The strategic use of debt reconsidered

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SOM-Theme E: Financial markets and institutions

Abstract

Wanzenried (2003, International Journal of Industrial Organization 21(2), 171-200) considers a two-stage differentiated goods duopoly model with demand uncertainty linking firms' capital structure choice to their output market decisions. Unfortunately, her analysis is flawed. We correct for this, and solve the model numerically to find some results that are qualitatively different from hers. First, in equilibrium, the use of debt *always* yields lower firm profits, i.e. even in the case of complements. Second, the equilibrium debt level *decreases* as demand becomes more volatile. We also discuss some problems with the debt contract commonly used in the strategic debt literature.

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1 Introduction

In an interesting paper in the *International Journal of Industrial Organization*, Gabrielle Wanzenried (2003) studies the effects of debt on product market competition. In a simple duopoly model with demand uncertainty and differentiated products, she considers the incentives of firms to take on debt, and also analyzes how equilibrium debt levels affect equilibrium prices, profits and welfare. She looks at the effects of a change in the degree of substitutability between the products, and a change in the volatility of demand.

Unfortunately however, her analysis is flawed. In this paper, we correct her results. In our analysis, we also avoid some other conceptual problems that are present in this literature. It is not possible to solve the model analytically. We therefore resort to numerical methods. We show that solving the model correctly yields results that are qualitatively different from those reported by Wanzenried (2003). For example, we show that in equilibrium, the use of debt *always* yields lower firm profits, i.e. even in the case of complements. Also, we show that the equilibrium debt level *decreases* as demand becomes more volatile.

Brander and Lewis (1986) were the first to show that the limited liability associated with debt financing affects the strategic decisions of firms. Firms holding debt will maximize their net profits, i.e. their profit after debt repayment. More debt then gives them an incentive to compete more aggressively. Brander and Lewis (1986) showed that, in the case of Cournot competition, this results in lower prices. For a more complete discussion of and references to this literature, see Wanzenried (2003).

The remainder of this paper is organized as follows. In section 2, we present

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Wanzenried's model. Section 3 discusses the solution of that model with Cournot competition. In section 4, we question some of the implicit assumptions that are commonly made in the strategic debt literature. We make some adjustments to the model to avoid these issues. Since it is not possible to find a closed-form solution for the model, we turn to a numerical solution approach in section 5. That section also presents our main results. The case of Bertrand competition is considered in section 6. Section 7 concludes.

2 The model

Wanzenried (2003) considers a two-stage duopoly model with product differentiation. In the first stage, firms choose their debt levels. In the second stage, they compete on the product market by setting quantities. Marginal costs of production are constant and normalized to zero. Inverse demand is given by

$$p_i = \alpha - q_i - \gamma q_j + z_i, \tag{1}$$

where p_i is the price for firm i's product, q_i is the quantity set by firm i, and z_i represents an exogenous demand shock, for $i, j = 1, 2$, $i \neq j$. The parameter α reflects the size of the market, and γ refers to the degree of substitutability between the products, with $\gamma \in [-1, 1]$. If $\gamma > 0$, the products are substitutes. With $\gamma < 0$, they are complements. With $\gamma = 0$, each firm is a monopolist. The shock z_i is uniformly distributed on $[-\overline{z}, \overline{z}]$. The shocks z_1 and z_2 are uncorrelated.[1]

In stage 1, firms can take on debt by borrowing from bondholders. We

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[1]Alternatively, we could assume that both firms face a common shock z_i. For the case of Cournot competition, this does not affect the results.

denote by S_i the debt of firm i. As usual, assume that firms choose their debt levels in order to maximize total expected profits. Given S_j, firm is first-stage maximization problem then is

$$\max_{S_i} \int_{-\bar{z}}^{\bar{z}} \left[(\alpha - q_i(S_i, S_j) - \gamma q_j(S_j, S_i) + z_i) q_i(S_i, S_j) \right] \frac{1}{2\bar{z}} dz_i, \qquad (2)$$

where $q_i(S_i, S_j)$ and $q_j(S_i, S_j)$ denote the equilibrium values of q_i and q_j that will be set in stage 2, given the debt levels S_i and S_j.

If a firm's operating profits fall short of its debt, then its net profits are zero, and all operating profits go to bondholders. We thus have a critical level of z_i, denoted by $\hat{z}_i$, for which firm i is just able to repay its debt. If $z_i < \hat{z}_i$, firm i's operating profits fall below its debt level. The critical debt level $\hat{z}_i$ is implicitly defined by

$$(\alpha - q_i - \gamma q_j + \hat{z}_i) q_i - S_i = 0 \qquad i = 1, 2, \quad i \neq j. \qquad (3)$$

Wanzenried takes $S_i \equiv (1 + r_i)D_i$, with D_i the amount firm i receives in period 1, and r_i the interest rate. When solving the model numerically, we will choose a slightly different specification (see section 4). For the purpose of the next section, this is immaterial.

In stage 2, firms choose quantities, and debt levels are given. Firms maximize net profits, i.e. the expected profits after repayment of their debt. The maximization problem of firm i is given by

$$\max_{q_i} \int_{\hat{z}_i}^{\bar{z}} \left[(\alpha - q_i - \gamma q_j + z_i) q_i - S_i \right] \frac{1}{2\bar{z}} dz_i. \qquad (4)$$

3   Solving the model

We solve the model using backward induction. In stage 2, maximizing (4) yields the first-order condition

$$\int_{\widehat{z}_i}^{\overline{z}} \left(\alpha - 2q_i - \gamma q_j + z_i\right) \frac{1}{2\overline{z}} dz_i - \left[\left(\alpha - q_i - \gamma q_j + \widehat{z}_i\right) q_i - S_i\right] \frac{1}{2\overline{z}} \frac{d\widehat{z}_i}{dq_i} = 0. \quad (5)$$

The second term vanishes because of (3). Solving this for q_i, we have

$$q_i\left(q_j, \widehat{z}_i\right) = \frac{1}{4}\overline{z} + \frac{1}{2}\alpha - \frac{1}{2}\gamma q_j + \frac{1}{4}\widehat{z}_i\left(q_i, q_j\right). \quad (6)$$

From this, the output levels can be derived by determining the intersection of the reaction functions $q_i\left(q_j, \widehat{z}_i\right)$ and $q_j\left(q_i, \widehat{z}_j\right)$. Note that the right-hand side of this equality also depends on q_i. In her next step, however, Wanzenried (2003) disregards this fact. She effectively assumes that $\widehat{z}_i\left(q_i, q_j\right) = \widehat{z}_i$, and derives that

$$q_i\left(\widehat{z}_i, \widehat{z}_j\right) = \frac{1}{2} \frac{2\widehat{z}_i - \gamma\widehat{z}_j + \left(\overline{z} + 2\alpha\right)\left(2 - \gamma\right)}{4 - \gamma^2}, \quad (7)$$

which is her equation (3.4).[2]   This is incorrect. Note however that the same mistake is made by Hughes et al. (1998) in a model which differs in some aspects of its specification but is equivalent in essential elements. Substituting $\widehat{z}_i$ from (3) into (6) yields

$$q_i = \frac{1}{4}\overline{z} + \frac{1}{2}\alpha - \frac{1}{2}\gamma q_j + \frac{1}{4}\left(q_i + \gamma q_j - \alpha + \frac{S_i}{q_i}\right). \quad (8)$$

Rewriting this yields the following reaction function for firm i, given its debt level S_i:

$$q_i\left(q_j\right) = \frac{1}{6}\overline{z} + \frac{1}{6}\alpha - \frac{1}{6}\gamma q_j + \frac{1}{6}\sqrt{\left(\overline{z} + \alpha - \gamma q_j\right)^2 + 12S_i}. \quad (9)$$

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[2]Note that Wanzenried (2003) has $-2\gamma\widehat{z}_j$ in the numerator of her (3.4), instead of $-\gamma\widehat{z}_j$. We take this to be a typo. This is confirmed by substituting $\widehat{z}^*$ from her (3.6) into our expression (7), which yields exactly the expression for q^* that she gives in her (3.7).

It is not possible to find a closed-form solution for the equilibrium output levels for general values of S_i and S_j, as this requires one to solve a polynomial function of degree 4.

Finally, note that total welfare is given by

$$W = \int_{-\bar{z}}^{\bar{z}} \int_{-\bar{z}}^{\bar{z}} \left[(\alpha + z_1) q_1 + (\alpha + z_2) q_2 - \frac{1}{2} \left(q_1^2 + 2\gamma q_1 q_2 + q_2^2 \right) \right] \frac{1}{4\bar{z}^2} dz_1 dz_2. \tag{10}$$

A priori, firms are identical. We therefore expect the resulting equilibrium quantities to be identical as well. Denote this value by $q \equiv q_1 = q_2$. We then have

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\begin{aligned}
W &= \int_{-\bar{z}}^{\bar{z}} \int_{-\bar{z}}^{\bar{z}} \left[2 (\alpha + z_1) q - (1 + \gamma) q^2 \right] \frac{1}{4\bar{z}^2} dz_1 dz_2 \\
&= 2\alpha q - (1 + \gamma) q^2. \tag{11}
\end{aligned}
$$

4   Some other issues

There are two additional aspects in which our approach differs from the approach that is common in the literature.

First, the literature effectively assumes that the amount of money that a firm borrows is burnt. Wanzenried (2003, p. 176, (2.3)), for example, uses the following equality to implicitly define $\hat{z}_i$:

$$(\alpha - q_i - \gamma q_j + \hat{z}_i) q_i - D_i (1 + r_i) = 0 \qquad i = 1, 2, \quad i \neq j, \tag{12}$$

so $S_i \equiv D_i(1 + r_i)$, using (3). Here, D_i denotes the size of the loan of firm i, and r_i the interest rate charged by its bondholders. Firm i thus receives an amount D_i in period 1, and promises to pay back $D_i(1 + r_i)$ in period 2. When a firm receives an amount D_i in period 1, it can be put to several uses. First, the firm can simply keep the funds. If it chooses to do so,

then its reserves in period 2 will be higher, which implies that it will be less likely to default on its debt. Its limited liability constraint (12) is then relaxed. Alternatively, the firm's owners or managers may expropriate the money; Brander and Lewis (1988) argue that "borrowed money is turned over directly to shareholders" (p. 225). But if this is the case, then it will have an effect on the incentive to take on debt. Effectively, the specification above implicitly assumes that the amount D_i is burnt immediately after receiving it: owners or managers do not obtain any utility from it, and it does not relax the limited liability constraint. We therefore prefer the following implicit definition of $\hat{z}_i$:

$$ D_i + \left(\alpha - q_i - \gamma q_j + \hat{z}_i \right) q_i - D_i \left(1 + r_i \right) = 0 \qquad i = 1, 2, \quad i \neq j. \quad (13) $$

This assumes that a firm still has the amount of D_i it initially received when it is time to repay its debt: this amount is neither burned nor expropriated. This immediately implies

$$ \left(\alpha - q_i - \gamma q_j + \hat{z}_i \right) q_i - D_i r_i = 0 \qquad i = 1, 2, \quad i \neq j. \qquad (14) $$

Therefore, we focus on the amount $S_i = D_i r_i$ that the firm has to pay to the creditors out of its operating profits. We ignore the value of the loan itself, since it is irrelevant from the point of view of the firm. For convenience, we refer to S_i as the 'debt' to the creditors of firm i.

Second, it is common in this literature to assume a competitive credit market that yields zero expected profits for bondholders (see e.g. Brander and Lewis, 1986, p. 966, and Hughes et al., 1998, p. 72). Wanzenried (2003, p. 175) uses this assumption to determine D_i and r_i. It is hard to see, however, why in this context expected bondholder profits would be zero. The strategic effect of debt is solely determined by the required

repayment firms have to make at the end of period 2. As argued above, firm i is only interested in its debt S_i, not in the amount of money it borrows, D_i. This can also be seen in the reaction functions (9). Creditors, however, *are* interested in the value of D_i. The expected repayment they receive depends solely on S_i. For a given value of S_i, we thus have that the lower D_i, the higher the creditors' expected profits. If bondholders are price-takers, it is hard to see why firms would offer them a contract with a D_i that is such that bondholders' expected profits are exactly zero, especially since firms are indifferent with respect to the level of D_i. If bondholders can offer contracts to firms, we have that for any contract (D_i, S_i) that yields a bondholder zero profits, competing bondholders can offer a contract (D'_i, S_i), with $D'_i < D_i$, which yields them strictly positive profits, and which the firm is also willing to accept. In our results, we therefore focus on $S_i = D_i r_i$, rather than on D_i, as Wanzenried (2003) does.

5   Solving numerically

We numerically solve the model using MATLAB. We do so for a large number of values for the parameters γ and $\bar{z}$. Basically, we use two algorithms.[3] Our second-stage algorithm takes as an input the parameters α, γ, and $\bar{z}$, and some debt levels S_1 and S_2, and uses (9) to find the corresponding equilibrium values of q_1 and q_2. The first-stage algorithm takes as an input the parameter values α, γ, and $\bar{z}$, and some debt level S_j, and finds the value of S_i which solves the first-stage maximization problem (2). Note that this optimization problem also depends on the values of q_1 and q_2 that will be chosen in the second stage. Hence, for every candidate best-reply $\hat{S}_i$ to the

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[3]Obviously, these are available from the authors upon request.

given S_j, this first-stage algorithm invokes the second-stage algorithm to calculate which values of q_1 and q_2 would be set in stage 2 when the vector of debt levels were $(\hat{S}_i, S_j)$.

We use these algorithms to derive the equilibrium of the model described above, for a grid of 200 values of γ on the interval $[-1, 1]$, and 200 values of $\bar{z}$ on the interval $(0, \bar{z}_{\max}]$. This yields equilibria for 40,000 combinations of parameter values. The entire exercise takes roughly 16 hours on a PC with a 2.0 GHz Pentium 4 processor.

The output from our algorithm can be used to derive comparative static results. Note that not all combinations of γ and $\bar{z}$ necessarily yield a solution, as Wanzenried also notes. For example, for $\bar{z}$ small and γ either close to 1 or close to -1, the reaction functions with respect to the debt levels S_i do not intersect within the feasible areas. With $\bar{z}$ large and γ high enough, an equilibrium also does not exist. We have chosen to set $\bar{z}_{\max} = 1$, and $\alpha = 2$. Choosing different values does not lead to qualitatively different results. It merely affects the size of the areas where an equilibrium does not exist.

As a first step, following Wanzenried, we compare the equilibria derived by our algorithm to the equilibria of the benchmark case without debt. That is, we compare our results to those for the case of fully equity financed firms (derived by Wanzenried, 2003, pp. 178-179). Note that such firms, by assumption, have no limited liability and therefore can have negative net profits if the realization of the demand shock z_i turns out to be very low. This is not the case with firms that do take on debt, and have limited liability.

Net expected firm profits in equilibrium are given in the left-hand panel of

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Figure 1, for all values of γ and $\bar{z}$ that we consider.[4] In equilibrium, the two firms take on the same debt levels in stage 1, and set the same quantity in stage 2. Hence, profits are also equal for both firms. Naturally, equilibrium profits are only reported for those parameter values where an equilibrium actually exists. The right-hand panel of Figure 1 gives the difference between these equilibrium profits and the equilibrium profits in a benchmark model without debt. The profit difference in Figure 1 is negative. In the left-hand panel of Figure 2, we plot the equilibrium quantities, and in the right-hand panel, the difference between these and those in the benchmark case. In the model with debt, quantities are always lower. From (1), this immediately implies that prices are always lower.[5]

- INSERT FIGURES 1 AND 2 ABOUT HERE -

We thus have the following:

Result 1 *Debt issue induces firms to raise their output. Hence, prices are lower than they are with a fully equity financed capital structure. In equilibrium, debt issue always yields lower firm profits compared to a model without the possibility of debt issue.*

Note that this result holds for both substitutes ($\gamma > 0$) and complements ($\gamma < 0$). Hence, this result is different from Wanzenried's (2003) Proposition 1, which claims that debt issue increases firms' profits in the case of

[4]For clarity of exposition, the figures are based on a 50 x 50 rather than a 200 x 200 grid. This, however, in no way affects the shape of the reported surfaces.
[5]Strictly speaking, quantities are always weakly higher, and prices weakly lower. They are equal when $\gamma = 0$.

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complements. The intuition is straightforward. As first argued by Brander and Lewis (1986), more debt induces firms to compete more aggressively, that is, to set higher quantities which implies lower prices. Clearly, debt issue is a prisoner's dilemma: in equilibrium both firms unilaterally choose to take on debt, yet they would be better off when they could both commit not to do so.

- INSERT FIGURE 3 ABOUT HERE -

Figure 3 gives the equilibrium debt level for our model, S^*, as a function of γ and $\bar{z}$. From close inspection of this graph[6], this yields

Result 2 *For the equilibrium debt level S^*, we have the following:*

1. *For intermediate values of $\bar{z}$, there is a $\gamma^*(\bar{z}) > 0$ such that S^* is decreasing in γ for $\gamma < \gamma^*(\bar{z})$, and increasing for $\gamma > \gamma^*(\bar{z})$. For extreme values of $\bar{z}$, the debt S^* is decreasing in γ for all feasible values of γ.*

2. *S^* is decreasing in $\bar{z}$.*

The first half of Part 1 confirms Wanzenried's Proposition 2, which states that the debt level is decreasing in γ for $\gamma < \gamma^*$, and increasing otherwise. For extreme values of $\bar{z}$ however, we find that S^* is *always* decreasing in γ. Part 2 is opposite to Wanzenried's Proposition 4: we find that the debt

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[6]Admittedly, part of this result is hardly discernible in the figure as we present it here. Equilibrium values of S^* for all values of γ and $\bar{z}$ are available from the authors upon request.

level is decreasing in $\bar{z}$, rather than increasing, as she claims. The intuition is as follows. A higher value of $\bar{z}$ implies more uncertainty. *Ceteris paribus*, this has no effect on $\hat{z}_i$, but does increase expected demand conditional on $z_i > \hat{z}_i$. This implies that both firms will set a higher quantity. Hence, an increase in $\bar{z}$ induces the firms to act even more aggressively, as can also be seen from (9). To get the same strategic effect, it now suffices to have a lower level of debt. In equilibrium, this implies a lower probability of bankruptcy, as we will show later.

One could suspect that we get a qualitatively different result merely because our definition of the debt level is different from that in Wanzenried. This, however, is not the case, as can be seen as follows. Comparing (3) and (12), our S_i can be interpreted as her $(1 + r_i) D_i$. Wanzenried derives D_i by setting the net expected bondholder profits to zero, which is equivalent to setting D_i equal to gross bondholder profits. Gross bondholder profits can easily be calculated from our analysis by taking the difference between total expected profits as given in (2), and net expected firm profits as given in (4). Careful inspection reveals that this variable is also decreasing in $\bar{z}$. This is illustrated in Figure 4.

- INSERT FIGURES 4 AND 5 ABOUT HERE -

Figure 5 shows the probability of bankruptcy, which in equilibrium is simply given by $\theta \equiv \Pr(z < \hat{z})$.

Result 3 *For the equilibrium probability of bankruptcy θ, we have the following:*

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1. *With complements ($\gamma < 0$), θ is decreasing in γ. With substitutes ($\gamma > 0$) it is increasing in γ.*

2. *The probability of bankruptcy θ is decreasing in $\bar{z}$, for $\gamma \neq 0$. With $\gamma = 0$, $\bar{z}$ does not affect θ.*

The effect of a change in γ confirms Wanzenried's Proposition 3. The effect of a change in $\bar{z}$ is a new result: this issue was not analyzed by Wanzenried. We find that higher uncertainty implies that the equilibrium probability of bankruptcy is lower. The intuition follows from that of Result 2: with higher uncertainty, the same strategic effect can be achieved with a lower level of debt. In itself, a lower level of debt implies a lower probability of bankruptcy. Yet, *ceteris paribus*, a higher level of uncertainty implies a higher probability of bankruptcy. We thus have two countervailing effects. In this model, the first effect dominates.

- INSERT FIGURE 6 ABOUT HERE -

Figure 6 shows the welfare effect, which is similar to that reported by Wanzenried:

Result 4 *Using debt financing implies higher welfare as compared to the case of fully equity financed firms.*

6   The Bertrand case

For the Bertrand case the demand function of firm i, (1), can be rewritten as

$$q_i = \frac{\alpha}{1+\gamma} + \frac{z_i - \gamma z_j}{1-\gamma^2} + \frac{-p_i + \gamma p_j}{1-\gamma^2}. \tag{15}$$

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Because firm i's demand now depends on z_j, the analysis for the case with uncorrelated shocks will be more complicated now (note that Wanzenried, 2003, equation (A.1), simply redefines the term involving the shocks as the 'new' z_i). We therefore focus on the case of a common (perfectly correlated) shock[7], $z_i = z_j = z$, so we have

$$q_i = \frac{\alpha + z}{1 + \gamma} + \frac{-p_i + \gamma p_j}{1 - \gamma^2}. \tag{16}$$

The reaction functions can now be derived as

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\begin{aligned}
p_i\,(p_j) \;=\; & \frac{1}{6}\,(1 - \gamma)\,(\alpha + z) + \frac{1}{6}\gamma p_j \\
& + \frac{1}{6}\sqrt{\left((1 - \gamma)\,(\alpha + z) + \gamma p_j\right)^2 + 12\,(1 - \gamma^2)\,S_i}.
\end{aligned}
\tag{17}
$$

We can derive $\widehat{z}$, the critical value of the shock for which the firm can just repay its debt, from

$$\left(\frac{\alpha + \widehat{z}}{1 + \gamma} + \frac{-p_i + \gamma p_j}{1 - \gamma^2}\right)p_i - S_i = 0. \tag{18}$$

Expected profits of firm i in equilibrium are given by

$$\int_{\widehat{z}}^{\overline{z}} \frac{1}{2\overline{z}}\left(\left(\frac{\alpha + \widehat{z}}{1 + \gamma} + \frac{-p_i + \gamma p_j}{1 - \gamma^2}\right)p_i - S_i\right)dz, \tag{19}$$

and expected total profits (including bondholders' profits) equal

$$\int_{-\overline{z}}^{\overline{z}} \frac{1}{2\overline{z}}\left(\frac{\alpha + \widehat{z}}{1 + \gamma} + \frac{-p_i + \gamma p_j}{1 - \gamma^2}\right)p_i dz. \tag{20}$$

In the symmetric equilibrium we have

$$q^* = \frac{\alpha + z - p^*}{1 + \gamma}, \tag{21}$$

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[7]As noted earlier, the analysis of the Cournot case is identical regardless of whether shocks are perfectly correlated or uncorrelated.

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so expected welfare is given by

$$\int_{-\bar{z}}^{\bar{z}} \left[2 \left(\alpha + z_1 \right) q^* - \left(1 + \gamma \right) q^{*2} \right] \frac{1}{2\bar{z}} dz = \frac{\alpha^2 + \bar{z}^2/3 - p^{*2}}{1 + \gamma}. \qquad (22)$$

Finally, in the benchmark case (without limited liability), we have an equilibrium price of $\frac{(1-\gamma)\alpha}{2-\gamma}$, and expected firm profits equal to $\frac{(1-\gamma)\alpha^2}{(2-\gamma)^2(1+\gamma)}$.

Using these expressions, we can use a numerical approach similar to that described above to derive results for the Bertrand case.

Result 5 *With Bertrand competition, we have the following:*

1. *Debt issue induces firms to raise their price. Hence, quantities are lower than they are with a fully equity financed capital structure. In equilibrium, debt issue always yields lower profits as compared to a model without the possibility of debt issue.*

2. *For the equilibrium debt level S^*:*

   (a) *There is a $\bar{z}^*$ such that for $\bar{z} \leq \bar{z}^*$, we have that S^* is decreasing in γ. For any $\bar{z} > \bar{z}^*$, there exist $\gamma^*(\bar{z})$ and $\gamma^{**}(\bar{z})$ such that S^* is increasing for $\gamma^*(\bar{z}) < \gamma < \gamma^{**}(\bar{z})$, and decreasing otherwise.*

   (b) *S^* is decreasing in $\bar{z}$.*

3. *For the equilibrium probability of bankruptcy θ:*

   (a) *With complements $(\gamma < 0)$, θ is decreasing in γ. With substitutes $(\gamma > 0)$ it is increasing in γ.*

   (b) *θ is decreasing in $\bar{z}$, for $\gamma \neq 0$. With $\gamma = 0$, $\bar{z}$ does not affect θ.*

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4. Using debt financing implies lower welfare as compared to the case of fully equity financed firms.

Figures 7-12 illustrate these results.

- INSERT FIGURES 7 THROUGH 12 ABOUT HERE -

Compared to the case of Cournot competition we thus have that prices are higher with debt financing, rather than lower. Note that this is confirmed by Showalter (1995): he shows that with Bertrand competition and demand uncertainty, prices increase when debt is issued. As a result, welfare is now lower with debt financing. The other results are qualitatively similar to those with Cournot competition.

7   Conclusion

In this paper, we corrected the results in Wanzenried's (2003) model of the strategic effects of debt on product market competition in a duopoly with demand uncertainty and differentiated products. We also addressed some other conceptual problems in the strategic debt literature. First, this literature implicitly assumes that a loan obtained in period 1 is burnt immediately after receiving it: owners or managers do not obtain any utility from it, and it does not relax the limited liability constraint. Second, the common assumption of zero expected profits for bondholders is hard to justify.

In the case of Cournot competition, the main results of our analysis are the following. Debt issue leads firms to increase their quantity, leading to lower

prices. Equilibrium profits are lower in a model with debt issue than in one without that possibility. Equilibrium debt levels decrease with the degree of substitutability when products are complements. With substitutes, the effect is ambiguous. Equilibrium debt levels are decreasing in the extent of uncertainty. The equilibrium probability of bankruptcy is minimized when the degree of substitutability between products is zero, and increases when products either become closer substitutes, or stronger complements. The equilibrium probability of bankruptcy is decreasing in the extent of uncertainty. Debt finance leads to higher welfare. With Bertrand competition, prices increase and welfare decreases in a model with debt issue. The other results are qualitatively similar to the case of Cournot competition.

In the case of Cournot competition, we thus find two results that are qualitatively different from those that Wanzenried (2003) reports. First, in equilibrium, the use of debt *always* yields lower firm profits, i.e. even in the case of complements. Second, the equilibrium debt level *decreases* as demand becomes more volatile. We also showed that more volatile demand leads to a lower equilibrium probability of bankruptcy. In the case of Bertrand competition, we find the same qualitative differences.

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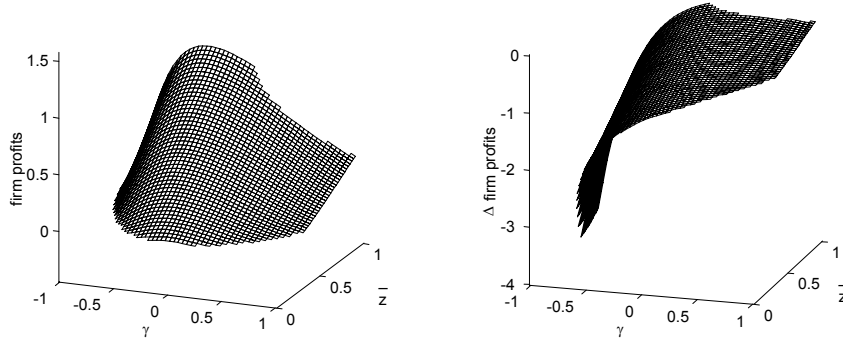
Figure 1: Net expected firm profits (left), and the difference between firm profits and the benchmark model equivalent (right). This difference is always negative, so firm profits in our model fall below the benchmark firm profits.
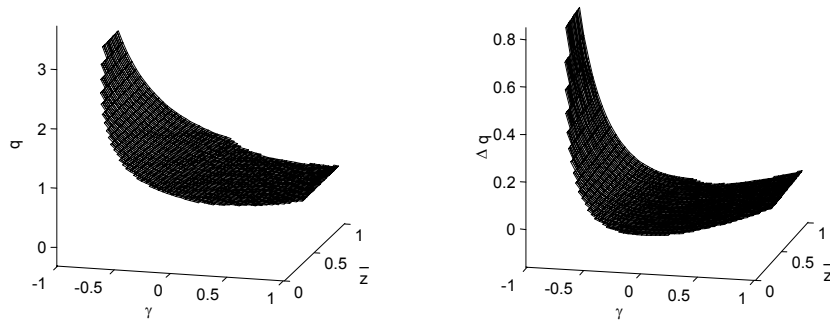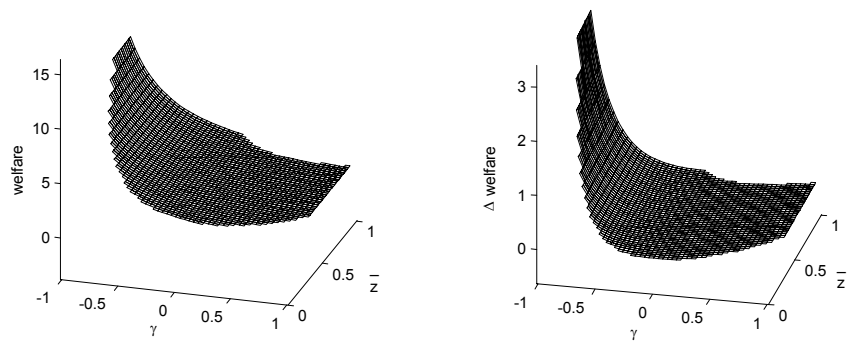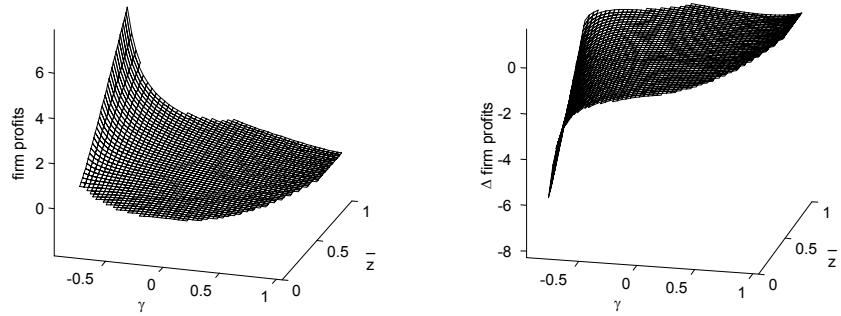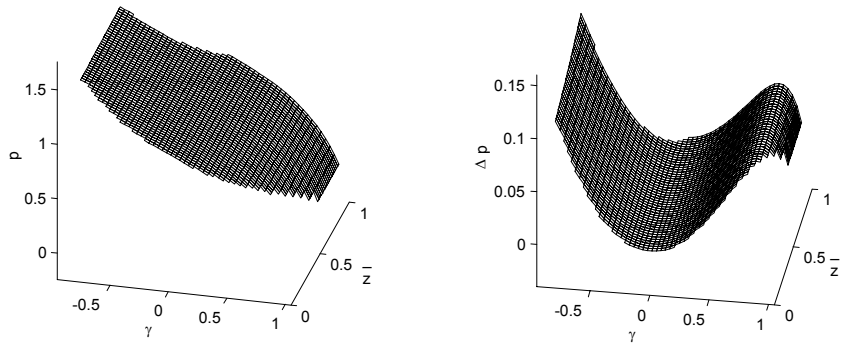

Figure 2: Equilibrium quantity q^* (left), and the difference between equilibrium quantity and the benchmark model equivalent (right). For $\gamma = 0$, this difference equals zero; for all other values of γ it is positive, so the equilibrium quantity in our model exceeds the benchmark quantity.
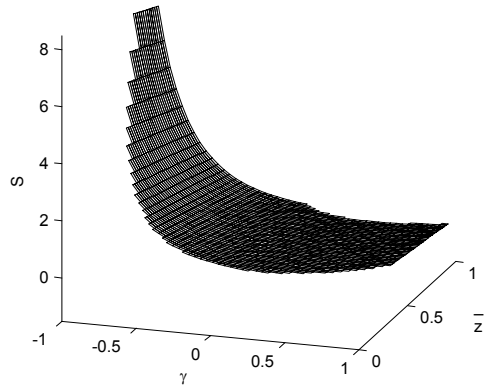
Figure 3: Equilibrium debt level S^*.
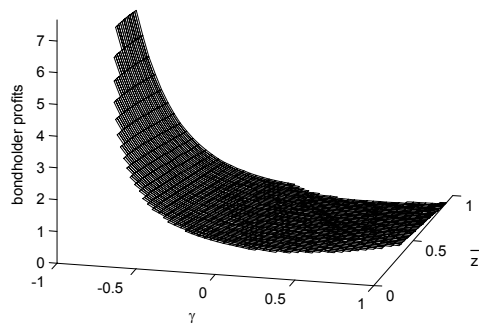
Figure 4: Bondholder profits.
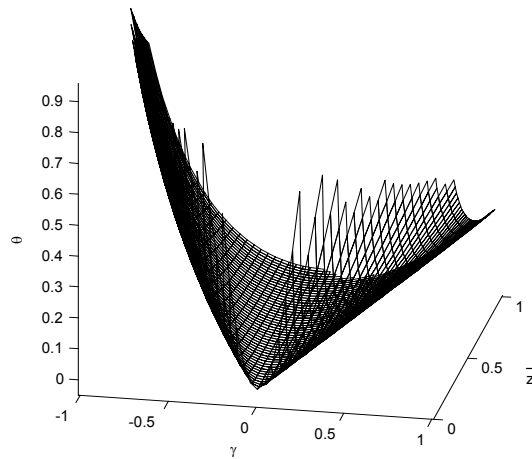
Figure 5: Bankruptcy probability θ.

Figure 6: Welfare (left), and the difference between welfare and the benchmark model equivalent (right). For $\gamma = 0$, this difference equals zero; for all other values of γ it is positive, so welfare in our model exceeds the benchmark welfare.

Figure 7: The Bertrand case: Net expected firm profits (left), and the difference between firm profits and the benchmark model equivalent (right). This difference is always negative, so firm profits in our model fall below the benchmark firm profits.

Figure 8: The Bertrand case: Equilibrium price p^* (left), and the difference between equilibrium price and the benchmark model equivalent (right). For $\gamma = 0$, this difference equals zero; for all other values of γ it is positive, so equilibrium price in our model exceeds the benchmark price.
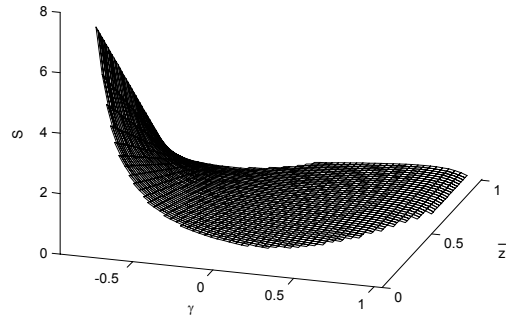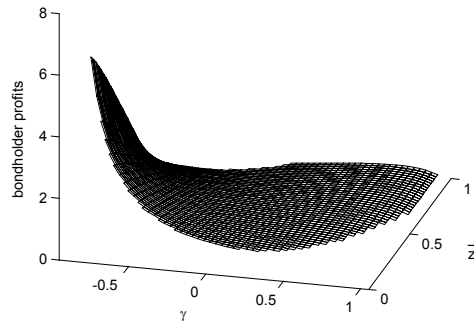
Figure 9: The Bertrand case: Equilibrium debt level S^*.
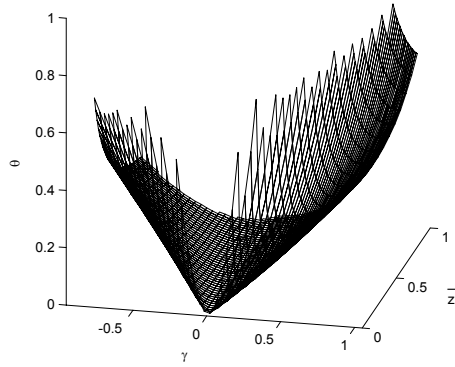

Figure 10: The Bertrand case: Bondholder profits.

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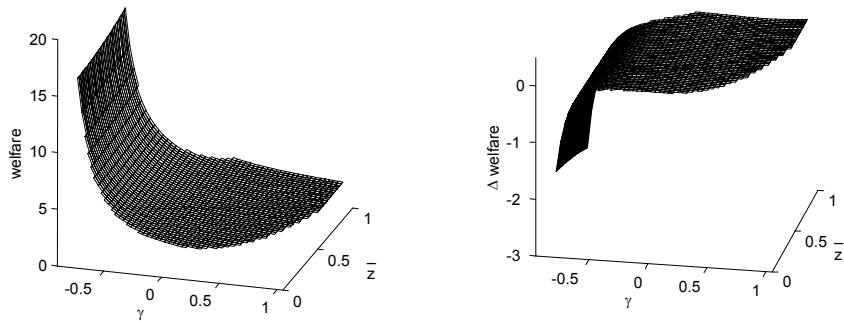Figure 11: The Bertrand case: Bankruptcy probability θ.

Figure 12: The Bertrand case: Welfare (left), and the difference between welfare and the benchmark model equivalent (right). For $\gamma = 0$, this difference equals zero; for all other values of γ it is negative, so welfare in our model falls below the benchmark welfare.