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Transparency, Price-Dependent Demand and Product Variety

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Transparency, Price-Dependent Demand and Product Variety[*]

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Abstract

This paper revisits the relationship between transparency on the consumer side and product variety as analyzed in Schultz (2009). We identify two welfare effects of transparency. More transparency decreases price-cost margins which is beneficial for welfare. On the other hand, more transparency reduces variety which can be positive or negative for welfare. Overall, more transparency is always welfare-improving.

Keywords: Market Transparency, Product Variety, Salop Model
JEL-Classification: L13, L15, L40

1   Introduction

This paper reconsiders the effects of consumer side transparency on product variety and social welfare in a differentiated product market. In a recent pa-

per, Schultz (2009) demonstrates within the framework of the Salop model that more transparency leads to fewer product variety. As the Salop model exhibits excess entry, more transparency necessarily is welfare-improving. The present paper considers the robustness of this welfare result in a more general model where product variety can be excessive or insufficient. In such a framework the welfare impacts of transparency are a priori not obvious.

We extend the model of Schultz (2009) in the following way. Schultz uses a version of the Salop (1979) model with two consumers groups, informed and uninformed consumers. Only informed consumers are fully aware of prices charged by all firms while uninformed consumers always buy from the nearest one. The proportion of informed consumers is then taken as a measure for the transparency in the market. We follow this approach. One feature of the Salop model and of Schultz (2009) is that consumer demand for the differentiated product is inelastic. A consumer demands one single unit as long as the price is lower than the reservation value. In contrast, following Gu and Wenzel (2009a), we consider a version wherein demand is price-dependent. In this setup, product variety can be excessive or insufficient.

We identify two effects of increasing transparency on welfare. Firstly, it decreases the price-cost margin which affects welfare positively. Secondly, transparency reduces entry which is positive for welfare when variety is excessive but negative if there is insufficient variety. The total welfare effect of transparency is the sum of these two effects. In the case of excessive variety, both effects point in the same direction and the total effect is unambiguous. In the case of insufficient variety, the effects point in opposite directions. Surprisingly, however, the price effect dominates and increasing transparency is always welfare-improving. Thus, the present paper strengthens the robustness of the welfare results in Schultz (2009). Note, however, that the reasons for the results differ. While in the paper by Schultz (2009) welfare increases due to a reduction in (excessive) variety, in our paper the decrease of the price-cost margin is responsible for the overall result.

2 The model

Consider a variant of the Salop (1979) model. We depart in two aspects from the standard model. Firstly, as in Varian (1980) and Schultz (2009), consumers of proportion $\phi \in (0, 1]$ are fully aware of prices charged by all firms. Other consumers $(1 - \phi)$, however, are unaware of prices and buy from the nearest store. Secondly, we introduce price-dependent demand. Following the approach in Gu and Wenzel (2009a), we consider a demand function with a constant elasticity.[1]

Consumer utility depends on the quantity of the differentiated product and the quantity of a homogeneous numeraire good:

$$U = \begin{cases} \left(V - \frac{\epsilon}{1-\epsilon} q_d^{\frac{\epsilon-1}{\epsilon}} - td \right) + q_h & \text{if consumes the differentiated product} \\ q_h & \text{otherwise,} \end{cases}$$

$$(1)$$

where q_d is the amount of the differentiated product and q_h the amount of the numeraire good. The parameter $0 < \epsilon < 1$ is the demand elasticity of the differentiated good.[2] Transportation costs are linear at a rate t and d is the distance between the consumer's location and the firm's.

Each consumer has a fixed budget of Y to finance the consumption of the differentiated and the homogeneous product. Normalizing the price of the homogeneous product to one the budget constraint is $Y = p_d q_d + q_h$, where p_d is the price of the differentiated product. Maximization of the utility function under the budget constraint yields the demand for the differentiated and the homogeneous product:[3]

$$\hat{q}_d = p_d^{-\epsilon}, \tag{2}$$

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[1] Using a demand function with constant elasticity has the advantage of yielding closed-form solutions. However, our results do also hold for other demand functions. In light of Gu and Wenzel (2009b), we have checked the robustness of our result when using a linear demand function. We had to rely on numerical solutions but the welfare results do not change compared to the specification used in this paper.

[2] When ϵ approaches zero, demand tends to be completely inelastic and the model converges to the one in Schultz (2009).

[3] We assume that all consumers decide to buy a positive amount of the differentiated good, i.e., the market is covered. This can be assured when V is sufficiently high.

$$\hat{q}_h = Y - p_d^{1-\epsilon}. \tag{3}$$

Inserting into (1) gives the indirect utility when consuming the differentiated product from a certain firm:

$$\hat{U} = V + Y - \frac{1}{1-\epsilon} p_d^{1-\epsilon} - td. \tag{4}$$

There are $n \geq 2$ firms offering the differentiated product. These firms are located equidistantly around the circle. We seek for a symmetric equilibrium. Therefore, we derive the demand of a representative firm i, for convenience to be located at zero. Firms attract consumers from both groups: informed and uninformed consumers. Uninformed consumers buy from the nearest firm. Therefore, each firm has a market share of $\frac{1}{n}$ of the uninformed consumers. Informed consumers are fully aware of all prices and choose to buy from the firm that offers the highest utility. The marginal consumer is given by:

$$x = \frac{1}{2n} + \frac{p^{1-\epsilon} - p_i^{1-\epsilon}}{2t(1-\epsilon)}. \tag{5}$$

Adding up informed and uninformed consumers the market share of firm i is:

$$m_i = \phi \left[\frac{1}{n} + \frac{p^{1-\epsilon} - p_i^{1-\epsilon}}{t(1-\epsilon)} \right] + (1-\phi)\frac{1}{n}. \tag{6}$$

As each consumer demands a quantity $p_i^{-\epsilon}$ of the differentiated product, total demand for its product is $D_i = m_i p_i^{-\epsilon}$.

3   Equilibrium analysis

Price equilibrium

We start by considering the price equilibrium for a given number of firms in the market. Assuming zero production costs, the profit function of the representative firm i is:

$$\Pi_i = D_i p_i = m_i p_i^{1-\epsilon}. \tag{7}$$

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Maximizing profits with respect to p_i and exploiting symmetry gives the equilibrium price:[4]

$$p^c = \left[\frac{t(1-\epsilon)}{\phi n} \right]^{\frac{1}{1-\epsilon}}. \tag{8}$$

The corresponding profits are

$$\Pi^c = \frac{t(1-\epsilon)}{\phi n^2}. \tag{9}$$

Both prices and profits decrease in the share of informed consumers.

Free entry

In the next step we determine equilibrium product variety. To enter the market an investment of f is needed. The number of entering firms is determined by setting (9) equal to f:

$$n^* = \sqrt{\frac{t(1-\epsilon)}{\phi f}}. \tag{10}$$

The number of entrants decreases with the share of informed consumers. Thus, transparency has an adverse impact on product variety in the market. Inserting n^* into (8) gives the free-entry equilibrium price:

$$p^* = \left[\sqrt{\frac{tf(1-\epsilon)}{\phi}} \right]^{\frac{1}{1-\epsilon}}. \tag{11}$$

The price decreases when the market is more transparent. As we have assumed zero production costs, the price is moving closer to marginal cost.

4   Welfare impact of transparency

Our main concern in this paper is to determine the impact of transparency on the welfare properties of the free-entry equilibrium. We study the im-

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[4]We focus on the case where firms want to serve both types of consumers, informed and uninformed. This can be guaranteed by letting transportation costs be sufficiently high. For a more detailed discussion see Schultz (2009).

pact of increased transparency on total welfare which is defined by the sum of consumer surplus and industry profits. For given prices and neglecting constants, welfare is

$$W = -\frac{1}{1-\epsilon}p^{1-\epsilon} - 2n\int_0^{\frac{1}{2n}} tx \, dx + p^{1-\epsilon} - fn. \tag{12}$$

Singling out variety effects

For our later results it is useful to determine the first-best optimal number of firms. In a first-best optimum, the price of the differentiated product is set equal to marginal cost. Maximizing of (12) with respect to n gives:

$$n^f = \sqrt{\frac{t}{4f}}. \tag{13}$$

The optimal number of entrants is determined by the classic trade-off between fixed costs and reduction in transportation costs. This number is independent of the price elasticity of demand and the proportion of informed consumers. Comparing (10) and (13) we find there is excessive entry if $\phi < \bar{\phi}$, insufficient entry if $\phi > \bar{\phi}$, and optimal entry if $\phi = \bar{\phi}$ where $\bar{\phi} = 4(1-\epsilon)$.

An increase in transparency always leads to fewer entry. If there is excessive entry, a decrease in entry is beneficial. However, if there is insufficient entry a further reduction in the number of entrants harms welfare. Thus, the impact of transparency on welfare is not clear-cut anymore as in the model by Schultz (2009). The possibility of insufficient entry may make less transparency desirable in order to promote additional entry. More specifically, if $\epsilon > 3/4$, then $\bar{\phi} < 1$. In this case, full transparency (or any level of transparency above $\bar{\phi}$) is not efficient when only variety effects are considered. However, in the present model market transparency affects welfare insofar as it affects price competition of the firms. We proceed to the investigation of total welfare when the price is determined by price competition.

Price and total effects

To determine the impact of transparency on total welfare we evaluate (12) at the free-entry values for variety and price given by (10) and (11). We have already seen transparency affects equilibrium price and variety. More transparency intensifies price competition and thus reduces price and firm profits, and hence product variety. ¿From (12), it is evident that both price and variety have welfare impacts. To disentangle these two effects we decompose welfare in the following way:

$$W_p = -\frac{1}{1-\epsilon}p^{1-\epsilon} + p^{1-\epsilon} = -\epsilon\sqrt{\frac{tf}{\phi(1-\epsilon)}}, \tag{14}$$

and

$$W_n = -2n\int_0^{\frac{1}{2n}} txdx - fn = -\frac{[4(1-\epsilon)+\phi]\sqrt{tf}}{4\sqrt{\phi(1-\epsilon)}}, \tag{15}$$

where $W = W_p + W_n$. The first term (W_p) regards welfare with respect to prices consisting of consumer surplus and firm revenue from selling the differentiated product. The second term (W_n) represents welfare with respect to variety, that is, the sum of transportation costs and fixed costs for establishing the varieties.

First, we evaluate how consumption efficiency is affected by transparency:

$$\frac{dW_p}{d\phi} = \frac{\epsilon\sqrt{tf}}{2\phi\sqrt{(1-\epsilon)\phi}} > 0. \tag{16}$$

Increasing transparency has a positive effect on consumption efficiency. This is intuitive. As price goes closer to marginal cost consumption efficiency increases. Note that this effect is not present in the analysis by Schultz (2009). In his model demand is inelastic and hence prices are mere transfers between firms and consumers without having real welfare effects.

Now we consider the effect of a larger share of informed consumers on product variety and the resulting effect on welfare:

$$\frac{dW_n}{d\phi} = \frac{(4(1-\epsilon)-\phi)\sqrt{tf}}{8\phi\sqrt{(1-\epsilon)\phi}}. \tag{17}$$

This term can be positive or negative according to the following condition:

$$\frac{dW_n}{d\phi} \gtreqqless 0 \iff \phi \lesseqqgtr 4(1-\epsilon) = \bar{\phi}, \tag{18}$$

which is (necessarily) identical to the condition from the first-best welfare analysis. This second effect can be positive or negative depending on whether there is excessive or insufficient entry.

The overall effect of transparency is the sum of the two individual effects. In situations with excessive variety both effects point into the same direction and the total effect of transparency is clearly positive. In case of insufficient variety the two effects oppose each other and the overall effect is a priori ambiguous and we have to calculate the overall effect:

$$\frac{dW}{d\phi} = \frac{dW_p}{d\phi} + \frac{dW_n}{d\phi} = \frac{\sqrt{tf}}{8\phi\sqrt{\phi(1-\epsilon)}}(4-\phi) > 0. \tag{19}$$

As $0 < \phi \leq 1$ the above expression is positive and hence, somewhat surprisingly, there is always a positive welfare impact of more transparency.

Besides the effect on total welfare we are also interested in consumer surplus. As in the free-entry equilibrium firms earn zero profits, total welfare and consumer surplus coincide. Hence, our results also hold for consumer surplus. We highlight our welfare results in the following proposition:

Proposition 1. Transparency always increases total welfare and consumer surplus.

This finding strengthens the result in Schultz (2009). In the presence of endogenous product variety, more transparency is unambiguously welfare-improving which holds true irrespective whether consumer demand is completely inelastic or price dependent. Note, however, that in the Schultz (2009) paper the welfare effect is derived solely by the reduction in excess entry. On the contrary, in our model this effect can be positive or negative. New is the consumption efficiency effect as prices influence the quantity consumed.

5 Conclusion

This paper strengthens the result that increasing transparency has positive welfare effects when considering competition in a differentiated product market with endogenous product variety. Though increasing transparency may decrease welfare by lowering variety this is more than offset by the benefits of reduced prices.

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