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**Conference Paper**

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Beiträge zur Jahrestagung des Vereins für Socialpolitik 2010: Ökonomie der Familie - Session: Oligopolistic Competition and Network Formation, No. F9-V2

**Provided in Cooperation with:**

Verein für Socialpolitik / German Economic Association

*Suggested Citation:* Gu, Yiquan; Hehenkamp, Burkhard (2010) : The Inefficiency of Market Transparency - A Model with Endogenous Entry, Beiträge zur Jahrestagung des Vereins für Socialpolitik 2010: Ökonomie der Familie - Session: Oligopolistic Competition and Network Formation, No. F9-V2, Verein für Socialpolitik, Frankfurt a. M.

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# The Inefficiency of Market Transparency - A Model with Endogenous Entry

Work in progress – Please do not quote!

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February 2010

## Abstract

Including the entry decision in a Bertrand model with imperfectly informed consumers, we introduce a trade-off at the level of social welfare. On the one hand, market transparency is beneficial when the number of firms is exogenously given. On the other, a higher degree of market transparency implies lower profits and hence makes it less attractive to enter the market in the first place. It turns out that the second effect dominates: too much market transparency has a detrimental effect on consumer surplus and on social welfare.

**Keywords:** Market transparency; Endogenous entry; Homogeneous products

**JEL Codes:** D43, L13, L15

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# 1 Introduction

Economists and others generally hold the view that market transparency benefits the functioning of markets and hence boosts welfare (at least in the one-shot context). Both theoretical and empirical evidence seem to underpin this. In this paper, we challenge this view, presenting a two-stage model where first firms independently decide whether to enter a market or not and then, knowing the number of entrants, pick prices. It turns out that too much market transparency generally harms competition and reduces social welfare once the entry decision is taken into account.

Including the entry decision in the model introduces a trade-off at the level of social welfare. On the one hand, market transparency fosters competition and enhances social welfare when the number of firms is exogenously given. On the other, a higher degree of market transparency implies lower firm profits and hence makes it less attractive to enter the market in the first place. As our analysis reveals, the second effect dominates the first, provided that market transparency is sufficiently large.

There are three strands of literature, to which we would like to connect. The literature on *market transparency* is comprehensive. We take market transparency as a broader term encompassing different aspects of market information. Papers with *common and captive markets* have firms facing a common market, in which they compete, and a captive market, where they can monopolize on their consumers (Shilony, 1977; Varian, 1980; Rosenthal, 1980). In our model informed consumers make up the common, uninformed consumers the captive market. Given that firms cannot price discriminate between these markets, equilibrium pricing is in mixed strategies, involving prices above marginal cost. *Sluggish consumers* (or demand inertia, as Selten calls it more technically) allow firms to exercise market power (Hehenkamp, 2002; Selten, 1965). Even if consumers have all the information on prices, but do not respond to it, firms will raise prices above marginal cost. In the case of extremely sluggish consumers, monopoly pricing results. Finally, we know from the literature on *consumer search* that firms gain market power if consumers have to search for prices and if search is costly (see e.g. Stahl, 1989; Robert & Stahl, 1993). In all the above papers, market transparency prevents firms from raising prices above marginal cost and hence is beneficial for welfare.

The second strand deals with models of *endogenous entry*. When *homogeneous products* are considered, an increase in the number of potential entrants surprisingly reduces welfare (Lang & Rosenthal, 1991; Elberfeld & Wolfstetter, 1999). The two papers differ in the timing of entry and pricing. In Lang & Rosenthal (1991) both decisions are made simultaneously, in El-

berfeld & Wolfstetter (1999) firms first decide upon entry and then, knowing the number of entrants, they choose prices. In both papers entry is in mixed strategies and the market is fully transparent. One might debate whether pure or mixed strategies are most reasonable at the entry stage. Dixit & Shapiro (1986) and Schultz (2009) number pros and cons of pure and *mixed entry strategies*, which we do not want to repeat here. However, both types of equilibria seem relevant to the analysis of market entry.

Finally, there is a third strand of literature, which connects the issue of market transparency with entry decisions (Gu & Wenzel, 2009a,b; Schultz, 2009). All these models deal with *differentiated products*. The effect of market transparency on welfare is unambiguous: more transparency entails higher social welfare, even when entry decisions are incorporated.

We proceed as follows. Section 2 presents the model, Section 3 the equilibrium analysis, and Section 4 the welfare analysis. Section 5 concludes.

## 2 The model

We examine a homogeneous product market with endogenous entry. Central to our research question is the degree of *market transparency*,  $\phi \in [0, 1]$ . A share  $\phi$  of all consumers is informed, i.e., they know all prices quoted in the market. The remaining consumers are uninformed about prices.

### The market game

The market game consists of two stages. At stage 1,  $N \geq 2$  potential firms decide whether to enter the product market or not. Entry costs  $f > 0$ . At stage 2, entry costs are sunk. Knowing the outcome of stage 1, the entrants compete in prices for the informed consumers.

The  $N$  symmetric firms produce with an identical constant returns to scale technology. Marginal cost crosses market demand. Without loss of generality, we normalize the marginal cost of production to zero. Each firm  $i \in \mathcal{N} := \{1, \dots, N\}$  sets a non-negative price  $p_i \in \mathcal{P} = [0, \infty)$ .

Market demand is given by a measurable function  $D(p)$ , mapping non-negative prices into non-negative demand. There exists a maximum reservation price  $\bar{P}$ , i.e.  $D(p) = 0$  for all prices  $p > \bar{P}$ . Market revenue,  $R(p) \equiv pD(p)$ , attains a unique global maximum at some price  $p^m$  and is increasing on  $[0, p^m]$ . Furthermore, market demand is bounded, non-increasing, and continuous on  $[0, p^m]$ .

Entry cost  $f$  of stage 1 satisfy two conditions: first, not all firms can profitably contest the market simultaneously, even if firms colluded perfectly,

i.e.  $f > R^m/N$ ; and, second, one firm alone would find it profitable to supply the market, i.e.  $f < R^m$ ; that is, we assume  $f \in (R^m/N, R^m)$ .

Central to our welfare analysis will be consumer surplus:

$$CS(p) := \int_p^\infty D(\tilde{p}) d\tilde{p},$$

where  $CS(p)$  is well defined for any price  $p \in \mathcal{P}$ , since  $D(p)$  is assumed measurable. Moreover,  $CS(p)$  is continuous on  $[0, p^m]$  by continuity of  $D(p)$  on  $[0, p^m]$ .

### Bertrand preferences

We further assume that consumers exhibit *Bertrand preferences* (Hehenkamp, 2002):

- Informed consumers buy from the cheapest firm. Given there are several, they distribute evenly.
- Uninformed consumers patronize their ‘favorite’ firm. Consumers’ favorite firms are distributed uniformly as well.

Like in the standard Bertrand model, preferences for low prices and favorite firms are lexicographic. From the perspective of firms, uninformed consumers are patrons: lower prices by other firms will not make them switch firms.

According to the assumption of Bertrand preferences, revenue of any firm  $i \in \mathcal{N}$  reads:

$$R_i(p_1, \dots, p_N) = \begin{cases} \frac{1-\phi}{N} R(p_i) & \text{if } p_i > \min \{p_1, \dots, p_k\} \\ \left( \frac{1-\phi}{N} + \frac{\phi}{\#I(p)} \right) R(p_i) & \text{if } p_i = \min \{p_1, \dots, p_k\} \end{cases},$$

where  $\#I(p)$  is the number of firms who tie at the lowest price, given a profile of prices,  $p = (p_1, \dots, p_N)$ .

## 3 Equilibrium analysis

We solve the game by backward induction, first analyzing the pricing games that arise at stage 2.

## Stage 2: Pricing behavior

Three cases can occur: (i) no firm has entered, the market does not come into existence; (ii) one firm has entered, a single firm faces a monopoly position; (iii) two or more firms have entered, we have hybrid Bertrand competition with both informed and uninformed consumers. Let  $k$  denote the number of firms that have entered at stage 1.

When no firm enters, all firms earn zero profit and consumer surplus is zero; no efficiency gain is realized:

$$\pi_i = 0, \quad CS = 0.$$

When  $k = 1$ , the monopolist will charge the monopoly price  $p^m$ , realizing a revenue of  $R^m := R(p^m)$  and earning positive profit; consumer surplus is ‘low’:

$$\pi^m := R^m - f > 0, \quad CS^m = CS(p^m).$$

The market outcome in these first two cases does not depend on market transparency  $\phi$ .

### The oligopoly case

In the oligopoly case ( $k \geq 2$ ), we distinguish three (sub)cases, depending on the degree of market transparency.

*No transparency* ( $\phi = 0$ ). All consumers are uninformed, effectively there is no competition among the entrants. Each of them gets a share of  $1/k$  consumers and sets  $p^m$  to obtain a revenue of  $R^m/k$ ; profit can be both positive or negative, depending on  $k$ ; consumer surplus corresponds to the monopoly case:

$$\pi_i = \frac{R^m}{k} - f \leq 0, \quad CS_{\phi=0}^k = CS(p^m).$$

*Full transparency* ( $\phi = 1$ ). All consumers are perfectly informed, the pricing game reduces to a standard Bertrand oligopoly. In equilibrium, at least two entrants price at marginal cost (of zero), all consumers buy at marginal cost, all entrants earn zero revenue, and consumer surplus is ‘maximal’:

$$\pi_i = -f < 0, \quad CS_{\phi=1}^k = CS(0).$$

*Intermediate transparency* ( $\phi \in (0, 1)$ ). For intermediate values of market transparency, the pricing equilibrium changes qualitatively:

**Proposition 1** *If  $k \geq 2$  and  $\phi \in (0, 1)$ , then there exists no equilibrium in pure strategies.*

**Proof.** Our proof consists of two parts. First, we show that there is no symmetric equilibrium in pure strategies. Subsequently, we establish that no asymmetric equilibrium in pure strategies exists either.

As to the first claim, notice that no symmetric price profile  $(p, \dots, p)$  with  $p > p^m$  can represent an equilibrium. For, in this case the monopoly price  $p^m$  yields strictly higher payoff than does  $p$  (this is independent of  $\phi$ ). If all firms charge the same price in  $(0, p^m]$ , slightly undercutting this price would produce a jump in a firm's share of consumers from  $(1 - \phi)/k$  to  $(1 - \phi)/k + \phi$ . Finally, a price of 0 is strictly dominated by  $p^m$  when  $\phi < 1$ , since by charging  $p^m$  a firm can obtain a revenue of  $(1 - \phi) R^m/k > 0$ .

To prove the second claim, suppose there were an asymmetric price equilibrium  $(p_1, \dots, p_k)$ , i.e.  $\min p_i < \max p_j$ . By the above dominance argument we have  $\min p_i > 0$ . Moreover, at most one firm will have the lowest price. This follows from the discontinuity argument used in the symmetric case. All other firms must then charge  $p^m$ , since, conditional on not charging the lowest price,  $p^m$  is the best choice. When all other firms charge  $p^m$ , however, there is no best response for the firm who has the lowest price. This is because there is no highest price that is strictly lower than  $p^m$ . ■

Yet, there exists a unique symmetric equilibrium in mixed strategies. We will first derive the equilibrium strategy and subsequently explore its properties.

### The symmetric mixed pricing equilibrium

In a symmetric mixed pricing equilibrium all firms adopt a common cumulative distribution function (cdf). Denote this by  $H(p) = \Pr\{P \leq p\}$ . Economically,  $H(p)$  represents a firm's probability of setting a price  $P$  less than  $p$ . It is sometimes convenient to work with the complementary probability  $\bar{H}(p) := 1 - H(p) = \Pr\{P > p\}$ .

**Proposition 2**  $H(p)$  has no atoms.

**Proof.** We confine ourselves with providing the underlying intuition. For a more detailed elaboration of the argument, see Proposition 3 in Varian (1980).

Suppose  $H(p)$  would have an atom at some price  $\hat{p}$ . Then price  $\hat{p}$  will be played with positive probability and hence two (or more) firms will tie at  $\hat{p}$  with positive probability  $\hat{p}$ . If  $\hat{p} > 0$  then a player would gain by shifting the probability mass of the atom towards a slightly lower price  $\hat{p} - \varepsilon$ . If  $\hat{p} = 0$ , then a player would gain by shifting the probability mass of the atom to the monopoly price  $p^m$ . ■

We have already argued that no firm will ever charge a price  $p > p^m$ . Therefore, the largest price ever set is the monopoly price  $p^m$ . Charging the monopoly price, an entrant will lose all informed consumers, but it monopolizes on its patrons. In this case he clears  $(1 - \phi) R^m/k$ . This is the right-hand side of equation (1).

Moreover, a symmetric mixed strategy  $H(p)$  must leave an entrant indifferent between all prices that are actually used. Correspondingly, the left-hand side of equation (1) represents the expected revenue of any price  $p$ :

$$\left[ \frac{1 - \phi}{k} + (\overline{H}(p))^{k-1} \phi \right] R(p) = \frac{1 - \phi}{k} R^m. \quad (1)$$

The first term in the brackets represents an entrant's share of uninformed consumers, i.e. its patrons. The second term includes the share of informed consumers, which only show up when the entrant charges the minimum price. This happens with probability  $(\overline{H}(p))^{k-1}$ . We can now solve equation (1) for  $\overline{H}(p)$ , which yields:

$$\overline{H}(p) = \left( \frac{1 - \phi}{\phi} \frac{R^m - R(p)}{kR(p)} \right)^{\frac{1}{k-1}}. \quad (2)$$

This equality holds for all prices in the support.

The lowest of all prices in the support,  $\underline{p}$ , corresponds to that price  $p \in [0, p^m]$  that satisfies

$$\begin{aligned} R(p) \left[ \frac{1 - \phi}{k} + \phi \right] &= \frac{1 - \phi}{k} R^m \\ \iff R(p) &= \frac{1 - \phi}{(k - 1)\phi + 1} R^m \end{aligned} \quad (3)$$

Observe that  $\underline{p}$  is uniquely defined, since  $R(p)$  is assumed strictly increasing on  $[0, p^m]$ . Charging  $\underline{p}$ , a firm will have the minimum price with probability one and hence attract all informed consumers.

**Proposition 3** *When  $k \geq 2$  firms have entered the market and market transparency is intermediate,  $\phi \in (0, 1)$ , there exists a unique symmetric mixed strategy pricing equilibrium. The corresponding equilibrium strategy is characterized by the following cumulative distribution function:*

$$H(p) = \begin{cases} 1 - \left( \frac{1 - \phi}{k\phi} \frac{R^m - R(p)}{R(p)} \right)^{\frac{1}{k-1}} & \text{for } \underline{p} \leq p \leq p^m \\ 0 & \text{for } p < \underline{p} \\ 1 & \text{for } p > p^m. \end{cases}$$



**Proof.** First, because  $R(p)$  is continuous, the intermediate value theorem implies that  $\underline{p}$  is well defined and that  $\underline{p} < p^m$ .

Second, the function  $H(p)$  indeed represents a cumulative probability distribution: As stated in Proposition 2,  $H(p) = 1 - \bar{H}(p)$  is continuous on  $[\underline{p}, p^m]$ . Moreover, we have  $H(\underline{p}) = 0$  and  $H(p^m) = 1$  for all  $\phi \in (0, 1)$  and  $\bar{H}(p)$  is non-decreasing in  $p$ .

Finally, prices  $p < \underline{p}$  and  $p > p^m$  imply expected profit strictly lower than  $(1 - \phi) R^m / k$ . Hence  $\bar{H}(p)$  maximizes an entrants expected profit given that all other firms use  $H(p)$  as well. ■

The equilibrium strategy in the case of intermediate transparency coincides with that of Rosenthal (1980), if we set  $(1 - \phi) D(p) / k$  as market demand of the captive market and  $\phi D(p)$  as market demand in the common market. Observe, however, that changing the degree of market transparency affects the relative size of the captive and the common market. Therefore, analyzing the impact of market transparency requires to use the equilibrium strategy of Proposition 3.

The following proposition provides expressions for expected profit and expected consumer surplus, respectively.

**Proposition 4** *Let  $k \geq 2$  and  $\phi \in (0, 1)$ . Then we find:*

(a) *The expected revenue of each entrant corresponds to the expected payoff of the monopoly price. Expected profit thus reads:*

$$\pi_i = \frac{1 - \phi}{k} R^m - f.$$

(b) *The expected consumer surplus is given by*

$$CS_\phi^k = \phi \int_{\underline{p}}^{p^m} CS(p) dH_{(1)}(p) + (1 - \phi) \int_{\underline{p}}^{p^m} CS(p) dH(p),$$

where  $H_{(1)}(p)$  denotes the cdf of the minimum price of all firms.

According to part (a), each entrant skims the complete informational rent from its patrons. Part (b) contains two terms. The first represents the consumer surplus of the informed consumers. Informed consumers only pay the minimum price, which is the first order statistic of  $k$  prices independently chosen from distribution  $H$ . The second term gives the consumer surplus of the uninformed ones.

## Properties of the pricing equilibrium

We have seen that both a fully transparent market ( $\phi = 1$ ) and a completely non-transparent market ( $\phi = 0$ ) give rise to a pure strategy equilibrium (of marginal cost and monopoly pricing, resp.) How does our model behave in the case of intermediate transparency when we take the limits of  $\phi \rightarrow 1^-$  and  $\phi \rightarrow 0^+$ ?

**Proposition 5** *Let  $k \geq 2$  and  $\phi \in (0, 1)$ .*

- (a) *As  $\phi \rightarrow 0^+$ , the NE strategy  $H(p)$  converges (in probability) to a degenerate probability distribution with unit probability mass on the monopoly price.*
- (b) *As  $\phi \rightarrow 1^-$ , the NE strategy  $H(p)$  converges (in probability) to a degenerate probability distribution with unit probability mass on marginal cost.*

**Proof.** Weak convergence can be shown easily, using the equilibrium strategy derived in Proposition 3. Convergence in probability is implied because the limit distribution has all probability on a single price (i.e. the corresponding limit random variable is constant). ■

We conclude the analysis of stage 2 with results on the comparative static properties of the symmetric mixed pricing equilibrium. Since the equilibrium strategy represents a distribution function, monotonicity of a firm's price and the minimum price is in terms of the usual stochastic order (which, in turn, is based on what economists commonly call 'first order stochastic dominance').

**Proposition 6** *Let  $k \geq 2$  and  $\phi \in (0, 1)$ .*

- (a) *The more transparent the market (the higher  $\phi$ ), the lower a firm's price, the lower the minimum price (both in stochastic terms), and the higher expected consumer surplus.*
- (b) *The more firms,  $k$ , have entered the market, the higher a firm's price, the higher the minimum price (in stochastic terms), and the lower is consumer surplus (Rosenthal, 1980).*

**Proof.** To see (a), observe that  $\bar{H}(p)$ , considered as function of  $\phi$ , decreases with  $\phi$ . Hence, a price strategy  $H(p)$  corresponding to low market transparency  $\phi'$  stochastically dominates another that corresponds to some larger degree of market transparency  $\phi''$ , for any  $\phi' < \phi''$ . The distribution of the first order stochastic,  $H_{(1)}(p)$ , (which is the minimum price here) inherits all stochastic monotonicity properties from its parent distribution,  $H(p)$  (see Theorem 4.4.1 in David & Nagaraja, 2003). Finally, consumer surplus is a bounded, continuous function, and strictly decreasing function of  $p$  on the interval  $[0, p^m]$ . The claim hence follows from Theorem 1.A.3 in Shaked & Shanthikumar, (2007).

Part (b) is then a direct consequence of Proposition 3 in Rosenthal (1980).

■

According to Proposition 6, market transparency has the intuitive effect of intensifying competition and increasing consumer surplus, given the number of entrants is fixed. An increase in the number of entrants, however, affects prices and consumer surplus in a counterintuitive way. More firms imply less competition! The latter result is due to Rosenthal (1980).

## Stage 1: Entry decisions

Having analyzed the equilibrium behavior of stage 1, we now proceed to investigate the entry decision of a single firm. Again, we confine our analysis to symmetric equilibria.

First of all, notice that there is no symmetric equilibrium in pure strategies. Recall that  $f \in (R^m/N, R^m)$ . If all firms enter, they incur losses because of  $f > R^m/k$ . Hence, no entry would be strictly better (given the other firms stick with entry). If no firm enters, entry is profitable because of  $f < R^m$  (given the other firms remain outside the market)

We now show that there is a symmetric entry equilibrium in mixed strategies. Let  $\varepsilon$  denote the probability of entry in this equilibrium. Each firm has to be indifferent between ‘entry’ and ‘no entry’. Since ‘no entry’ entails zero profit, ‘entry’ does so too:

$$(1 - \varepsilon)^{N-1} R^m + \sum_{i=1}^{N-1} \binom{N-1}{i} \varepsilon^i (1 - \varepsilon)^{N-i-1} \frac{(1 - \phi) R^m}{i + 1} = f. \quad (4)$$

The left-hand side of (4) contains the expected revenue of entry, which has to equal the entry cost  $f$ . The left-hand side collects the revenue terms associated with the different number of other firms entering the market. If no other firm enters, the entrant becomes monopolist, earning monopoly revenue  $R^m$ . This happens with probability  $(1 - \varepsilon)^{N-1}$ . If  $i$  other firms enter, then there will be hybrid Bertrand competition among  $i + 1$  firms. Accordingly, the entrant earns  $(1 - \phi) R^m / (i + 1)$  (cp. Prop. 4). This happens with probability  $\binom{N-1}{i} \varepsilon^i (1 - \varepsilon)^{N-i-1}$ .

Dividing (4) by  $R^m$  and juggling with indices, one can simplify (4) to obtain

$$(1 - \varepsilon)^{N-1} + (1 - \phi) \frac{1 - (1 - \varepsilon)^N - N\varepsilon(1 - \varepsilon)^{N-1}}{N\varepsilon} = \frac{f}{R^m}. \quad (5)$$

It can be shown that the left-hand side of (5) is strictly decreasing in  $\varepsilon$ . Moreover, the left-hand side assumes  $(1 - \phi) / N < 1 / N$  for  $\varepsilon = 1$  and goes

to one as  $\varepsilon \rightarrow 0$ . By the intermediate value theorem, there hence exists a unique  $\varepsilon$  satisfying (5), for any  $\phi \in [0, 1]$ . We have established:

**Proposition 7** *For any degree of market transparency  $\phi \in [0, 1]$ , there exists a unique symmetric equilibrium in mixed strategies at the entry stage. The corresponding probability of entry is implicitly given by (4) and (5).*

We conclude the equilibrium analysis with results on the comparative static properties of this equilibrium:

**Proposition 8** *Entry is the less likely,*  
 (a) *the more transparent the market (the higher  $\phi$ ) and*  
 (b) *the less profitable the market (the higher  $f/R^m$ ).*

**Proof.** The claims hold because the left-hand side of (5) is decreasing in  $\varepsilon$  and  $\phi$ . ■

## 4 Social welfare

In this section we state our main result. Up to now, we have an analytical proof for the case of two potential competitors. Yet, a comparison of the polar extremes of no and full transparency indicates that the result extends to cases with more than two firms.

As a preliminary, observe that expected producer surplus is zero. Therefore, consumer surplus and social welfare coincide. Accordingly, social welfare  $W$  is given by

$$W = N\varepsilon(1 - \varepsilon)^{N-1} CS^m + \sum_{k=2}^N \binom{N}{k} \varepsilon^k (1 - \varepsilon)^{N-k} CS_{\phi}^k.$$

Lacking an explicit representation of  $CS_{\phi}^k$ , we will have to build on the comparative static properties of consumer surplus in order to draw welfare conclusions.

**Theorem 1** *Let  $N = 2$  and suppose market demand is strictly decreasing on  $[0, p^m]$ , hits both axes, and entry cost  $f$  satisfy  $f \in (R^m/N, R^m)$ . Then social welfare decreases with market transparency  $\phi$  for  $\phi$  sufficiently close to one.*

**Proof.** To be written. ■

Theorem 1 provides a limit result for  $\phi \rightarrow 1$ . Full transparency is not welfare optimal if the entry decision is taken into account (and if entry cost give rise to a mixed entry equilibrium). The example of linear demand and the comparison of polar extremes of transparency indicate that the welfare-optimal level of market transparency can be quite low (see further below).

The assumptions of strictly decreasing demand and on the feasible range of entry cost are necessary for our result. As to the first, one can show for the case of unit demand that market transparency unambiguously benefits social welfare.<sup>1</sup> Regarding our second assumption, there exists a unique equilibrium in pure strategies outside the feasible range of entry cost. If  $f < R^m/N$  all firms enter the market with probability one and if  $f > R^m$  then all firms remain absent. If all firms enter, Proposition 6 implies that market transparency increases social welfare (we have  $k = N$ ).

## Linear demand

We continue with examining the example of linear demand to illustrate that the optimal level of market transparency can be quite low.

Consider the linear demand function  $D(p) = 1 - p$  (for  $p \leq 1$  and zero otherwise). It follows that  $p^m = 1/2$  and  $R^m = 1/4$ . The entry condition (4) reduces to

$$\varepsilon = \frac{8}{\phi + 1} \left( \frac{1}{4} - f \right).$$

Consumer surplus in the monopoly case is  $CS^m = 1/8$ , while in the duopoly case it is a function of market transparency  $\phi$  (via the pricing behavior in equilibrium). Welfare is hence given by

$$W = 2\varepsilon(1 - \varepsilon) \frac{1}{8} + \varepsilon^2 CS_\phi^2.$$

Observe that welfare depends on  $\phi$  both via the probability of entry and via consumer surplus. In contrast, entry cost  $f$  affect welfare only via the probability of entry.

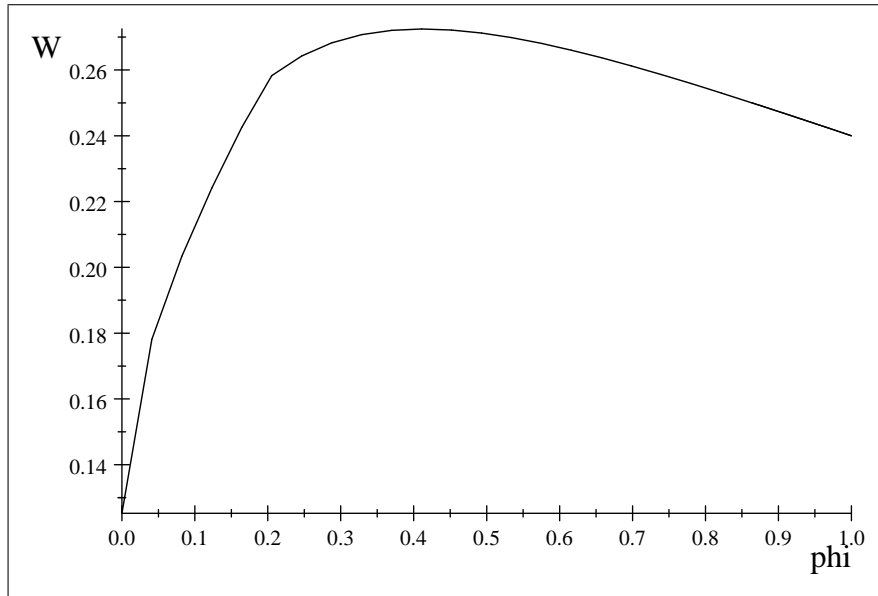
Below we present three figures, each plotting social welfare as a function of market transparency  $\phi$ . The three plots correspond to different sizes of entry cost. Recall that entry cost need to satisfy  $f < R^m = 1/4$  (otherwise no firm enters) and  $(1 - \phi)/8 < f$  (otherwise each firm enters with probability

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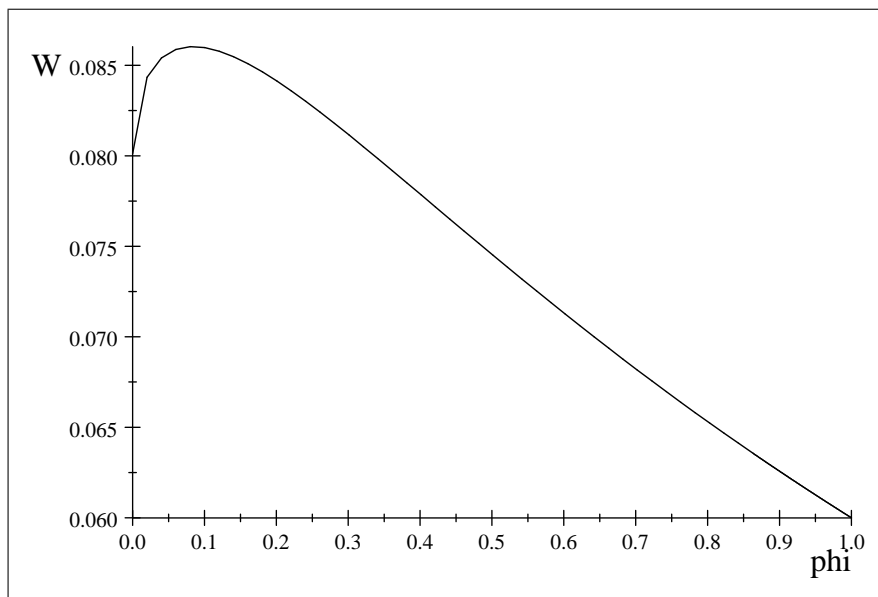
<sup>1</sup>Schultz (2009) obtains a similar finding. Investigating a model of product differentiation with unit demand, he addresses the case of ‘the almost homogeneous market’ by taking the limit of transportation cost to zero (see his sections 4 and 5). Social welfare is maximal under full transparency.

one). For a given level of entry cost, the latter condition provides a lower bound on market transparency (see the first example).

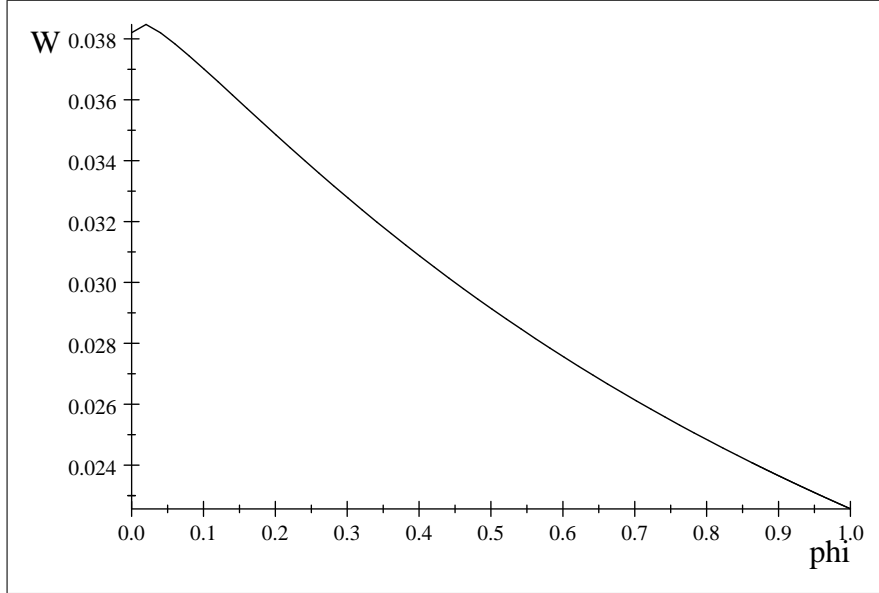
**Example 1** (*Low entry cost*) Let  $f = 1/10$ . This implies  $\varepsilon = \frac{6}{5(\phi+1)}$  and  $\phi \geq 1/5$ .



**Example 2** (*Intermediate entry cost*) Let  $f = 1/5$ . This implies  $\varepsilon = \frac{2}{5(\phi+1)}$ , which satisfies  $\varepsilon \in (0, 1)$  for all  $\phi \in [0, 1]$ .



**Example 3** (*High entry cost*) Let  $f = 11/48$ . This implies  $\varepsilon = \frac{1}{6(\phi+1)}$ , which satisfies  $\varepsilon \in (0, 1)$  for all  $\phi \in [0, 1]$ .



In all three cases the welfare-optimal level of market transparency is below 0.5. Moreover, the three plots indicate that the optimal level of transparency decreases with the size of entry cost.

### ‘Full’ versus ‘no transparency’

We close this section comparing the polar extremes of full and no transparency, i.e of  $\phi = 1$  and  $\phi = 0$ , respectively. Restricting attention to these cases simplifies the analysis in that we avoid the mixed pricing equilibrium.

In case of ‘no transparency’,  $\phi = 0$ , the equilibrium probability of entry,  $\varepsilon_0 := \varepsilon_{\phi=0}$ , is still implicitly characterized:

$$\frac{1 - (1 - \varepsilon_0)^N}{N\varepsilon_0} = \frac{f}{R^m}.$$

Social welfare in this case simplifies to

$$\begin{aligned} W_{\phi=0} &= N\varepsilon(1 - \varepsilon)^{N-1} CS^m + \sum_{k=2}^N \binom{N}{k} \varepsilon^k (1 - \varepsilon)^{N-k} CS_{\phi=0}^k \\ &= N\varepsilon(1 - \varepsilon)^{N-1} CS^m + \left(1 - N\varepsilon(1 - \varepsilon)^{N-1} - (1 - \varepsilon)^N\right) CS^m \\ &= \left(1 - (1 - \varepsilon)^N\right) CS^m, \end{aligned} \tag{6}$$

where each expression is evaluated at  $\varepsilon = \varepsilon_0$ .

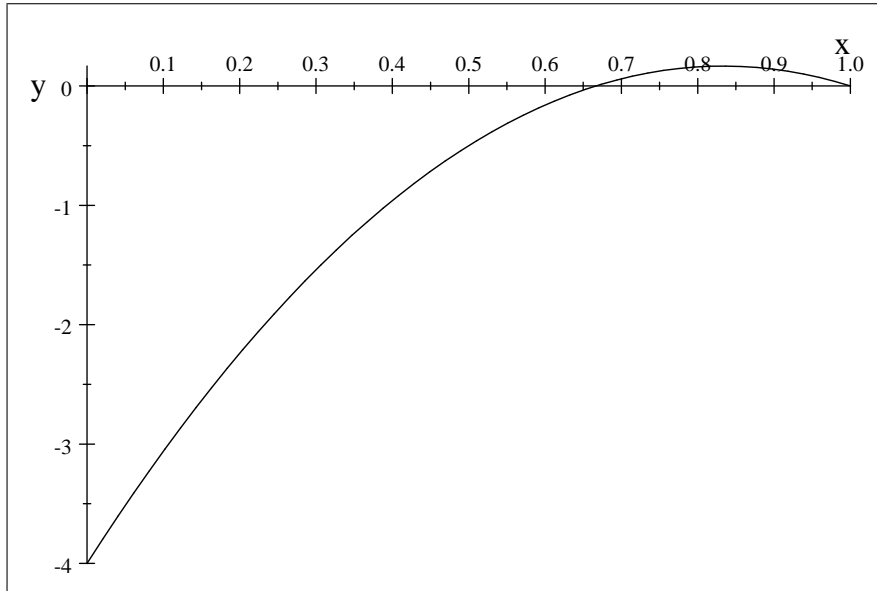
As to the case of full transparency,  $\phi = 1$ , we obtain the explicit expression  $\varepsilon_{\phi=1} = 1 - (f/R^m)^{\frac{1}{N-1}}$ . From (5), it directly follows that  $\varepsilon_{\phi=0} > \varepsilon_{\phi=1}$ , that is, ‘no transparency’ gives rise to the higher entry probability. Social welfare under ‘full transparency’ is given by

$$\begin{aligned} W_{\phi=1} &= N\varepsilon(1-\varepsilon)^{N-1}CS^m + \sum_{k=2}^N \binom{N}{k} \varepsilon^k (1-\varepsilon)^{N-k} CS_{\phi=1}^k \\ &= N\varepsilon(1-\varepsilon)^{N-1}CS^m \\ &\quad + \left(1 - N\varepsilon(1-\varepsilon)^{N-1} - (1-\varepsilon)^N\right) CS_{\phi=1}^k, \end{aligned} \quad (7)$$

where each term is evaluated at  $\varepsilon = \varepsilon_{\phi=1}$  and where  $CS_{\phi=1}^k = CS(0)$ .

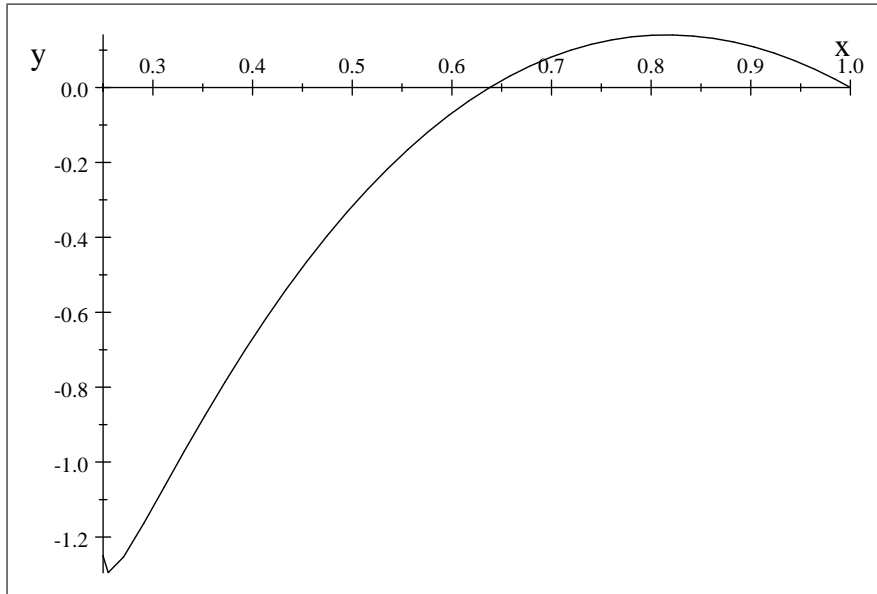
Comparing expressions (6) and (7), we see the trade-off at the welfare level: on the hand, if entry probabilities were the same in both polar cases then consumer surplus would be higher under ‘full transparency’, since transparency entails lower prices and hence higher welfare in the oligopoly cases; on the other hand, entry probabilities are higher under ‘no transparency’.

To illustrate that welfare can be higher under no transparency than under full transparency, we return to our above example of linear demand. We plot the normalized welfare difference  $(W_{\phi=0} - W_{\phi=1})/CS^m$  as a function of  $\rho := f/R^m \in [1/N, 1]$  for the cases of two, three, and four firms:

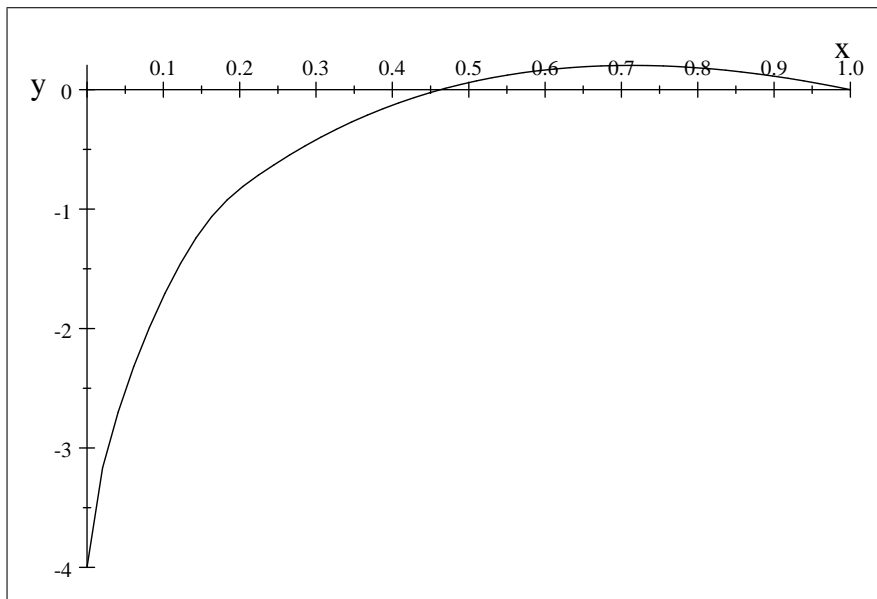


Welfare difference for  $N = 2$





Welfare difference for  $N = 3$



Welfare difference for  $N = 4$

For  $\rho = f/R^m$  sufficiently large, the welfare difference is positive. Therefore, the three figures indicate that our main result extends to cases with more than two firms. Moreover, the range of feasible  $\rho = f/R^m$  seems to increase with  $N$ . It is larger for  $N = 4$  than for  $N = 3$  than it is for  $N = 2$ .

## 5 Concluding remarks

We have provided a framework in which *too much market transparency* generally *harms competition* and *reduces social welfare*. Society faces a trade-off: On the one hand, more transparency intensifies competition, lowers prices and enhances welfare in each oligopoly subgame of stage 2 (in terms of the usual stochastic order). On the other hand, this reduces the profitability of entry, which causes firms to reduce their probability of entry. Market breakdown becomes more and oligopoly less likely. As our main theorem shows, the second effect dominates if market transparency is (almost) full.

Why then does the product differentiation literature on market transparency and endogenous entry find a positive welfare effect of market transparency? We first remark that the notion of entry does not seem to play a role, since we and Schultz (2009) apply the same notion. Schultz, like most of the product differentiation literature, however, focuses on the case of price-inelastic unit demand. As we have just learned from Theorem 1, this assumes away a crucial channel of how market transparency can affect social welfare.

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