h)\left(k_x^l/n^h\right)$ is negative, so, comparing to (7), k^l/n^l decreases when the economy is opened. Sellers reallocate resources from domestic to export price posting and reach fewer buyers on the domestic market. Lemma 2 summarizes the properties of the domestic and export price posting scopes:

Lemma 2: Open economy price posting scopes

The equilibrium price posting scopes under free entry are uniquely determined by (16) and (19) holding in both countries, as these four equations define four monotonous one-for-one relationships in the four variables $\left(k^H, k_x^H, k^F, k_x^F\right)$.From (19), the fraction of domestic buyers reached by each individual seller is lower in the open economy. From (16), $k^l < k_x^h$, a domestic seller still reaches more buyers in market l than do sellers exporting from h.

With k^l determined, again by price posting technology only, but in a more complicated manner, the equilibrium contact frequency under free entry can be found from (14):

Proposition 4: Trade and the contact frequency

In the open economy, the contact frequency that prevails under free entry is given by

$$\lambda^l = \ln\left(\frac{n^l(\bar{p}-c)}{v'(k^l/n^l)}\right). \tag{20}$$

Since k^l is lower in the open economy and v is convex, the contact frequency is higher in the open economy. The increased contact frequency implies that price offers are stochastically lower in the open economy – (4) stochastically dominates (12) – and that the lower price bound is closer to c.

Because the export market presents a whole new set of buyers to the seller, with initially no risk of hitting the same buyer twice, export price posting is on the margin both more efficient and more profitable. When sellers in both countries reduce their domestic price posting to finance export price posting, the net effect (in both countries) is therefore an increase in λ^l. As buyers on average receive more offers, sellers reduce prices. The expected mark-up of setting a high price falls, since the buyer is now more likely to have received an offer with a lower price.

The equilibrium number of sellers can be found by combining (17) and (20) and solving the two equations ($l = H, F$) for m^l:

$$m^l = \frac{1}{k^l k^h - k_x^l k_x^h}\left[k^h n^l \ln\left(\frac{n^l(\bar{p}-c)}{v'(k^l/n^l)}\right) - k_x^h n^h \ln\left(\frac{n^h(\bar{p}-c)}{v'(k^h/n^h)}\right)\right]. \tag{21}$$

Comparing with (9), it is ambiguous whether the number of sellers falls or increases when the economies are opened. Import competition tends to squeeze sellers out, but it may be that the domestic price posting expenditure falls sufficiently to allow the number of sellers to increase in both countries. In itself, the number of sellers has no implications for welfare, what matters is the total number of buyers reached by their price posting campaigns.

All sellers expect the same profit on the export market, but sellers setting higher export prices export less in expected terms and are more likely not to carry out any export sales at all.

3.2 Welfare and Trade

Welfare in the open economy is found by replacing the relevant terms in (10) by their open economy counterparts.

Corollary of proposition 4: Welfare gains from opening the economy.

Welfare in the open economy is given by

$$W^l = n^l \left(\bar{p} - c\right) \left(1 - \exp(-\lambda^l) \left(\lambda^l + 1\right)\right). \tag{22}$$

The increased contact frequency leads to higher welfare in the open economy. The intransparency loss, $\left(1 - \exp(-\lambda^l) \left(\lambda^l + 1\right)\right)$, is reduced, raising welfare towards the Bertrand level $n^l \left(\bar{p} - c\right)$.

The welfare gain from the increased contact frequency is twofold: Buyers benefit both from having more offers to select among and from the lower prices now offered. To quantify this welfare gain, Figure 1 depicts the intransparency loss $\left(1 - \exp(-\lambda^l) \left(\lambda^l + 1\right)\right)$ as a function of the contact frequency λ^l. The impact of international trade on welfare may be substantual, if the closed economy value of λ^l is small. On the other hand, welfare cannot rise over the Bertrand level. If buyers are already reached by many sellers prior to the opening of trade, the welfare gain is negligible. Since economies with fewer buyers have lower contact frequencies (from (8)), small economies will benefit more from trade.

Figure 1 about here

Trade may be facilitated through lower cost of price posting abroad, represented by a downward shift in $v_x(k_x^l/n^h)$. There are two effects of such a shift, they can be thought of as substitution and income effects. The substitution effect arises when sellers shift expenditure from domestic to export price posting, financing an increase in $\left(k_x^l/n^h\right)$ with a decrease in $\left(k^l/n^l\right)$. From (15), this effect occurs only if the marginal cost of price posting falls when $v_x(k_x^l/n^h)$ shifts down. The income effect arises because each seller has lower total costs.when export price posting is cheaper. Entry of new sellers will drive profits back to zero again, and this forces the individual seller to reduce her price posting, $\left(k^l/n^l\right)$ falls.[2] Both the income and substitution effects hence decreases k^l/n^l, and by proposition 4, the net implication is an increase in λ^l and therefore welfare gains.

It is plausible that in countries sharing the same language or having similar cultures, foreign price posting costs v_x will be closer to domestic costs v, and therefore trade and the gains thereof will be higher. The analysis of this paper thus presents an explicit channel for the well-known empirical result that countries with similar languages trade more.

The IT revolution of the last two decades has presented a cheap price posting device for sellers, which does not require any physical proximity to buyers. In terms of the model, the ascent of the internet represents a reduction in both v and v_x. with the reduction in v_x likely being more pronounced. Im-

[2] In (19), the income effect is the decrease in $v_x\left(k_x^l/n^h\right)$ for unchanged k_x^l/n^h, the substitution effect is the effect of the increase in k_x^l/n^h. Both lead to a decrease on the right hand side of the equation, and k^l/n^l must therefore fall.

proved information technology thus has important implications in markets where buyers have incomplete information. It raises welfare and is likely to promote international trade.

Some markets, however, have centralized exchange mechanisms that ensures full information to buyers. The most striking examples are the futures exchanges that exist for many commodities such as unprocessed metals and the main crops. The model presented here gives a rationale for why buyers would want to set up these kinds of institutions to avoid the intransparency loss associated with incomplete information.

4 Conclusion

I have presented a model that demonstrates how informational frictions may play an important role in international trade. Sellers face costs of communicating their offers to buyers, and risk wasting resources on contacting the same buyer multiple times. In equilibrium, sellers randomize their price offers over a continuous distribution, there is no single market clearing price.

Posting prices in two markets separately diminishes the risk of contacting the same buyer twice, and so the informational friction turns out to be a driver of international trade. Were it not costly for sellers to communicate their offers to buyers, the model would revert to a Bertrand equilibrium with no need for trade between countries. By giving buyers more offers to select among and pushing the price distribution down, international trade mitigates the problem of incomplete information and increases welfare. An interesting additional feature of the model is that it replicates many predictions of models with heterogeneous firms, even though sellers are initially identical.

Due to its link between the ease of diffusing information and trade, the model gives an explicit channel for why countries with similar languages trade more, and shows how improved information technology may boost international trade in final goods.

Appendix A:

Proof of propositon 1:

Continuity of $F(p)$ implies that the distribution has no mass points. Therefore, there is no pure strategy equilibrium where all sellers offer the same price. To see this, first observe that if all sellers offer the same price, the probability q that a buyer accepts the seller's offer among x other offers is

$$q = \sum_{i=0}^{\infty} \left(\frac{1}{1+x} \right) \frac{e^{-\lambda} \lambda^x}{x!} = \frac{1}{\lambda} \sum_{i=0}^{\infty} \frac{e^{-\lambda} \lambda^{x+1}}{(x+1)!} = \frac{1}{\lambda} \sum_{i=1}^{\infty} \frac{e^{-\lambda} \lambda^x}{x!} = \frac{1-e^{-\lambda}}{\lambda} < 1$$

Therefore, a seller can do strictly better by decreasing its price with ε and being certain that its offer is accepted, $k(p-\varepsilon-c) > kq(p-c)$ for ε sufficiently small. If all firms were to offer $p=c$, one firm could instead offer $p=\hat{p}$ and earn positive expected profits, since the probability that this is the only offer a consumer receives is $e^{-\lambda} > 0$.

A similar argument rules out any equilibrium where some strictly positive fraction of sellers set the same price, establishing continuity of $F(p)$. Connectedness follows from the fact that a gap, say between p and p'', with $p' < p''$, would lead to the contradition $\pi(p, F(p)) > \pi(p', F(p'))$ for all $p \in (p', p'']$, since $F(p') = F(p'')$.

The upper support must be equal to $\bar{p}$: if a seller is certain that no higher price will be posted, she can only sell the good if the buyer receives no other offer. If a buyer receives no other offer, the seller earns the most by offering $p = \bar{p}$: $\arg\max_{p \leq \bar{p}} \pi(p, 1) = \arg\max_{p \leq \bar{p}} ke^{-\lambda}(p-c) = \bar{p}$.

It is never profitable to offer a price lower than c.

***

Calculating $E_b(p)$, the expected price that buyers pay:

The purchase probability, $Q(p)$, calculated in (3) denotes the probability that all offers that a buyer receives have prices equal to or greater than p. The complimentary event, that at least one price is lower than p has probability

$$\Pr(\text{at least one offer has price lower than } p) = 1 - Q(p) = 1 - e^{-\lambda \frac{\bar{p}-c}{p-c}}.$$

The probability of receiving no offer is equal to $e^{-\lambda}$.

If the buyer has received an offer lower than p, it means that the price he paid for the good, call it p_{paid}, is no lower than p:

$$\Pr(p_{paid} \leq p) = 1 - e^{-\lambda \frac{\bar{p}-c}{p-c}}$$

This probability gives the cumulative distribution of the price buyers pay, call it $F_b(p)$:

$$F_b(p) = 1 - e^{-\lambda \frac{\bar{p}-c}{p-c}}$$

As buyers getting no offers receive no buyer surplus and therefore in welfare terms are equivalent to buyers paying $\bar{p}$, the cumulative distribution has mass point $\Pr(P = \bar{p}) = e^{-\lambda}$. The corresponding density is given by

$$f_b(p) = e^{-\lambda}(\bar{p} - c)\frac{1}{(p-c)^2}, \text{ and } f_b(\bar{p}) = e^{-\lambda}.$$

$E_b(p)$ can now be computed:

$$\begin{aligned} E_b(p) &= \int_{e^{-\lambda}\bar{p}+(1-e^{-\lambda})c}^{\bar{p}} p f_b(p)\, dp + e^{-\lambda}\bar{p} \\ &= e^{-\lambda}(\bar{p} - c) \int_{e^{-\lambda}\bar{p}+(1-e^{-\lambda})c}^{\bar{p}} \frac{p}{(p-c)^2} dp + e^{-\lambda}\bar{p} \end{aligned}$$

Integrating by parts gives:

$$\begin{aligned} E_b(p) &= e^{-\lambda}(\bar{p} - c)\left[\frac{-\bar{p}}{\bar{p}-c} - \left(e^{-\lambda}\bar{p} + \left(1 - e^{-\lambda}\right)c\right)\frac{(-1)}{e^{-\lambda}(\bar{p}-c)} - \int_{e^{-\lambda}\bar{p}+(1-e^{-\lambda})c}^{\bar{p}} \frac{(-1)}{(p-c)} dp\right] + e^{-\lambda}\bar{p} \\ &= e^{-\lambda}\bar{p} + \left(1 - e^{-\lambda}\right)c - e^{-\lambda}\bar{p} + e^{-\lambda}(\bar{p} - c)\left[\ln(\bar{p} - c) - \ln(e^{-\lambda}(\bar{p} - c)\right] + e^{-\lambda}\bar{p} \\ &= \left(1 - e^{-\lambda}\right)c + e^{-\lambda}\bar{p} + \lambda e^{-\lambda}(\bar{p} - c) \\ &= c + e^{-\lambda}(\bar{p} - c)(\lambda + 1) \end{aligned}$$

Figures

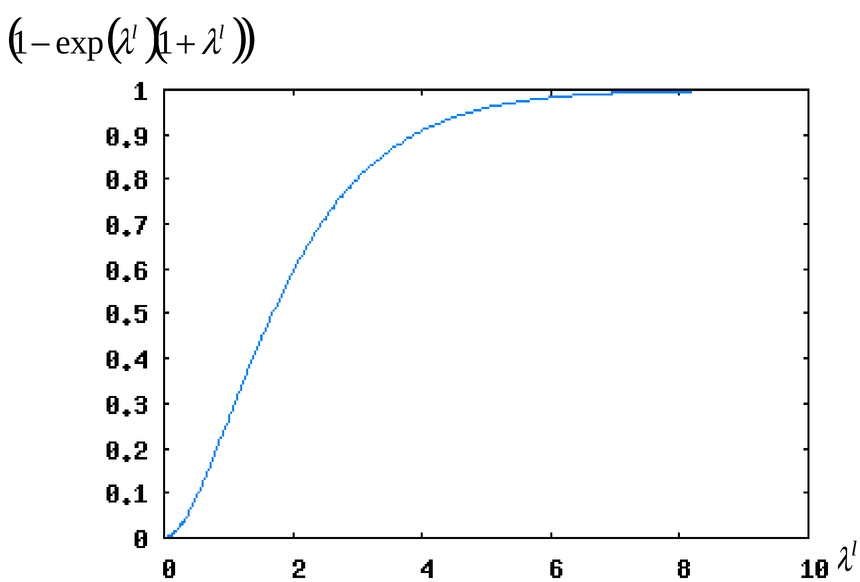

Figure 1: The intransparency loss

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