Intransparent Markets and Intra-Industry Trade[*]

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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 market intransparency. Sellers must communicate their offers through costly advertising, but cannot reach all buyers. Consequently, no market clearing price exists, and sellers randomize over an equilibrium price distribution. Letting sellers advertise their offers abroad leads to international trade, which would not take place under complete information. Buyers then receive more offers, leading to lower prices and welfare gains. Sellers in the model are identical, but appear heterogeneous due to their price randomization. In larger and more open economies, prices and markups will be lower, and exports are primarily realized by sellers who charge low prices. These predictions are similar to those of trade models where firm heterogeneity is assumed exogenously.

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

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1 Introduction

Information costs have long been thought to matter for international trade flows. Stylized facts of modern trade, such as the consistent findings of significantly higher trade flows between countries with a common language and the trade-promoting effect of ethnic networks, strongly support the hypothesis. To date, however, theoretical treatments have been sparse. Against this background, Anderson and Van Wincoop (2004, p720) conclude their review of the literature on information costs by stating that "More careful modeling of the underlying information costs in future work will probably be illuminating."

This paper takes up the task. The point of departure is the observation that many real world markets are "intransparent": The information necessary to carry out an exchange, such as who sells, what price these sellers charge and what the quality offered is, will not automatically reach buyers. Rather, sellers spend considerable resources on advertising their goods. Modeling intransparent markets and the associated advertising costs uncovers intricate interactions between international trade and information costs. For example, in the model, the motive for intra-industry trade is generated by advertising costs – if information could diffuse costlessly, entering a foreign market would not be profitable.

Moreover, the analysis offers a new perspective on the role of firm heterogeneity, which has been a key issue in international trade since the seminal paper by Melitz (2003). When markets are intransparent, different pricing strategies are equally profitable. Even though sellers are identical, some will sell many units at low prices, others will charge high prices and sell fewer units. The pattern is similar to the one generated in Melitz (2003) by differences in productivities across firms, as are the effects of international trade on sector composition. The novel hypothesis offered by this paper is that some of the heterogeneity and variations in international activity observed in the firm-level data may stem from similar firms following different strategies.

I construct a model with two types of agents, buyers, who demand one unit of a good, and sellers, who produce it. Buyers are initially unaware of the characteristics of offers, and sellers must therefore advertise their offers. For expositional clarity, the focus is on homogeneous goods, where advertisement reduces to price posting. In this interpretation, the model is intended to describe industries where goods are relatively cheap, and where most buyers are primarily sensitive to price.[1] Relatively cheap goods imply that any gains for buyers of actively searching for offers, rather than passively evaluating offers received, are likely to be outweighed by time costs.

The setup for the closed economy is adapted from the wage posting model of Mortensen (1990, 2003). Sellers' advertising technology is similar to the seminal 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

[1] A few examples could be kitchen utensils, detergents, basic office equipment, and also copyrighted goods with multiple sellers, such as a particular book or recorded piece of music. As outlined in section 4, the modeling approach generalizes to quality-adjusted prices of non-homogeneous goods, where advertisement must transmit more information than the price. With this reinterpretation, the model covers any industry where goods are not tailored to fit individual buyers' particular tastes or needs.

space. Even if sellers to some degree can segment buyers, this form of advertising inherently has some randomness to it. As a consequence, if there are many buyers, it becomes too expensive for the individual seller to reach them all. The randomness in advertising also leads to an ex post heterogeneity among buyers: Some buyers receive offers from multiple sellers and can select the best one, others receive no offer at 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. The price dispersion is sustained by unfortunate buyers, who, upon receiving only one expensive offer, have no better option for purchase.

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 advertising campaign. The net implication of international trade is an increase in the average number of offers 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 Bertrand equilibrium already.

Associated with the information costs is therefore a new gain from international trade, a transparency gain: Buyers gain from receiving more information and from the subsequent intensified price competition. The closest parallel in the trade literature is the gain from trade put forward by the Cournot models of Brander (1981) and Brander and Krugman (1983), where welfare gains arise from the strategic responses of firms when the economy is opened.

International advertisement is likely to be easier between countries that share languages. Lower costs of export advertising will enable sellers to export more, the model thus presents an explicit channel for the well-established result that countries with shared languages trade more, see Melitz (2008) for a detailed empirical treatment.

Price dispersion, even for homogeneous goods or within specific brands, is a consistent finding in economics. It has been documented empirically by, among others, Stigler (1961) and Pratt, Wire and Zeckhauser (1979); Clay et al. (2001) and Feenstra and Shapiro (2003) document that the phenomenon has not disappeared in the internet age. A rich theoretical literature has put forward different explanations for how price dispersion may occur, Butters (1977) and Burdett and Judd (1983) are seminal papers, see Baye, Morgan and Scholten (2006) for a recent review.

The result that information costs may encourage international trade differs markedly from Arkolarkis (2008), which to my knowledge is the only other paper modeling information costs of international trade explicitly. Arkolakis (2008) shares a building block with this paper, advertisement costs in line with Butters (1977). The crucial difference is specification of demand; Arkolakis (2008) builds on a loveof-variety model. To draw lines sharply: Suppose a buyer receives advertisement about five different tumble-driers. In Arkolakis (2008), the buyer would purchase all five, in this paper the buyer selects the best of the five offers.

The next section sets up the model for the closed economy, the economy is opened in section three. Section four features a discussion of the model's predictions and how they may be tested, along with extensions to quality differences and additional forms of trade costs. Concluding remarks follow in the final section.

2 The Closed Economy

There are n buyers, m sellers and one homogenous good. Buyers can either be thought of as consumers, or as firms wishing to buy an intermediate input. They each demand one unit of the good and have common reservation price of $\bar{p}$. Sellers produce the good at marginal cost c, with $c < \bar{p}$. Initially, buyers do not know individual sellers nor the prices they are charging for the good, and they are therefore unable to make a purchase. Sellers must inform buyers of their offers through advertising. The good is homogenous, and so the only information buyers need is the price; advertising therefore reduces to price posting. Throughout the analysis m and n are assumed to be large, there are many buyers and sellers.

The costs of price posting fall into two parts. There is a fixed cost, f_v, of employing the relevant people and have them design the advertising 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 wasted on reaching the same buyer twice, $v'(k/n) > 0$ and $v''(k/n) > 0$. In the end, reaching all other buyers becomes unprofitable:

$$\lim_{k \longrightarrow n} \frac{v'(k/n)}{n} > (\bar{p} - c),$$

the cost of reaching the last buyer is higher than what the seller could potentially earn.[2]

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. Buyers can only buy offers they learn about, and actively searching for goods is assumed to be too costly.[3]

[2] The price posting technology does not have to be completely random. The modeling is consistent with sellers splitting buyers into segments and advertising to some segments only. Buyers are homogenous, however: Sellers' choices of which segments to target are uncorrelated.

[3] A sufficient condition to rule out buyer search is that the expected cost of finding an offer through search is higher than

2.1 Price Randomization

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

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

where $Q(p)$ denotes the probability that a buyer purchases the good when the seller charges price p.

Prior to finding the sellers' optimal strategies for pricing and contacting buyers, it is helpful to consider what the equilibrium must look like. Let $F(p)$ denote the cumulative distribution of prices offered by sellers. In equilibrium The following characteristic will then hold:

Proposition 1: Price dispersion (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 equilibrium 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 $p = \bar{p}$: the probability that the buyer gets no other offer is positive, since no seller contacts all buyers.

That the upper bound of the distribution must be $\bar{p}$ is also quite apparent: If a seller is charging the highest price, she can only make a sale if the buyer gets no other offer. Given that the buyer gets no other offer, she might as well charge him $\bar{p}$.

Maximization of (1) with respect to p_j and k_j leads to the first order conditions:

$$Q'(p_j)(p_j - c) = Q(p_j) \tag{2}$$

$$\text{and } Q(p_j)(p_j - c) = v'(k_j/n). \tag{3}$$

In Appendix A, it is shown that all sellers will contact the same number of buyers, $k_j = k$, independently of the prices they are charging. This symmetry in price posting simplifies the derivation of the mixed strategy equilibrium in prices. All prices offered must give the same expected profits, $\pi(p, k) = \pi(\bar{p}, k)$, or

$$Q(p)(p - c) = Q(\bar{p})(\bar{p} - c). \tag{4}$$

To derive $Q(p)$, consider the number of offers a buyer receives, call it X. Buyers are targeted at random, and so X must be binomially distributed: The probability of being hit by a given seller j is k/n (for all j), and there are m sellers making contacts, which gives us the two parameters of the binomial distribution. The expected number of offers a buyer receives will be their product, $\bar{X} = mk/n$. When m

$\bar{p} - c$. This condition is more likely to hold for relatively cheap goods. See also the discussion in footnote 5.

and n are large (and k/n therefore small), the distribution of X can be well approximated by the Poisson distribution:

$$\Pr(X = x) = \frac{e^{-\lambda}\lambda^x}{x!}, \qquad \text{where } \lambda = \frac{mk}{n}. \tag{5}$$

The poison parameter λ will be key to the model's results. It is equal to the expected number of offers a buyer receives, and as will be shown shortly changes in λ will shift the distribution of prices. I will hereafter refer to λ as the contact frequency.

As hinted in the reasoning behind proposition 1, there are two forces governing sellers' choice of price. The incentive to raise the price and earn a high mark-up, hoping that the buyer does not get a better offer, and the incentive to lower the price, increasing the probability of undercutting the other offers that a buyer receives. The equilibrium distribution of prices offered, $F(p)$, is the distribution where these two incentives cancel each other out. 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

$$Q(p) = \sum_{x=0}^{\infty} [1 - F(p)]^x \frac{e^{-\lambda}\lambda^x}{x!} = e^{-\lambda F(p)} \sum_{x=0}^{\infty} \frac{e^{-\lambda[1-F(p)]} \left(\lambda [1 - F(p)]\right)^x}{x!} = e^{-\lambda F(p)}. \tag{6}$$

Inserting (6) in (4) and using that $F(\bar{p}) = 1$ gives the distribution of prices that is consistent with sellers earning the same profits:

$$\begin{aligned} e^{-\lambda F(p)} (p - c) &= e^{-\lambda} (\bar{p} - c) \\ \iff F(p) &= 1 - \frac{1}{\lambda} \ln\left(\frac{\bar{p} - c}{p - c}\right) \end{aligned} \tag{7}$$

$F(p)$ has 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, 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.[4] The price distribution is plotted in Figure 1 for two different values of λ.

Figure 1 about here

The more offers buyers learn about on average (higher λ), the more the incentive for sellers to undercut other offers will dominate, and prices will be lower stochastically. As long as there is a positive probability that some buyers only know one offer ex post, price dispersion can exist in equilibrium, even though the good is homogeneous. Buyers accepting unfavorable offers do not irrationally perceive these as superior, they simply do not know of any better offers.[5]

[4] 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, which is unprofitable relative to entering as a seller.

[5] Butters (1977) provides a discussion of allowing for buyer search in a related framework. If search is not too costly, buyers will search if the offers they receive are all priced above a certain threshold $\tilde{p}$. This will lead sellers never to price above $\tilde{p}$, the equlibrium now holding with $\tilde{p}$ replacing the reservation price.

The price dispersion implies a "pseudo-heterogeneity" among sellers. 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. Observationally, this pattern is equivalent to the one generated in Melitz (2003) by differences in productivities.

With the price distribution determined, the optimal number of contacts follows from the first order condition (3). As any price offered gives the same expected mark-up, this condition reduces to

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

2.2 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:

$$e^{-\lambda} \left(\bar{p} - c\right) k = v(k/n) + f_v. \tag{9}$$

Combining this zero profit condition with the optimality condition for k, (8), one gets

Lemma 1: Buyers contacted under free entry

$$k/n = \frac{v(k/n) + f_v}{v'(k/n)} \tag{10}$$

Under free entry, (k/n) must be at the level where the average cost of price posting is minimized, this happens where the marginal price posting cost equals the average price posting cost. The 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 (8) as

$$\lambda = \ln\left(\frac{n\left(\bar{p} - c\right)}{v'(k/n)}\right). \tag{11}$$

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

$$m = \frac{n}{k} \ln\left(\frac{n\left(\bar{p} - c\right)}{v'(k/n)}\right). \tag{12}$$

In markets with more buyers, the contact frequency will be higher. As a 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. With a higher contact frequency, lower prices and mark-ups follow (stochastically), and larger markets will also attract more sellers. These effects of a larger market size resemble those of Melitz and Ottaviano (2008).

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 (10), 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 in expected terms. Buyers receiving no offers are equivalent to buyers paying $\bar{p}$. By the law of large numbers, welfare, W, will be:

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

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 $E_b(p) = c + e^{-\lambda}(\bar{p} - c)(\lambda + 1)$.

Proposition 2: Welfare and the intransparency loss

$$W = n(\bar{p} - c)\left(1 - e^{-\lambda}(\lambda + 1)\right). \qquad (13)$$

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

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"). Similarly to domestic price posting costs, $v_x'(k_x^l/n^h) > 0$, $v_x''(k_x/n^h) > 0$ and

$$\lim_{k_x^l \longrightarrow n^h} v_x(k_x^l/n^h) > \bar{p} - c.$$

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 scope 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. There may be a fixed cost of translating, modifying and launching the price posting campaign abroad, but it is lower than f_v, i.e. $v_x(1/n^h) < f_v$.[6]

A seller in country l has expected profit of:

$$\pi(p, k^l, p_x, k_x^l) = Q^l(p)(p-c)k^l + Q^h(p_x)(p_x - c)k_x^l - v(k^l/n^l) - v_x(k_x^l/n^h) - f_v \tag{14}$$

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

$$F^l(p) = 1 - \frac{1}{\lambda^l}\ln\left(\frac{\bar{p}-c}{p-c}\right). \tag{15}$$

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

$$\exp\left(-\lambda^l F^l(p_x)\right)(p_x - c)k_x^h = \exp\left(-\lambda^l\right)(\bar{p}-c)k_x^h \tag{16}$$

for exporters from h, and to

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

for domestic sellers in l. These two conditions both lead to (15).

The domestic and export price posting scopes are set to maximize (14). A seller in l thus sets her domestic price posting scope k^l to satisfy

$$\frac{v'(k^l/n^l)}{n^l} = \exp\left(-\lambda^l\right)(\bar{p}-c), \tag{17}$$

whereas the export price posting scope k_x^l satisfies

[6] Introducing additional per-unit trade costs into the model is possible, but cumbersome. For clarity, they are left out. A discussion is provided in section 4.

$$\frac{v_x'(k_x^l/n^h)}{n^h} = \exp\left(-\lambda^h\right)(\bar{p} - c)\,; \tag{18}$$

the expected markups have been inserted in both expressions. It follows that the values for k^l and k_x^l do not vary across sellers in l. Equations (17) and (18) hold for each country, using this, one gets

$$v'\left(k^l/n^l\right) = v_x'\left(k_x^h/n^l\right), \tag{19}$$

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:

$$\lambda^l = \frac{k^l m^l + k_x^h m^h}{n^l}. \tag{20}$$

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:

$$\exp(-\lambda^l)\,(\bar{p} - c)\,k^l + \exp(-\lambda^h)\,(\bar{p} - c)\,k_x^l = v(k^l) + v_x(k_x^l) + f_v \tag{21}$$

The zero profit condition, combined with the optimality conditions for price posting scopes, (17) and (18), gives a relation between a seller's domestic and export price posting scopes:

$$\left(k^l/n^l\right) = \frac{v(k^l/n^l) + f_v + \left(v_x(k_x^l/n^h) - v_x'(k_x^l/n^h)\left(k_x^l/n^h\right)\right)}{v'(k^l/n^l)}. \tag{22}$$

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 (10), 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 (19) and (22) 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 (22), the fraction of domestic buyers reached by each individual seller is lower in the open economy. From (19), $k^l < k_x^h$, 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 (17):

Proposition 4: Trade and the contact frequency

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

$$\lambda^l = \ln\left(\frac{n^l\,(\bar{p}-c)}{v'(k^l/n^l)}\right). \tag{23}$$

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 – (7) stochastically dominates (15) – 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. Although the mechanism is different, this outcome is similar to how opening the economy squeezes out unproductive firms in trade models with heterogeneous firms.

The equilibrium number of sellers can be found by combining (20) and (23) and solving the two equations ($l = H, F$) for m^l:

$$m^l = \frac{1}{k^l k^h - k_x^l k_x^h}\left[k^h n^l \ln\left(\frac{n^l\,(\bar{p}-c)}{v'(k^l/n^l)}\right) - k_x^h n^h \ln\left(\frac{n^h\,(\bar{p}-c)}{v'(k^h/n^h)}\right)\right]. \tag{24}$$

Comparing with (12), 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.

Sellers all 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 Trade and Welfare

Welfare in the open economy is found by replacing the relevant terms in (13) by their open economy counterparts.

Corollary of proposition 4: Gains from trade

Welfare in the open economy is given by

$$W^l = n^l\,(\bar{p}-c)\left(1 - \exp(-\lambda^l)\left(\lambda^l + 1\right)\right). \tag{25}$$

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

The rise in welfare from the increased contact frequency captures two effects: Buyers benefit both from having more offers to select among (increase in λ^l) and from the lower prices now offered (downward shift in $F(p)$).

Figure 2 about here

This novel gain from trade, which I have dubbed the intransparency gain, can be quantified. Figure 2 depicts the intransparency loss, $\exp(-\lambda^l)\left(\lambda^l + 1\right)$, as a function of the contact frequency λ^l. When the closed economy value of λ^l is small, even if international trade only brings a modest increase in λ^l, the resultant transparency gain is high. On the other hand, welfare cannot rise over the Bertrand level. When buyers on average receive six offers, the market is only 2% from the Bertrand equilibrium. Economies, markets or sectors where the contact frequency already was high in the closed economy (for instance due to a large number of buyers, as seen from (11)), have lower transparency gains from trade.

4 Discussions and Perspectives

The new motive for intra-industry trade outlined in this paper is therefore not omni-present: When buyers already have good information on sellers' offers, there is little revenue for potential foreign sellers to reap, and export price posting may not take place at all. Moreover, some markets have institutions that ensure full information to buyers, notably the futures exchanges where many commodities, such as unprocessed metals and the main crops, are sold. The model presented outlines one of the benefits of such institutions, they remove the intransparency loss and the need to spend resources on price posting.

The transparency gain from proposition 4 is a result of the changed strategic reactions of sellers: The open economy offers a broader strategic scope with the possibility of posting prices abroad, but also tougher competition, since buyers now on average have a larger choice set, leading to more aggressive pricing strategies. Arising from strategic interactions, the transparency gain is more closely related to the "competition gain" in the Cournot models of intra-industry trade presented in Brander (1981) and Brander and Krugman (1983). In these models, opening for international trade leads to reciprocal dumping, firms in both countries export their good. The present model may be regarded as a homogeneous good Bertrand counterpart to Brander and Krugman's Cournot model, although the mechanisms at play are rather different.[7]

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,

[7] There is another model of intra-industry trade in a homogeneous good Bertrand setting, due to Cukrowski and Aksen (2003). Trade is here driven by uncertain demands in both market and brings with it a "diversification gain", as risk-averse firms can reduce their risk exposure by serving both the domestic and the export market. As sellers' realized sales in my model are stochastic, serving both markets also brings reduced revenue variance. Being risk-neutral, however, sellers do not value this. Stretching the interpretation of their model a bit, Cukrowski and Aksen (2003) show a result regarding incomplete information similar to this model: The driver of intra-industry trade is incomplete information, and, as in my model, improved flows of domestic market information is a detriment to trade.

and their relative importance depends on how price posting costs change. For illustration, suppose export price posting costs are reduced proportionally, to $\alpha v_x(k_x^l/n^h)$, with $0 < \alpha < 1$. The relation between domestic and export price posting is changed to

$$v'\left(k^l/n^l\right) = \alpha v_x'\left(k_x^h/n^l\right)$$

which clearly implies an increase in export price posting (the substitution effect), while the zero profit condition, (21) now reads

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

With lower export price posting costs, there is profit potential for new sellers to enter, the income effect is swallowed up by entry. Moreover, the new entrants force each seller to reduce her domestic price posting. Both the income and substitution effects hence decrease k^l/n^l, and by proposition 4 the net implication is an increase in λ^l and therefore welfare gains.

This comparative statics exercise provides an additional insight: It is plausible that in countries sharing a 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, see for instance Melitz (2008).

The IT revolution of the last two decades has provided sellers with a cheap price posting device, 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. It is not certain, however, that the internet will promote trade. Comparative statics allow for the possibility that the drop in v is sufficient to remove the motive for export price posting. However, if v_x drops from a prohibitive level and approaches v, intra-industry trade is likely to increase. This pattern seems to apply to the markets for books and compact discs, which prior to the internet were dominated by local retail sales.

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 enables firms to internationalize organization and production processes. This paper suggests that IT may also impact trade flows more directly by facilitating extra-firm exports.

4.1 Quality Differences

A natural extension of the model is to allow for vertical quality differences. The model is then able to describe a much larger set of industries, now including for example domestic appliances, household electronics, computers and other office machinery, as well as standardized production machinery and intermediates (common chemicals, for instance). The key characteristics of such industries are: Goods are not tailored to fit a particular buyer's taste or needs; goods may represent a significant share of a buyer's income; and goods are to some degree experience goods, quality differences are typically hard to assess completely before purchase.

The broader interpretation of prices also calls for a reinterpretation of buyer behavior and advertising activities. Since these goods are relatively expensive for the buyers, it is worthwhile for the buyers to actively search for offers. The time costs of searching for offers on light bulbs or tumble dryers are presumably more or less equal, but the cost of buying the first, the best light bulb is much lower. A natural assumption is therefore that in a quality-adjusted price-interpretation of the model, all sellers' prices are known to buyers. What buyers cannot know is their reservation price of a particular offer, and this is why sellers must advertise, otherwise buyers will not buy the goods.

Advertising in these industries often contains no information on price. The literature on experience goods and signaling, with Nelson (1970, 1974) and Milgrom and Roberts (1986) as key contributions, has interpreted advertising in this context as credible signals of quality characteristics that buyers cannot verify before purchase. Reinterpreting for my model, advertising now enables buyers to determine their willingness to pay for a particular offer.[8] If a buyer sees an advertisement from only one seller, he will purchase this seller's good if the sales price is lower than his newly computed willingness to pay. If he sees several advertisements, he will purchase the good from the seller that offers the highest difference between reservation price and sales price.

The aim here is not to develop a full-fledged model, but to show how it may be constructed. I do therefore not dwell on why sellers produce at different quality levels; they simply do, for some exogenous reason. I consider a fixed number of sellers rather than free entry.

A necessary assumption to retain the predictions of the homogenous good case is that the cost of quality is proportional to its value: When a good has quality θ, it implies that the buyer's willingness to pay for the good is $\theta\bar{p}$ and that the marginal cost of producing the good is θc. A seller producing with quality θ has expected profits of

$$\pi(p,k^l,p_x,k_x^l,\theta) = Q^l\left(p,\theta\right)\left(p-\theta c\right)k^l + Q^h\left(p_x,\theta\right)\left(p_x-\theta c\right)k_x^l - v(k^l/n^l,\theta) - v_x(k_x^l/n^h,\theta) - f_v\left(\theta\right), \quad (26)$$

where the costs of advertising may vary with quality.

A buyer selects the offer observed that offers the lowest quality adjusted price, defined as $p/\theta\bar{p}$. The purchase probability can be derived as in (6), $Q^l\left(p,\theta\right) = \exp\left(-\lambda F\left(p/\theta\right)\right)$, and sellers will still randomise their price, with $\theta\bar{p}$ as the highest price charged.The condition that any price, which a seller with quality θ charges, must make the same expected profits as charging $\theta\bar{p}$ is

$$\exp\left(-\lambda F\left(p/\theta\right)\right)\left(p-\theta c\right) = \exp\left(-\lambda\right)\left(\theta\bar{p}-\theta c\right).$$

The cumulative distribution of quality-adjusted prices follows:

[8] My model abstracts from heterogeneity in buyers' preferences for quality, which is a key issue in the mentioned literature.

$$F^l(p/\theta) = 1 - \frac{1}{\lambda^l} \ln\left(\frac{\bar{p}-c}{p/\theta - c}\right). \tag{27}$$

The optimal pricing strategy is to raise the price proportional to the quality of the good and then randomize according to (27). International trade increases λ^l, pushing the price/quality trade-offs offered to buyers downwards, with prices approaching the marginal cost of quality.[9]

Naturally, one can think of more sophisticated purchase processes, with buyers inferring or learning the good's quality through repeated exposure to advertisement, peer effects or observed sales. Advertisement may spill over across borders, perhaps enabling some sellers to create an international brand for their good. A particular seller may exploit his brand by expanding his product range (see Choi (1998)), giving a demand-side angle for the emergent literature of multi-product firms in international trade. Some countries may end up being perceived as providing superior quality for particular goods (French wine, German machinery, etc.). This paper hopefully provides a framework for further work on these issues.

Per unit trade costs have been left out so far in order to simplify the exposition. Conceptually, they fit in nicely as supplementary costs of delivering the good to foreign buyers. Whenever a seller has a higher marginal cost, her incentive to undercut other sellers will be weaker. The implication is that the equilibrium price distribution will split in two, with foreign sellers pricing in the upper part of the distribution and domestic sellers in the lower part. This prediction, although somewhat extreme, is more in line with firms' export pricing than the customary iceberg cost of exporting: Firms raise their f.o.b. price when exporting to distant markets.[10]

The "knife-edge" prediction, where the price distribution splits in two, is also the reason behind the above assumption that quality affects willingness to pay and costs proportionally. Interplays between quality differences and trade costs would allow for less stark predictions, such as Alchian-Allen effects: only high-quality products are worth exporting. Allowing sellers to have different marginal costs due to productivity differences would also lead to a further partitioning of the price distribution, and under certain conditions, only productive sellers would export.

4.2 Empirical Considerations

Even though the proposed model has clear and testable empirical predictions, the data requirements are substantial. One would need price data at the seller level, and ideally a natural experiment of reduced advertisement costs. The studies of pricing by online bookstores by Clay et al. (2001) and Clay et al. (2002), and of retailers vs online sellers of books and CDs by Brynjolfsson and Smith (2000) come close to meeting these conditions. Their findings seem in line with the predictions of the present paper. First of

[9] The optimal number of buyers to advertise to will vary with the quality offered, but does not vary with the price charged.

[10] The iceberg cost assumption is that for one unit to arrive at the export destination, $\tau > 1$ units must be shipped, the remaining $\tau - 1$ units "melt away" during transit. This assumption leads to the erroneous prediction that firms f.o.b. prices will either be lower on the export market or equal to the domestic price. See Martin (2009) for derivations and empirical documentation.

all, the internet has not led to perfect convergence of prices, price dispersion remainsm and it cannot be related to differentiation: There are smaller sellers setting prices higher than amazon.com. Unfortunately, none of the papers report how price dispersion evolves over time.

With the increasing availability of scanner data (see Feenstra and Shapiro (2003)), the prospects of formally testing the model are good. Moreover, there is a shortcut to evaluating the importance of market intransparency and indirectly test the model: A strong point in the model is that to evaluate welfare relative to the Bertand level, one only needs to know the parameter λ^l:.

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

Data on the average number of offers a buyer receives are not available through traditional data sources, but if buyers of a given product can be identified, it is straightforward to survey them on how many alternative offers they considered before purchase. In computing an estimator of λ, one must take into account the $\exp\left(-\lambda^l\right)n^l$ potential buyers that did not receive any offer and therefore cannot be sampled, but this correction should not pose any major problems. A low estimate of λ, compared to the number of sellers, would in itself provide support for intransparent markets.

5 Conclusion

This paper has demonstrated that the relations between information costs and international trade are not as simple as one might expect: Information costs do not always reduce trade flows between countries. The case treated in this paper, advertising costs, may in fact generate international trade. The more costly advertising is, the less advertising is done by domestic sellers, leaving more profit potential for foreign sellers. International trade mitigates the problem of incomplete information and increases welfare.

The framework outlined here applies to any industry where goods are not tailormade for individual buyers and where there is no market institution that resolves the information problem, such as a futures exchange. Moreover, many of the stylized facts in international trade that can be generated with heterogeneous firms models are replicated in the present framework, even though sellers are initially identical. With its explicit treatment of information flows, the model predicts that countries with similar languages will trade more, and it shows how improved information technology may boost international trade.

Appendix A:

Proof of proposition 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 $1/(1+x)$. The probability of making a sale is therefore

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

(The result, proven below that all sellers contact the same number of buyers also holds in this case)

Therefore, a seller can do strictly better by decreasing her price with ε and being certain that her offer is accepted, $k(p-\varepsilon-c) > kQ(p)(p-c)$ 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 contradiction $\pi(p, F(p)) > \pi(p', F(p'))$ 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 $p = \bar{p}$: $\arg\max_{p \leq \bar{p}} \pi(p, 1) = \arg\max_{p \leq \bar{p}} k e^{-\lambda}(p-c) = \bar{p}$.

It is never profitable to offer a price lower than c, as long as sellers make non-negative profits, the lower bound will be larger than c.

***

Proof that $k_j = k$, all sellers contact the same number of buyers:

Any (p_j, k_j) pair offered must give the same profit. Specifically, it must hold that $\pi(p_j, k_j) = \pi(\bar{p}, \bar{k})$, where $\bar{k}$ is the optimal number of contacts when offering $\bar{p}$. Inserting (3) in this condition gives

$$v'(k_j/n)(k_j/n) - v(k_j/n) = v'(\bar{k}/n)(\bar{k}/n) - v(\bar{k}/n).$$

Differentiating the right-hand side with respect to k_j/n gives $v''(k_j/n)(k_j/n)$, which is positive when $k_j/n > 0$. The function $f(k/n) = v'(k/n)(k/n) - v(k_j/n)$ is monotonously increasing for (k_j/n) positive. It follows that $k_j = \bar{k}$:. In equilibrium all sellers contact the same number of buyers, and this optimal number of contacts does not depend on the prices they offer.

***

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

The purchase probability, $Q(p)$, calculated in (6) 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: Cumulative distributions of prices offered

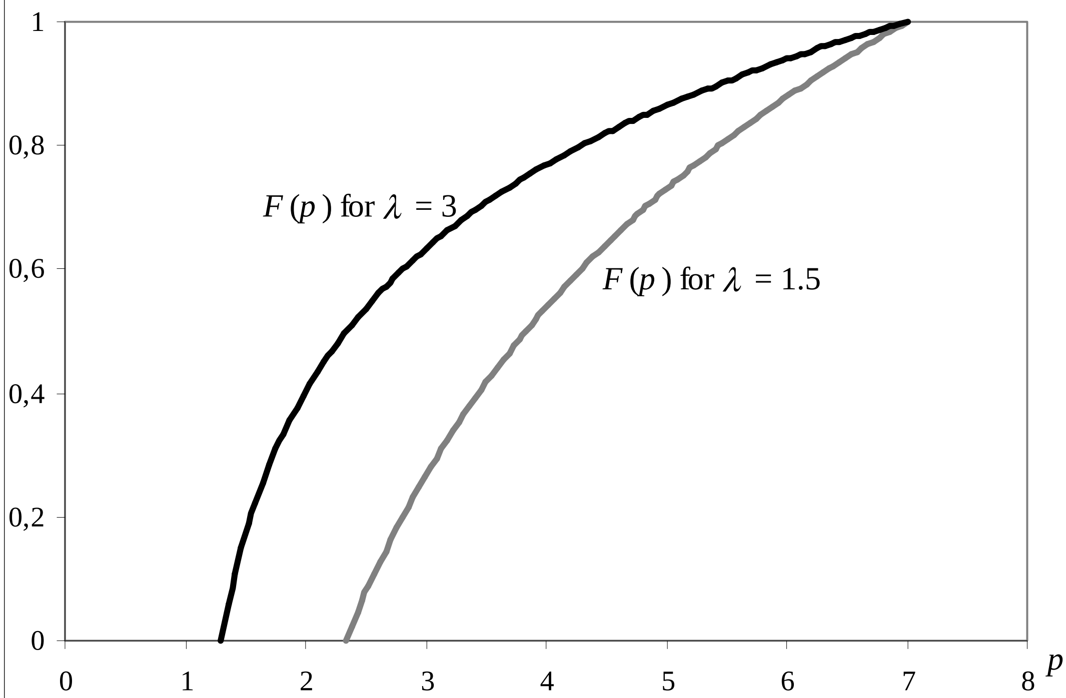
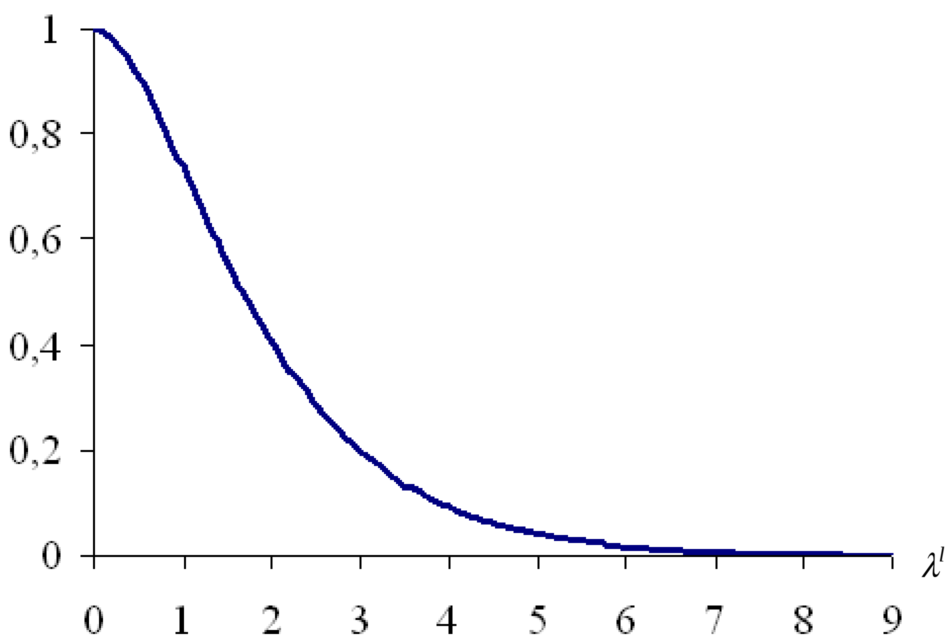


Figure 2: The intransparency loss



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