# Too much of a good thing: The consequences of market transparency *

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**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.

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## 1 Introduction

Economists and others generally hold the view that consumer-sided market transparency benefits the functioning of markets and hence boosts welfare. 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 between static and dynamic efficiency. 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 profits and hence makes it less attractive to enter the market in the first place. As our analysis reveals, the second effect dominates, provided that market transparency and the number of potential entrants are sufficiently large.

Like Armstrong and Chen (2009), we take consumer behaviour as given and assume that only a fraction of consumers is fully attentive. Accordingly, we define market transparency as the share of informed consumers in the market. Informed consumers know all prices and buy from the cheapest firm. When there are several cheapest firms, informed consumers distribute evenly. Uninformed consumers patronize a certain firm and do not compare prices. Still the amount actually purchased depends on the price charged at their favourite firm.

There are three strands of literature to which we connect. The literature on *market transparency* is comprehensive. We perceive 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, 1965a,b). Even if consumers have full information on prices, but do not all respond to it, firms raise prices above marginal cost. In the case of extremely sluggish consumers, monopoly pricing results. The share of responsive consumers in this context corresponds to the share of informed consumers in our model.

Finally, the literature on *consumer search* has shown that firms gain market power if consumers have to search for prices and if this search is costly (e.g., Diamond, 1971; Stahl, 1989; Robert and Stahl, 1993). Stahl's model of shoppers and non-shoppers can be embedded into our model if search cost is high. In Stahl (1989), shoppers have zero search cost and are perfectly informed about prices; non-shoppers search rationally, i.e. they compare the expected benefit of continued search with the corresponding search cost. Stahl's endogenously determined fraction of shoppers and informed non-shoppers then equates to our share of informed consumers.

In all the above papers, an increase in market transparency reduces the firms' ability to raise prices above marginal cost and hence is beneficial for welfare.

The second strand of literature deals with models of *endogenous entry*. When *homogeneous products* are considered, an increase in the number of potential entrants surprisingly reduces welfare (Lang and Rosenthal, 1991; Elberfeld and Wolfstetter, 1999). The two papers differ in the timing of entry and pricing. In Lang and Rosenthal (1991) both decisions are made simultaneously, in Elberfeld and 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 more reasonable at the entry stage. Dixit and 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 market transparency with entry decisions (Schultz, 2009; Gu and Wenzel, 2011). All these models deal primarily with *differentiated products.* The effect of market transparency on welfare is unambiguous: more transparency entails higher social welfare, even when entry decisions are included in the modelling framework.

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. A share $\phi \in [0, 1]$ of all consumers is informed, i.e., they know all prices quoted in the market. The remaining consumers are uninformed about prices. In what follows, we refer to $\phi$ as (the degree of) *market transparency*.

### The market game

The market game consists of two stages. At stage 1, $N \geq 2$ identical firms decide whether to enter the market or not. Entry costs $f > 0$. Let $\mathcal{N} := \{1, \ldots, N\}$ denote the corresponding set of *potential* entrants. At stage 2, entry costs are sunk. Knowing how many firms have entered at stage 1, the entrants compete in prices for the informed consumers. Let $\mathcal{K} := \{1, \ldots, K\}$ denote the corresponding set of *actual* entrants (after appropriate relabelling). Then, each entrant $i \in \mathcal{K}$ sets a non-negative price $p_i \in \mathcal{P} := [0, \infty)$. Production is assumed to be costless.

Market demand is given by a measurable and integrable function $D(p)$, mapping non-negative prices into non-negative demand. Market revenue $R(p) := pD(p)$ attains a unique global maximum at some price $p^m \in (0, \infty)$. Furthermore, market demand is non-increasing and continuous on $[0, p^m]$.

Entry cost $f$ of stage 1 satisfies two conditions: first, not all firms can profitably contest the market simultaneously, even if firms colluded perfectly, i.e. $f > R^m/N$; second, one firm alone would find it profitable to supply the market, i.e. $f < R^m$; in sum, we assume $f \in (R^m/N, R^m)$.

Central to our welfare analysis will be consumer surplus,

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

Note that $CS(p)$ is well defined and finite for any price $p \in \mathcal{P}$, since $D(p)$ is assumed measurable and integrable. Moreover, $CS(p)$ is continuously differentiable 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 buy from their 'favourite' firm. Consumers' favourite firms are distributed uniformly as well.

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

According to the assumption of Bertrand preferences, the revenue of entrant $i \in \mathcal{K}$ reads

$$R_i(p_1, \ldots p_K) = \begin{cases} \frac{1-\phi}{K} R(p_i) & \text{if } p_i > \min\{p_1, \ldots p_K\} \\ \left(\frac{1-\phi}{K} + \frac{\phi}{\#\mathcal{I}(p)}\right) R(p_i) & \text{if } p_i = \min\{p_1, \ldots p_K\} \end{cases},$$

where $\#\mathcal{I}(p)$ is the number of entrants who tie at the lowest price, given a profile of prices, $p = (p_1, \ldots p_K)$.

## 3 Equilibrium analysis

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

## Stage 2: Pricing behaviour

Three cases can occur. First, no firm has entered: the market is not covered. Second, one firm has entered: this firm faces a monopoly position. Third, two or more firms have entered: we have *hybrid Bertrand competition*, that is, entrants compete for informed consumers while uninformed consumers represent patrons.

When no firm enters, i.e. $K = 0$, 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, which differ in 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 that of the monopoly case,

$$\pi_i = \frac{R^m}{K} - f \lesseqgtr 0, \quad CS^K_{\phi=0} = CS(p^m).$$

*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',

$$\pi_i = -f < 0, \quad CS^K_{\phi=1} = CS\left(0\right).$$

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

**Proposition 1.** If $K \geq 2$ and $\phi \in (0,1)$, 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 $(p, \ldots, p)$ with $p > p^m$ can represent an equilibrium, because, for $\phi \in (0,1)$, any price $p > p^m$ is strictly dominated by the monopoly price $p^m$. If all firms charge an identical price from $(0, p^m]$, slightly undercutting this price would produce a jump in a firm's share of consumers from $1/K$ to $\left(1-\phi\right)/K + \phi$ and hence be profitable. 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 at least $\left(1-\phi\right) R^m / K > 0$.

To prove the second claim, suppose there were an asymmetric price equilibrium $\left(p_1, \ldots, p_K\right)$, i.e. $\min_i p_i < \max_j p_j$. 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, no price strictly below $p^m$ is optimal, since there is no highest price that is strictly lower than $p^m$. *Q.E.D.*

**The symmetric mixed pricing equilibrium**

Yet, there exists a unique symmetric equilibrium in mixed strategies, where all entrants adopt a common cumulative distribution function (cdf). Denote this by $H(p) := \Pr\{P \leq p\}$. It is sometimes convenient to work with the complementary probability $\overline{H}(p) := 1 - H(p) = \Pr\{P > p\}$.

**Proposition 2.** $H(p)$ has no point masses.

**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 a point mass at some price $\widehat{p}$. Then price $\widehat{p}$ will be played with positive probability and hence two (or more) entrants will tie at $\widehat{p}$ with positive probability. If $\widehat{p} > 0$ then a player would gain by shifting the point mass towards a slightly lower price $\widehat{p} - \xi$, for $\xi > 0$ sufficiently small. If $\widehat{p} = 0$, he would gain by shifting the probability mass to the monopoly price $p^m$. *Q.E.D.*

**Proposition 3.** Suppose $K \geq 2$ firms have entered the market and market transparency is intermediate, $\phi \in (0,1)$. Let $\underline{p}$ be defined by

$$\underline{p} := \inf\{p \in [0, p^m] : ((1-\phi)/K + \phi) R(p) = (1-\phi) R^m/K\}$$

and set

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

Then $(H, \ldots, H)$ represents the unique symmetric Nash equilibrium of the $K$-firm oligopoly pricing game at stage 2.

**Proof**: We start with establishing the equilibrium property. 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: we have $H(\underline{p}) = 0$, and $H(p^m) = 1$ for all $\phi \in (0,1)$ and $H(p)$ is non-decreasing in $p$ by construction of $H(p)$. Moreover, by Proposition 2, $H(p)$ is continuous on $[\underline{p}, p^m]$.

Third, prices $p < \underline{p}$ and $p > p^m$ imply expected revenue strictly lower than $(1-\phi) R^m/K$. For, prices $p > p^m$ are strictly dominated by $p^m$ and prices $p < \underline{p}$ yield expected revenue $((1-\phi)/K + \phi) R(p) < (1-\phi) R^m/K$ by definition of $\underline{p}$. Furthermore, by construction of $H(p)$, we have

$$\left[\frac{1-\phi}{K} + \left(\overline{H}(p)\right)^{K-1} \phi\right] R(p) \leq \frac{1-\phi}{K} R^m \tag{1}$$

for all prices $p \in \left[\underline{p}, p^m\right]$, with equality holding everywhere in the support of $H(p)$. By eq. (1), prices $p \in \left[\underline{p}, p^m\right]$ outside the support of $H(p)$ earn at most $(1-\phi) R^m/K$. Thus, $H(p)$ maximizes an entrant's expected profit given that all other entrants use $H(p)$ as well.

Finally, uniqueness of the symmetric Nash equilibrium can be established along the lines of Proposition 4 in Rosenthal (1980). *Q.E.D.*

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.

The following proposition collects 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 entrants.

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 consumers.

**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 $\phi \to 1^-$ and $\phi \to 0^+$?

**Proposition 5.** Let $K \geq 2$ and $\phi \in (0, 1)$.
(a) As $\phi \to 0^+$, the Nash equilibrium strategy $H(p)$ converges (in probability) to a degenerate probability distribution with unit probability mass on the monopoly price.
(b) As $\phi \to 1^-$, the Nash equilibrium 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. because the corresponding limit random variable is constant). *Q.E.D.*

According to Proposition 5, our model behaves smoothly at the boundaries of no and full transparency, respectively.

We end the analysis of stage 2 with the comparative static effect of transparency on the symmetric mixed pricing equilibrium. Since the equilibrium strategy represents a distribution function, monotonicity of an entrant's price and the minimum price is phrased in terms of the usual stochastic order (which is based on what is commonly called 'first order stochastic dominance').

**Proposition 6.** Let $K \geq 2$ and $\phi \in (0, 1)$. The more transparent the market (the higher $\phi$), the lower an entrant's price, the lower the minimum price of all entrants (both in stochastic terms), and the higher expected consumer surplus.

**Proof**: Observe that $\overline{H}(p)$, 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, $H_{(1)}(p)$, inherits all stochastic monotonicity properties from its parent distribution, $H(p)$ (see Theorem 4.4.1 in David and Nagaraja, 2003). Finally, consumer surplus is a bounded, continuous, and strictly decreasing function of $p$ on the interval $[0, p^m]$. The claim hence follows from Theorem 1.A.3 in Shaked and Shanthikumar (2007). *Q.E.D.*

According to Proposition 6, market transparency has the intuitive effect of intensifying competition and increasing consumer surplus, given the number of entrants is fixed.

### Stage 1: Entry decisions

Having analysed the equilibrium behaviour 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 stay out of 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:

$$(1-\varepsilon)^{N-1} R^m + \sum_{i=1}^{N-1} \binom{N-1}{i} \varepsilon^i (1-\varepsilon)^{N-i-1} \frac{(1-\phi) R^m}{i+1} = f. \qquad (2)$$

The left-hand side of (2) 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 $(1-\phi)\,R^m/\,(i+1)$ (see Prop. 4). This happens with probability $\binom{N-1}{i}\varepsilon^i\,(1-\varepsilon)^{N-i-1}$.

Dividing (2) by $R^m$, one can simplify (2) to obtain

$$(1-\varepsilon)^{N-1} + (1-\phi)\,\frac{1-(1-\varepsilon)^N - N\varepsilon\,(1-\varepsilon)^{N-1}}{N\varepsilon} = \frac{f}{R^m}. \tag{3}$$

It can be shown that the left-hand side of (3) is strictly decreasing in $\varepsilon$. Moreover, the left-hand side assumes $(1-\phi)\,/N \leq 1/N < f/R^m$ for $\varepsilon = 1$ and goes to $1 > f/R^m$ as $\varepsilon \to 0$. By the intermediate value theorem, there hence exists a unique $\varepsilon$ satisfying (3), 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 (2) or (3).

We finish the equilibrium analysis with two 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 (3) is decreasing in $\varepsilon$ and $\phi$. *Q.E.D.*

## 4 Social welfare

In this section we present our main finding: Too much market transparency is detrimental to social welfare.

To begin with, observe that *ex ante* expected producer surplus is zero. Therefore consumer surplus and social welfare coincide. Social welfare $W$ is hence given by

$$W = N\varepsilon \left(1-\varepsilon\right)^{N-1} CS^m + \sum_{K=2}^{N} \binom{N}{K} \varepsilon^K \left(1-\varepsilon\right)^{N-K} CS_\phi^K. \tag{4}$$

To establish our main finding, we show that social welfare decreases in the limit as the market becomes fully transparent ($\phi \to 1$). Taking this limit, firms' prices converge to marginal cost (recall Proposition 5). It would be quite natural to assume that the resulting increase in demand is bounded as the market price approaches marginal cost. However, the following more general assumption turns out to be sufficient for our purpose.

**Assumption D** *Demand* $D(p)$ *is differentiable on* $(0, p^m]$, *it satisfies* $\lim_{p\to 0} pD'(p) = 0$[1] *and* $D(p) + pD'(p) > 0$ *on* $(0, p^m)$.

We then have:

**Theorem** *Let Assumption D be met, suppose that there are* $N < \infty$ *potential entrants, and let entry cost satisfy* $f \in (R^m/N, R^m)$. *Further assume that either of the following two conditions holds:*

(a) $CS(0) - CS^m - R^m > 0$ or (b) $CS^m > 0$.

*Then social welfare decreases with market transparency* $\phi$ *for* $\phi$ *sufficiently large.*

**Proof**: See the appendix. *Q.E.D.*

The theorem identifies conditions (a) and (b) each as sufficient for the negative impact of too much transparency. Condition (a) posits a strictly positive

[1] That is, we allow for $\lim_{p\to 0} D'(p) = -\infty$. In that case, Assumption D requires that convergence is at a rate lower than that of $p \to 0$.

deadweight loss (associated with the case of monopoly relative to that of perfect competition). Condition (b) postulates a strictly positive consumer surplus at the monopoly price. Notice that conditions (a) and (b) always hold weakly.

Both conditions could easily be replaced by conditions on the (primitive) demand function. For instance, condition (b) would be implied if $D(p)$ were assumed continuous at $p^m$ from both sides (or, less generally, on the interval $[0,\infty)$). Similarly, condition (a) would follow if $D(p)$ were assumed strictly decreasing at some price $p \in (0, p^m)$ (or, less generally, on the whole interval $(0, p^m)$).

Both conditions are weak in that the remaining class of demand functions, not covered by the theorem, is small. These are the constant demand functions of the type

$$D(p) = \begin{cases} d & \text{for } p \in [0, \widehat{p}] \\ 0 & \text{if } p > \widehat{p} \end{cases},$$

where $\widehat{p}, d > 0$. As can be shown, the theorem does not extend to this class of demand functions, since the marginal effect of transparency on welfare is always positive (and only vanishes in the limit as $\phi \to 1$).[2]

### The optimal level of transparency

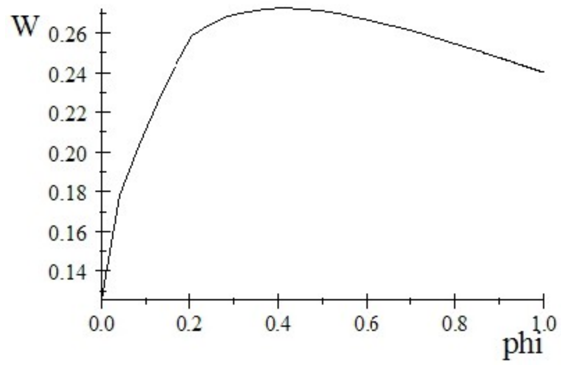
We end this section with illustrating that the optimal level of market transparency can be quite low. To this end, we consider the example of linear demand, $D(p) = 1 - p$, and two potential entrants, $N = 2$.

**Example 1.** The following three figures each plot social welfare as a function of market transparency $\phi$. The figures differ in the size of entry cost $f$. Observe that entry is in mixed actions for a given $\phi \in [0,1]$ if the entry cost satisfies $f < R^m = 1/4$ (otherwise no firm enters) and $f > (1-\phi) R^m/N = (1-\phi)/8$ (otherwise each firm enters with probability one). For a given level of entry cost, the latter condition provides a lower bound on market

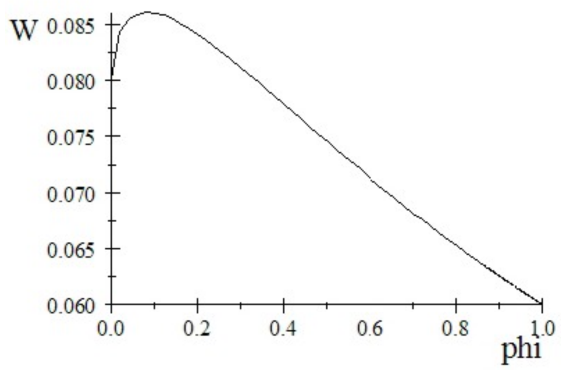
[2]For unit demand functions (where $d = 1$), Schultz (2009) makes a similar observation. Investigating a model of product differentiation, he addresses the case of 'the almost homogeneous market' by taking the limit of transportation cost to zero (see his sections 4 and 5). Social welfare is then maximal in this limit.

transparency (see the first case).

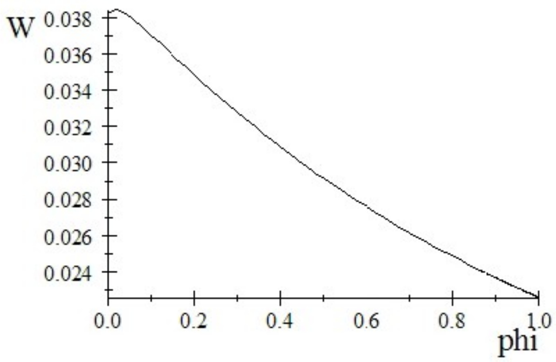
**Low entry cost** Let $f = 1/10$. Then it follows from equation (2) that $\varepsilon = \min\left\{\frac{6}{5(\phi+1)}, 1\right\}$ and entry is in mixed actions for $\phi > 1/5$.




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




**High entry cost** Let $f = 11/48$. This implies $\varepsilon = \frac{1}{6(\phi+1)}$ and entry is in mixed actions for all $\phi \in [0, 1]$ , as well.




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.

## 5 Conclusion

We have provided a framework in which too much market transparency harms competition and reduces social welfare under fairly general conditions. Society faces a trade-off: On the one hand, more transparency intensifies competition, lowers prices and enhances welfare in each oligopoly subgame at the post-entry stage (in *stochastic* terms). On the other, entry becomes less profitable and hence less likely. As a consequence, market breakdown occurs more and oligopoly less often, both of which effects reduce welfare. As our main result shows, the welfare-diminishing effects dominate when markets are sufficiently transparent.

To establish the welfare result we need either one of two weak conditions on the demand function: *At the monopoly price* the demand function either has to exhibit (1) *a strictly positive consumer surplus* or it has to display (2) *a strictly positive deadweight loss* (or both). The only class of demand functions not covered by these conditions are constant demand functions (of which unit demand functions represent a special case).

Our theorem identifies this class as special in two ways. Recall first that social welfare coincides with consumer surplus, because *ex ante* the producer surplus will be eaten up by the entry costs. Then the violation of

(1), i.e. zero consumer surplus in the monopoly case, takes away one comparative advantage of market coverage over market breakdown. In particular, monopoly is put on the same level with market breakdown. The violation of condition (2), i.e. zero deadweight loss at the monopoly price, takes away the welfare gain from competition (relative to monopoly). Both effects weaken the negative welfare effect of market transparency caused via the reduction in entry probability. This is why, *(only) for constant demand functions*, the welfare effect of transparency is unambiguously positive.

We have also imposed two conditions that guarantee an equilibrium with entry in mixed actions. These conditions relate market profitability, entry cost, and the number of potential entrants to each other. First, the market needs to be profitable to at least a single entering firm. Second, there has to be a sufficiently large pool of potential entrants such that firms incur losses in case all potential entrants should happen to enter the market. The role of these assumptions is merely to keep the model as simple as possible. Resorting to Harsanyi's purification theorem (Harsanyi, 1973), we could as well have introduced uncertainty about entry cost into the model in order to obtain equilibrium entry in pure actions.

We conclude this paper relating our findings to the product differentiation literature on market transparency and endogenous entry (Schultz, 2009; Gu and Wenzel, 2011). This literature finds a unique positive effect of market transparency even when entry decisions are taken into account. This finding applies also when the degree of product differentiation approaches zero, i.e., when the product becomes almost homogeneous. We, in contrast, show that too much market transparency is detrimental to social welfare when goods are perfect substitutes and firms simultaneously decide about entry. What exactly drives this difference in the results? Schultz (2009) includes simultaneous entry, but assumes unit demand. Gu and Wenzel (2011), on the other hand, consider price-elastic demand, but investigate sequential entry. It is thus the combination of simultaneous entry and price-elastic demand that entails the negative impact of too much market transparency on welfare in our model.

## Appendix: Proof of the theorem

After some preliminary results, we first investigate the marginal impact of $\phi$ on the entry probability $\varepsilon$ in the limit as $\phi \to 1$. Subsequently, we examine the marginal impact of $\phi$ on the consumer surplus $CS_{\phi}^{K}$ of any $K$-firm oligopoly in the limit as $\phi \to 1$. Finally, we combine these two results to show that the total marginal effect of $\phi$ on *ex ante* expected welfare is negative in the limit as $\phi \to 1$.

### Preliminaries

Consider the $K$-firm oligopoly case with intermediate transparency $\phi \in (0,1)$. By Assumption (D), the equilibrium pricing strategy and its density reduce to

$$\begin{aligned} H^{K}(p) &= H(p) = 1 - \left(\frac{1-\phi}{K\phi}\frac{R^{m}-R(p)}{R(p)}\right)^{\frac{1}{K-1}} \quad \text{and} \qquad (5) \\ h^{K}(p) &= \frac{1-\phi}{K(K-1)\phi}\left(\frac{1-\phi}{K\phi}\frac{R^{m}-R(p)}{R(p)}\right)^{\frac{2-K}{K-1}}\frac{R^{m}R'(p)}{R^{2}(p)}. \qquad (6) \end{aligned}$$

From (5) and (6), we derive the distribution of the minimum price among the $K$ entrants and its density,

$$\begin{aligned} H_{(1)}^{K}(p) &= 1 - \left(1 - H^{K}(p)\right)^{K} \quad \text{and} \\ h_{(1)}^{K}(p) &= K\left(1 - H^{K}(p)\right)^{K-1} h^{K}(p). \end{aligned}$$

To determine consumer surplus further below, we combine the two above distributions, weighing them with the share of uninformed and informed consumers, respectively. The corresponding density and its derivative read

$$\begin{aligned} \overline{h}^{K}(p) &= \phi h_{(1)}^{K}(p) + (1-\phi)\, h^{K}(p) \\ &= \frac{(1-\phi)^{2}}{K(K-1)\phi}\frac{(R^{m})^{2}R'(p)}{R^{3}(p)}\left(\frac{1-\phi}{K\phi}\frac{R^{m}-R(p)}{R(p)}\right)^{\frac{2-K}{K-1}} \\ &= \frac{(1-\phi)R^{m}}{R(p)}h^{K}(p) \quad \text{and} \qquad (7) \\ \frac{d\overline{h}^{K}(p)}{d\phi} &= -\frac{(K-1)\phi+1}{(K-1)\phi(1-\phi)}\overline{h}^{K}(p). \qquad (8) \end{aligned}$$

The lowest price $\underline{p}^K$ in the support is implicitly defined by

$$R\left(\underline{p}^K\right) = \frac{1-\phi}{(K-1)\,\phi+1}R^m.$$

Evaluating the combined density at this price yields

$$\overline{h}^K\left(\underline{p}^K\right) = \frac{[(K-1)\,\phi+1]^3}{K\,(K-1)\,\phi\,(1-\phi)}\frac{R'\left(\underline{p}^K\right)}{R^m} \tag{9}$$

and the derivative of this price with regard to $\phi$ reduces to

$$\frac{d\underline{p}^K}{d\phi} = \frac{-K}{[(K-1)\,\phi+1]^2}\frac{R^m}{R'\left(\underline{p}^K\right)}. \tag{10}$$

### Probability of entry

The equilibrium probability of entry $\varepsilon$ is implicitly given by

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

Using the implicit function theorem, we determine the marginal impact of transparency on the entry probability

$$\frac{d\varepsilon}{d\phi} = \frac{-\varepsilon\left(1-(1-\varepsilon)^N - N\varepsilon\,(1-\varepsilon)^{N-1}\right)}{(1-\phi)\left[1-(1-\varepsilon)^N - N\varepsilon\,(1-\varepsilon)^{N-1}\right] + \phi N\,(N-1)\,\varepsilon^2\,(1-\varepsilon)^{N-2}}.$$

This expression is clearly negative. Moreover, in the limit as $\phi \to 1$, we have

$$\lim_{\phi\to 1}\frac{d\varepsilon}{d\phi} = -\frac{1-(1-\widehat{\varepsilon})^N - N\widehat{\varepsilon}\,(1-\widehat{\varepsilon})^{N-1}}{N\,(N-1)\,\widehat{\varepsilon}\,(1-\widehat{\varepsilon})^{N-2}}, \tag{11}$$

where $\widehat{\varepsilon}$ denotes the entry probability when $\phi \to 1$, i.e.

$$\widehat{\varepsilon} = 1 - (f/R^m)^{1/(N-1)}. \tag{12}$$

Notice that $\widehat{\varepsilon} \in (0,1)$ because of $f \in (R^m/N, R^m)$.

## Consumer surplus of a $K$-firm oligopoly

When $K \geq 2$ firms have entered the market, consumer surplus is (after suppressing the index $K$)

$$CS_{\phi}^{K} = \int_{\underline{p}(\phi)}^{p^m} CS(p)\,\overline{h}(p)\,dp.$$

The marginal impact of $\phi$ on $CS_{\phi}^{K}$ is given by

$$\begin{aligned}
\frac{dCS_{\phi}^{K}}{d\phi} &= -CS\left(\underline{p}(\phi)\right)\overline{h}\left(\underline{p}(\phi)\right)\frac{d\underline{p}}{d\phi} + \int_{\underline{p}(\phi)}^{p^m} CS(p)\,\frac{d\overline{h}(p)}{d\phi}dp \\
&= CS\left(\underline{p}(\phi)\right)\frac{(K-1)\phi+1}{(K-1)\phi(1-\phi)} - \frac{(K-1)\phi+1}{(K-1)\phi(1-\phi)}CS_{\phi}^{K} \\
&= \frac{(K-1)\phi+1}{(K-1)\phi}\frac{CS\left(\underline{p}(\phi)\right)-CS_{\phi}^{K}}{(1-\phi)}, \qquad (13)
\end{aligned}$$

where the second equality follows from equations (8), (9), and (10).

We decompose the second fracture into two terms,

$$\frac{CS\left(\underline{p}(\phi)\right)-CS_{\phi}^{K}}{(1-\phi)} = \frac{CS\left(\underline{p}(\phi)\right)-CS(0)}{(1-\phi)} + \frac{CS(0)-CS_{\phi}^{K}}{(1-\phi)}. \qquad (14)$$

Taking the limit $\phi \to 1$, the first term reduces to

$$\begin{aligned}
& \lim_{\phi\to 1}\frac{CS\left(\underline{p}(\phi)\right)-CS(0)}{(1-\phi)} \\
= {} & \lim_{\phi\to 1}\left(D\left(\underline{p}(\phi)\right)\frac{d\underline{p}(\phi)}{d\phi}\right) \\
= {} & \lim_{\phi\to 1}\left(D\left(\underline{p}(\phi)\right)\frac{-K}{\left[(K-1)\phi+1\right]^2}\frac{R^m}{R'\left(\underline{p}^K\right)}\right) \\
= {} & \left(\lim_{\phi\to 1}\frac{-KR^m}{\left[(K-1)\phi+1\right]^2}\right)\left(\lim_{\phi\to 1}\frac{D\left(\underline{p}(\phi)\right)}{D\left(\underline{p}(\phi)\right)+\underline{p}(\phi)D'\left(\underline{p}(\phi)\right)}\right) \\
= {} & -\frac{R^m}{K}, \qquad (15)
\end{aligned}$$

where the first equality follows from applying l'Hôpital's rule and the second from equation (10). The last equation holds because the second limit is one by Assumption (D).

To evaluate the second term, we divide it by $R^m$,

$$\begin{aligned}
\frac{CS(0)-CS_\phi^K}{(1-\phi)R^m} &= \frac{1}{(1-\phi)R^m}\int_{\underline{p}(\phi)}^{p^m}\left(\int_0^p D(\widetilde{p})\,d\widetilde{p}\right)\overline{h}(p)\,dp \\
&= \int_{\underline{p}(\phi)}^{p^m}\frac{\left(\int_0^p D(\widetilde{p})\,d\widetilde{p}\right)}{R(p)}h(p)\,dp \\
&= \int_{\underline{p}(\phi)}^{p^m}\Psi(p)\,h(p)\,dp, \qquad (16)
\end{aligned}$$

where the second equality follows from equation (7) and the third from setting $\Psi(p) := \left(\int_0^p D(\widetilde{p})\,d\widetilde{p}\right)/R(p)$ for any price $p \in (0, p^m]$. By Proposition 5, as $\phi \to 1$, the Nash equilibrium strategy converges (in probability) to the degenerate mixed strategy assigning probability one to marginal cost. Moreover, notice that $\Psi(p)$ is continuous on $p \in (0, p^m]$ and that, by Assumption (D),

$$\lim_{p\to 0}\Psi(p) = \lim_{p\to 0}\frac{D(p)}{D(p)+pD'(p)} = 1.$$

Since the last expression in (16) represents the expected value of $\Psi(p)$ under the symmetric Nash equilibrium strategy $H(p)$, we thus obtain

$$\lim_{\phi\to 1}\frac{CS(0)-CS_\phi^K}{(1-\phi)R^m} = \lim_{\phi\to 1}\int_{\underline{p}(\phi)}^{p^m}\Psi(p)\,h(p)\,dp = 1. \qquad (17)$$

Combining (15) and (17), we obtain the limit of (14) as $\phi \to 1$,

$$\begin{aligned}
\lim_{\phi\to 1}\frac{CS\left(\underline{p}(\phi)\right)-CS_\phi^K}{(1-\phi)} &= \lim_{\phi\to 1}\frac{CS\left(\underline{p}(\phi)\right)-CS(0)}{(1-\phi)} + \lim_{\phi\to 1}\frac{CS(0)-CS_\phi^K}{(1-\phi)} \\
&= \frac{K-1}{K}R^m.
\end{aligned}$$

Thus, as $\phi \to 1$, marginal consumer surplus (13) converges to

$$\lim_{\phi\to 1}\frac{dCS_\phi^K}{d\phi} = \lim_{\phi\to 1}\frac{(K-1)\phi+1}{(K-1)\phi}\frac{CS\left(\underline{p}(\phi)\right)-CS_\phi^K}{(1-\phi)} = R^m. \qquad (18)$$

## *Ex ante* expected welfare

Recall equation (4), representing expected welfare before entry:

$$\mathbf{E}\left[CS\right] = N\varepsilon\left(1-\varepsilon\right)^{N-1}CS^{m} + \sum_{K=2}^{N}\left(\begin{array}{c} N \\ K \end{array}\right)\varepsilon^{K}\left(1-\varepsilon\right)^{N-K}CS_{\phi}^{K}.$$

The corresponding marginal impact of transparency is hence given by

$$\begin{aligned}
\frac{d\mathbf{E}\left[CS\right]}{d\phi} &= \frac{\partial\mathbf{E}\left[CS\right]}{\partial\varepsilon}\frac{d\varepsilon}{d\phi} + \frac{\partial\mathbf{E}\left[CS\right]}{\partial\phi} \\
&= \left[N\left(1-N\varepsilon\right)\left(1-\varepsilon\right)^{N-2}CS^{m}\right]\frac{d\varepsilon}{d\phi} \\
&\quad + \left[\sum_{K=2}^{N}\left(\begin{array}{c} N \\ K \end{array}\right)\left(K-N\varepsilon\right)\varepsilon^{K-1}\left(1-\varepsilon\right)^{N-K-1}CS_{\phi}^{K}\right]\frac{d\varepsilon}{d\phi} \\
&\quad + \sum_{K=2}^{N}\left(\begin{array}{c} N \\ K \end{array}\right)\varepsilon^{K}\left(1-\varepsilon\right)^{N-K}\frac{dCS_{\phi}^{K}}{d\phi}. \qquad (19)
\end{aligned}$$

Observe that taking the limit $\phi \to 1$, all expressions that depend on $\phi$ converge. First, $CS_{\phi}^{K}$ approaches $CS\left(0\right)$ for all $K \geq 2$ by Proposition 5 and continuity of $CS\left(p\right)$. Second, by equation (18), $dCS_{\phi}^{K}/d\phi$ converges to $R^{m}$, which holds independently of $K \geq 2$. Third, by equation (11), $\lim_{\phi\to 1} d\varepsilon/d\phi$ exists. Fourth and finally, the equilibrium probability of entry converges as well by equation (12). Therefore, we can take the limit $\phi \to 1$ of equation (19) to obtain

$$\begin{aligned}
\lim_{\phi\to 1}\frac{d\mathbf{E}\left[CS\right]}{d\phi} &= \left[N\left(1-N\widehat{\varepsilon}\right)\left(1-\widehat{\varepsilon}\right)^{N-2}CS^{m}\right]\left(\lim_{\phi\to 1}\frac{d\varepsilon}{d\phi}\right) \\
&\quad + \left[\sum_{K=2}^{N}\left(\begin{array}{c} N \\ K \end{array}\right)\left(K-N\widehat{\varepsilon}\right)\widehat{\varepsilon}^{K-1}\left(1-\widehat{\varepsilon}\right)^{N-K-1}CS\left(0\right)\right]\left(\lim_{\phi\to 1}\frac{d\varepsilon}{d\phi}\right) \\
&\quad + \sum_{K=2}^{N}\left(\begin{array}{c} N \\ K \end{array}\right)\widehat{\varepsilon}^{K}\left(1-\widehat{\varepsilon}\right)^{N-K}R^{m},
\end{aligned}$$

where again $\widehat{\varepsilon}$ denotes the limit entry probability (12) when $\phi \to 1$.

To simplify the second bracket, we make use of the following two identities,

$$\sum_{K=2}^{N}\left(\begin{array}{c} N \\ K \end{array}\right)K\varepsilon^{K-1}\left(1-\varepsilon\right)^{N-K-1} = \frac{N}{1-\varepsilon}\left[1-\left(1-\varepsilon\right)^{N-1}\right] \qquad \text{and}$$

$$N\sum_{K=2}^{N}\left(\begin{array}{c}N\\K\end{array}\right)\varepsilon^{K}(1-\varepsilon)^{N-K-1} = \frac{N}{1-\varepsilon}\left[1-(1-\varepsilon)^{N}-N\varepsilon(1-\varepsilon)^{N-1}\right],$$

which imply

$$\begin{aligned}
&\sum_{K=2}^{N}\left(\begin{array}{c}N\\K\end{array}\right)(K-N\varepsilon)\varepsilon^{K-1}(1-\varepsilon)^{N-K-1}\\
=\; &\frac{N}{1-\varepsilon}\left[1-(1-\varepsilon)^{N-1}\right]-\frac{N}{1-\varepsilon}\left[1-(1-\varepsilon)^{N}-N\varepsilon(1-\varepsilon)^{N-1}\right]\\
=\; &N(N-1)\varepsilon(1-\varepsilon)^{N-2}.
\end{aligned}$$

We hence obtain

$$\begin{aligned}
&\lim_{\phi\to 1}\frac{d\mathbf{E}[CS]}{d\phi}\\
=\; &\left[N(1-N\widehat{\varepsilon})(1-\widehat{\varepsilon})^{N-2}CS^{m}\right]\left(\lim_{\phi\to 1}\frac{d\varepsilon}{d\phi}\right)\\
&+\left[\sum_{K=2}^{N}\left(\begin{array}{c}N\\K\end{array}\right)(K-N\widehat{\varepsilon})\widehat{\varepsilon}^{K-1}(1-\widehat{\varepsilon})^{N-K-1}CS(0)\right]\left(\lim_{\phi\to 1}\frac{d\varepsilon}{d\phi}\right)\\
&+\sum_{K=2}^{N}\left(\begin{array}{c}N\\K\end{array}\right)\widehat{\varepsilon}^{K}(1-\widehat{\varepsilon})^{N-K}R^{m}\\
=\; &\left[N(1-N\widehat{\varepsilon})(1-\widehat{\varepsilon})^{N-2}CS^{m}+N(N-1)\widehat{\varepsilon}(1-\widehat{\varepsilon})^{N-2}CS(0)\right]\\
&\times\left(-\frac{1-(1-\widehat{\varepsilon})^{N}-N\widehat{\varepsilon}(1-\widehat{\varepsilon})^{N-1}}{N(N-1)\widehat{\varepsilon}(1-\widehat{\varepsilon})^{N-2}}\right)\\
&+R^{m}\left[1-(1-\widehat{\varepsilon})^{N}-N\widehat{\varepsilon}(1-\widehat{\varepsilon})^{N-1}\right]\\
=\; &\left[(1-N\widehat{\varepsilon})CS^{m}+(N-1)\widehat{\varepsilon}CS(0)\right]\left(-\frac{1-(1-\widehat{\varepsilon})^{N}-N\widehat{\varepsilon}(1-\widehat{\varepsilon})^{N-1}}{(N-1)\widehat{\varepsilon}}\right)\\
&+R^{m}\left[1-(1-\widehat{\varepsilon})^{N}-N\widehat{\varepsilon}(1-\widehat{\varepsilon})^{N-1}\right]\\
=\; &-(1-N\widehat{\varepsilon})CS^{m}\frac{1-(1-\widehat{\varepsilon})^{N}-N\widehat{\varepsilon}(1-\widehat{\varepsilon})^{N-1}}{(N-1)\widehat{\varepsilon}}\\
&-(CS(0)-R^{m})\left[1-(1-\widehat{\varepsilon})^{N}-N\widehat{\varepsilon}(1-\widehat{\varepsilon})^{N-1}\right]\\
=\; &-CS^{m}\frac{1-(1-\widehat{\varepsilon})^{N}-N\widehat{\varepsilon}(1-\widehat{\varepsilon})^{N-1}}{(N-1)\widehat{\varepsilon}}\\
&+CS^{m}\frac{N\left(1-(1-\widehat{\varepsilon})^{N}-N\widehat{\varepsilon}(1-\widehat{\varepsilon})^{N-1}\right)}{N-1}
\end{aligned}$$

$$
\begin{aligned}
& -\left(CS\left(0\right)-R^{m}\right)\left[1-\left(1-\widehat{\varepsilon}\right)^{N}-N\widehat{\varepsilon}\left(1-\widehat{\varepsilon}\right)^{N-1}\right] \\
= \; & -CS^{m}\left(\frac{1-\left(1-\widehat{\varepsilon}\right)^{N}-N\widehat{\varepsilon}\left(1-\widehat{\varepsilon}\right)^{N-1}}{\left(N-1\right)\widehat{\varepsilon}}\right) \\
& +CS^{m}\frac{1-\left(1-\widehat{\varepsilon}\right)^{N}-N\widehat{\varepsilon}\left(1-\widehat{\varepsilon}\right)^{N-1}}{N-1} \\
& +CS^{m}\left(1-\left(1-\widehat{\varepsilon}\right)^{N}-N\widehat{\varepsilon}\left(1-\widehat{\varepsilon}\right)^{N-1}\right) \\
& -\left(CS\left(0\right)-R^{m}\right)\left[1-\left(1-\widehat{\varepsilon}\right)^{N}-N\widehat{\varepsilon}\left(1-\widehat{\varepsilon}\right)^{N-1}\right] \\
= \; & -\left(\frac{1-\left(1-\widehat{\varepsilon}\right)^{N}-N\widehat{\varepsilon}\left(1-\widehat{\varepsilon}\right)^{N-1}}{N-1}\right)\frac{1-\widehat{\varepsilon}}{\widehat{\varepsilon}}CS^{m} \\
& -\left[1-\left(1-\widehat{\varepsilon}\right)^{N}-N\widehat{\varepsilon}\left(1-\widehat{\varepsilon}\right)^{N-1}\right]\left(CS\left(0\right)-CS^{m}-R^{m}\right).
\end{aligned}
$$

Thus, either of the two conditions, $CS\left(0\right)-CS^{m}-R^{m}>0$ and $CS^{m}>0$, imply a negative impact of transparency on social welfare as long as $\phi$ is sufficiently close to $1$. *Q.E.D.*

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