DISCUSSION PAPER SERIES

DP14009

MARKET SIZE AND COMPETITION: A "HUMP-SHAPED" RESULT

Iris Grant, Iris Kesternich, Heiner Schumacher and
Johannes Van Biesebroeck

INDUSTRIAL ORGANIZATION

ISSN 0265-8003

MARKET SIZE AND COMPETITION: A "HUMP-SHAPED" RESULT

Iris Grant, Iris Kesternich, Heiner Schumacher and Johannes Van Biesebroeck

Discussion Paper DP14009
Published 18 September 2019
Submitted 16 September 2019

Centre for Economic Policy Research
33 Great Sutton Street, London EC1V 0DX, UK
Tel: +44 (0)20 7183 8801
www.cepr.org

MARKET SIZE AND COMPETITION: A "HUMP-SHAPED" RESULT

Abstract

An active empirical literature estimates entry threshold ratios, introduced by Bresnahan and Reiss (1991), to learn about the impact of firm entry on the strength of competition. These ratios measure the increase in minimum market size needed per firm to sustain one additional firm in the market. We show that there is no monotonic relationship between a change in the entry threshold ratio and a change in the strength of competition or in the price-cost margin. In the standard homogenous goods oligopoly model with linear or constant elasticity demand, the ratio is hump-shaped in the number of active firms, increasing at first and only when additional firms enter it gradually decreases and converges to one. Empirical applications should use caution and interpret changes in the entry threshold ratios as indicative of changes in competition only from the third entrant onwards.

JEL Classification: D43, L13

Keywords: Competition, Market entry, market size, Entry Threshold Ratio

Iris Grant - iris.grant@kuleuven.be
KU Leuven

Iris Kesternich - iris.kesternich@kuleuven.be
KU Leuven

Heiner Schumacher - heiner.schumacher@kuleuven.be
KU Leuven

Johannes Van Biesebroeck - jo.vanbiesebroeck@kuleuven.be
KU Leuven and CEPR

Acknowledgements
We thank Frank Verboven for discussions on this topic. The authors gratefully acknowledge financial support through the Flemish Research Foundation and KU Leuven research funds (Grant, Kesternich, and Schumacher) and Methusalem project METH/15/004 (Van Biesebroeck).

Market Size and Competition: A "Hump-Shaped" Result*

Iris Grant† Iris Kesternich‡
Heiner Schumacher§ Johannes Van Biesebroeck¶

April 10, 2019

Abstract

An active empirical literature estimates entry threshold ratios, introduced by Bresnahan and Reiss (1991), to learn about the impact of firm entry on the strength of competition. These ratios measure the increase in minimum market size needed per firm to sustain one additional firm in the market. We show that there is no monotonic relationship between a change in the entry threshold ratio and a change in the strength of competition or in the price-cost margin. In the standard homogenous goods oligopoly model with linear or constant elasticity demand, the ratio is hump-shaped in the number of active firms, increasing at first and only when additional firms enter it gradually decreases and converges to one. Empirical applications should use caution and interpret changes in the entry threshold ratios as indicative of changes in competition only from the third entrant onwards.

Keywords: Competition, Market Entry, Market Size, Entry Threshold Ratio
JEL Classification: D43, L13

---

*We thank Frank Verboven for discussions on this topic. The authors gratefully acknowledge financial support through the Flemish Research Foundation and KU Leuven research funds (Grant, Kesternich, and Schumacher) and Methusalem project METH/15/004 (Van Biesebroeck).

†KU Leuven, iris.grant@kuleuven.be.

‡KU Leuven, iris.kesternich@kuleuven.be.

§KU Leuven, heiner.schumacher@kuleuven.be.

¶Corresponding Author. KU Leuven and CEPR, jo.vanbiesebroeck@kuleuven.be.

1 Introduction

The entry threshold ratio (ETR) was introduced in a seminal paper of Bresnahan and Reiss (1991). It is defined as the ratio of two consecutive entry thresholds, for example for n and $n-1$, which are both normalized by the number of active firms. The entry threshold S_n indicates the minimum market size or number of customers needed for n active firms to break even. The ratio $(S_n/n)/(S_{n-1}/(n-1))$ then measures the increase in market size per firm that is needed for an additional firm to be able to enter a market with $n-1$ incumbents without incurring a loss.

The ETR is intended to measure the rate at which variable profits fall with entry. If competition becomes more intense such that price-cost margins are reduced when additional firms compete and fixed entry costs are nondecreasing in the order of entry, the ratio will be higher than one. When market competition approaches the monopolistically competitive benchmark, additional entry no longer changes the price-cost margin and the ETR will converge to unity.

The original application studied a few local service professions, namely doctors, dentists, druggists, plumbers, and tire dealers, but it has since been applied in a wide range of circumstances. This includes industries as varied as banking (Feinberg and Reynolds, 2010), hospitals (Abraham et al., 2007), brewing (Manuszak, 2002), broadband (Xiao and Orazem, 2011), newspapers (Pfann and Van Kranenburg, 2003), or TV stations (Nishida and Gil, 2014), among many more applications.[1]

While most applications identify the entry thresholds solely from cross-sectional variation in market size, a few studies have relied directly on actual entry or exit events (Varela, 2018) or verified whether entry or exit occurs in the expected direction when the market size changes (Carree and Dejardin, 2007). The ETRs have also been adapted to product differentiation where entry can expand the market (Schaumans and Verboven, 2015) or where two types of competitors have asymmetric competitive effects (Dranove, Gron and Mazzeo, 2003; Cleeren et al., 2010).

Each of the studies cited above reports a sequence of ETRs to gauge how the intensity of competition changes with the number of active firms. Using s_n for the per-firm entry threshold (S_n/n), an estimate of s_2/s_1 that exceeds one is interpreted

[1] The literature contains several more specialized applications, for example there are studies on health insurers entering the marketplaces created by the Affordable Care Act (Abraham et al., 2017), funeral homes (Chevalier et al., 2009), fertilizer plants (Itin-Shwartz, 2017), notaries (Lee, 2007), charitable nonprofits (Gayle et al., 2017), driving schools (Asplund and Sandin, 1999), African-American movie theatres (Gil and Marion, 2018), etc.

as evidence that a duopoly is more competitive and leads to lower variable profits than a monopoly. Results are generally discussed relative to a benchmark of a diminished effect on the price-cost margin for each additional entrant, and an expectation that the ratio s_3/s_2 will be lower than s_2/s_1. However, we show that such a monotonic decline in ETRs is not predicted by the standard model that assumes Cournot quantity competition and a linear per-consumer demand curve. With constant marginal costs and no heterogeneity across firms, we show that $s_2/s_1 < s_3/s_2$, i.e., the ETR for the third entrant is higher than for the second even though the price-cost margin is lower. We further show that ETRs decline monotonically once there are more than three entrants, but in the simplest model it takes seven firms before it falls below the value for s_2/s_1.

The intuition for this surprising theoretical finding can be seen from the fact that the ETR depends on the number of firms in the same way as industry profit does. Both decline monotonically with aggregate quantity, and thus with the number of active firms, but they do not decline at a constant rate. Entry has two opposing effects on aggregate profits, a negative effect through a reduced price-cost margin, but also a positive one due to higher total output. The rate of decline is determined by the net effect; profits decline slowly initially, but the rate increases with n. Importantly, we also show that this hump-shaped pattern in dependency of the ETR on the number of active firms is robust for other demand systems, for example for constant elasticity demand.

This insight is not only interesting from a theoretical perspective, it is important to keep in mind from an applied perspective. It implies that the evolution of estimated ETRs with the number of active firms does not map directly into a change in intensity of market competition or a change in the effect of entry on the price-cost margin.[2] It only becomes a reliable predictor once we limit the comparison to situations with three or more firms.

A solution could be to add additional assumptions, for example a functional form for demand and cost homogeneity, in which case more features of the economy, such as the change in price-cost margins, can be identified. However, the ETR's appeal primarily comes from the light modeling and data requirements. The main message then is to avoid attaching any interpretation to the change from s_2/s_1 to

[2]Our finding is not about the *level* of the ETRs for successive entrants or whether the ratios are above or below one. It pertains to what the *change* in the ETR implies for the change in competitive effect of the marginal entrant, or the *relative* competitive effect compared to previous entrants.

s_3/s_2. It is particularly important to keep this in mind given that the approach is most frequently used for small markets with only a few active firms.

The remainder of the paper is organized as follows. In Section 2, we derive the hump-shaped evolution for the ETRs in the case of linear demand and we elaborate on the intuition. In Section 3, we show the robustness of this result. In Section 4, we review implications for empirical work and Section 5 concludes.

2 Linear Demand

We consider the canonical oligopoly model of competition in quantities, with n identical firms and constant marginal costs. The market demand function is $Q = S\left(a/b - p/b\right)$, which is linear for each representative consumer, and S represents the total market size. Let q_i be the quantity produced by firm i such that $Q = q_1 + ... + q_n$ is the total quantity. The inverse demand function is then

$$p = a - \frac{b}{S}Q. \tag{1}$$

The firms' constant marginal costs are c and firm i chooses its quantity q_i to maximize profit

$$\pi_i = \left(a - \frac{b}{S}Q - c\right) q_i - F.$$

Standard arguments show that there is a unique symmetric equilibrium and that the allocation in this equilibrium is as follows:

$$\begin{aligned}
\text{quantity per firm:} \quad & q_n^* = \frac{1}{n+1}\frac{S}{b}(a-c) \\
\text{total quantity:} \quad & Q_n^* = \frac{n}{n+1}\frac{S}{b}(a-c) \\
\text{equilibrium price:} \quad & p_n^* = \frac{a+cn}{n+1} \\
\text{markup per unit:} \quad & p_n^* - c = \frac{a-c}{n+1} \\
\text{industry gross profit:} \quad & n \times q_n^* \times (p_n^* - c) = \frac{n}{(n+1)^2}\frac{S}{b}(a-c)^2 \\
\text{firm profit:} \quad & q_n^* \times (p_n^* - c) - F = \frac{1}{(n+1)^2}\frac{S}{b}(a-c)^2 - F
\end{aligned}$$

The industry gross profit will be important at a later stage. In the following, we drop the "gross" and call it "industry profit."

We calculate the entry threshold per firm for a market with n firms. This is the number of customers that each firm needs to serve such that the n'th firm can enter the market without making a loss. Since firm profits decrease in n, the reverse holds for the market size S_n that is needed to support n firms. Setting firm-profit equal to zero and solving for S_n, we find

$$S_n = (n+1)^2 \frac{Fb}{(a-c)^2},$$

or S_n equals fixed costs over variable firm profits. The entry threshold per firm for a market with n firms is therefore given by

$$s_n = \frac{S_n}{n} = \frac{(n+1)^2}{n} \frac{Fb}{(a-c)^2}. \tag{2}$$

The entry threshold ratio is then defined as $g_n = s_n/s_{n-1}$ for $n \geq 2$. One can interpret it as the growth rate in the customer base per firm that is needed to sustain at least zero profits when the number of firms increases from $n-1$ to n. Market entry affects the firms' strategic behavior and thus the markup per unit. Therefore, g_n measures the rate at which firm profits fall when the number of firms increases, which depends on both the markup and quantity. In the current framework, the per-firm entry threshold ratio equals

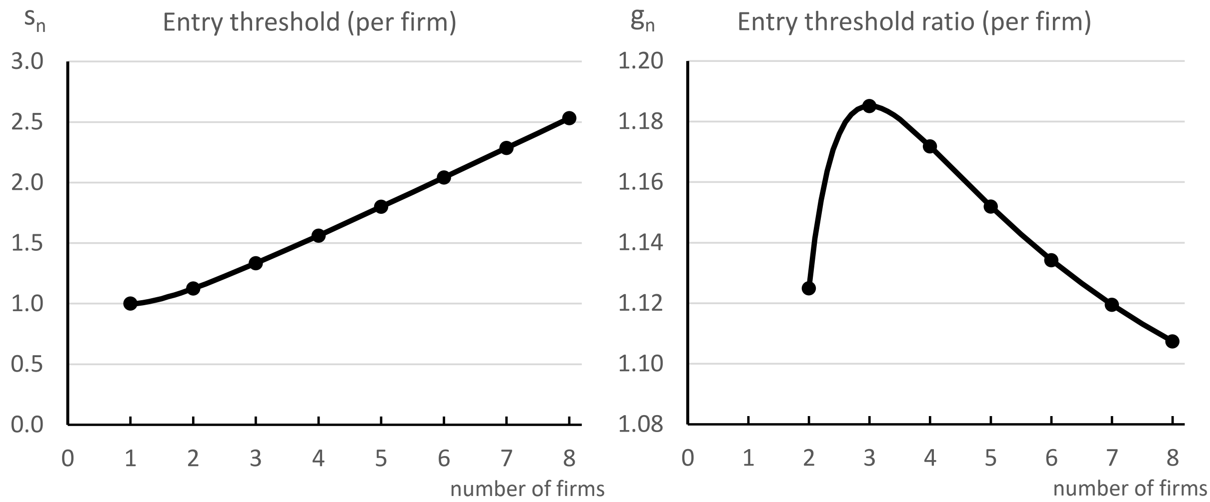
$$g_n = \frac{s_n}{s_{n-1}} = \frac{n-1}{n^2} \frac{(n+1)^2}{n}. \tag{3}$$

Note that the value of g_n does not evolve monotonically. It increases in n for $n \leq 3$ and decreases in n for $n > 3$. Specifically, we have

$$g_2 = 1.125 \quad g_3 = 1.185 \quad g_4 = 1.171 \quad g_5 = 1.152 \quad g_6 = 1.134$$

Figure 1 shows the per-firm entry thresholds (on the left) and the evolution it implies for the entry threshold ratios (on the right) for continuous n. Given that the entry threshold initially increases in a convex manner, the ratio first rises as the number of active firms increases from $n = 2$ to $n = 3$. It means that a firm's variable profit falls less if the number of firms grows from $n = 1$ to $n = 2$ than if the number of firms grows from $n = 2$ to $n = 3$. From $n \geq 3$ onwards, the reduction in variable profits after yet another firm enters the market decreases monotonically in the number of firms, and the entry threshold ratio slowly converges to one. We

Figure 1: Entry threshold and entry treshold ratio for linear demand



state this result formally.

Proposition 1 *In the canonical oligopoly model of competition in quantities with n firms, constant marginal costs, and linear demand, the (per-firm) entry threshold ratio g_n is hump-shaped in n. Specifically, we have $g_2 < g_3$ and $g_n > g_{n+1}$ for all $n \geq 3$.*

The intuition for this result can be seen from the fact that the ETR g_n in (3) depends on n in exactly the same way as the decline in industry profit when the industry goes from $n-1$ to n incumbents. Holding the market size and other parameters in the model constant, (gross) industry profits $\Pi(n)$ scales with a factor $n/(n+1)^2$. The ratio of industry profits $\Pi(n-1)/\Pi(n)$ is determined by the combined effect of declining markups and rising output when the number of active firms increases.[3]

In Table 1 we show the two components separately for successive numbers of active firms. The factor that scales the markup per unit $p_n^* - c$ equals $1/(n+1)$, while the factor that scales total quantity Q equals $n/(n+1)$. As the number of firms n gradually increases, the markup decreases at a relatively constant rate. The percent decline for each successive new entry is around three quarters of the decline

[3]The result in Proposition 1 can be illustrated with the factor $H(n) = n/(n+1)^2$ that combines the scale factors for markup per unit and total quantity. This factor scales industry profits with respect to the number of firms *and* appears in the definition of g_n, i.e., $g_n = H(n-1)/H(n)$. It is straightforward to verify that $H(1) - H(2)$ is smaller than $H(2) - H(3)$, which in turn is larger than $H(3) - H(4)$, while $H(3) - H(4)$ is larger than $H(4) - H(5)$, and so forth. From $H(2) - H(3) > H(1) - H(2)$ it follows immediately that $g_2 < g_3$ and thus our hump-shaped result.

for the previous entry, as the overall change gradually drops to zero and the price asymptotes to the marginal cost. The increase in total quantity with n is much more pronounced when the second firm enters than for the third entrant. The percent increase in aggregate output is more than twice as high at $n = 2$ than at $n = 3$.

Table 1. Evolution of industry profits with the number of active firms

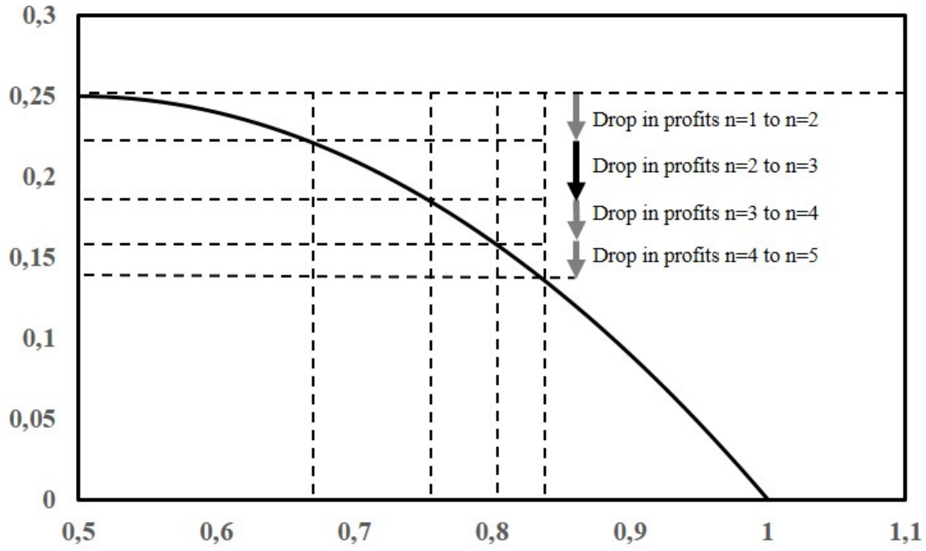
number	markup per unit		total quantity		industry profits
of firms	level	% change	level	% change	% change
n	$\frac{1}{n+1}$	$\log \frac{n}{n+1}$	$\frac{n}{n+1}$	$\log \frac{n^2}{(n-1)(n+1)}$	$\log(\Delta^{mu}) + \log(\Delta^{Q})$
1	$\frac{1}{2}$	–	$\frac{1}{2}$	–	–
2	$\frac{1}{3}$	$\log \frac{2}{3} = -0.405$	$\frac{2}{3}$	$\log \frac{4}{3} = 0.288$	-0.117
3	$\frac{1}{4}$	$\log \frac{3}{4} = -0.288$	$\frac{3}{4}$	$\log \frac{9}{8} = 0.118$	-0.170
4	$\frac{1}{5}$	$\log \frac{4}{5} = -0.223$	$\frac{4}{5}$	$\log \frac{16}{15} = 0.065$	-0.158
5	$\frac{1}{6}$	$\log \frac{5}{6} = -0.182$	$\frac{5}{6}$	$\log \frac{25}{24} = 0.041$	-0.141

Note: The percent change is calculated as the log-ratio for the values for n and $n - 1$.

The change in industry profits depends on the relative strength of these two effects. In the last column of Table 1 we show the sum of the two log-changes, which amounts to the percentage change in industry profit. Note that the values of $\log g_n$ exactly equal the percent changes in the last column. Because total output increases most with the second entrant, it compensates a large fraction of the markup decline. Industry profits decline by only 11.7 percent as the industry moves from a monopoly to a duopoly. For the change from $n = 2$ to $n = 3$ the percent change in markups is more robust than the output increase and the reduction in industry profit is larger at 17.0 percent. For even more entrants, the percent changes in markups and total quantity slowly converge to constant rates, but smaller absolute changes as the markup converges to zero and the output to the competitive quantity. The difference in the rate of change for the two quantities gradually disappears and the percentage change in industry profit converges to zero.

This pattern is illustrated in Figure 2 for continuous values of n. It shows the evolution of industry profits against total quantity in the oligopoly model with fixed market size S. As more firms enter, output per firm falls more slowly than the rate of entry, which raises aggregate output, but lowers industry profits. The key pattern to note is that starting from the monopoly quantity Q_1^*, industry profits decrease only slightly in quantity. As the monopolist maximizes industry profits, there is

Figure 2: Industry profits as a function of total quantity (for fixed market size)



Note: Parameters are chosen as $\frac{S}{b} = a - c = 1$, such that $Q^*_n = \frac{n}{n+1}$ and industry profits equal $\frac{n}{(n+1)^2}$.

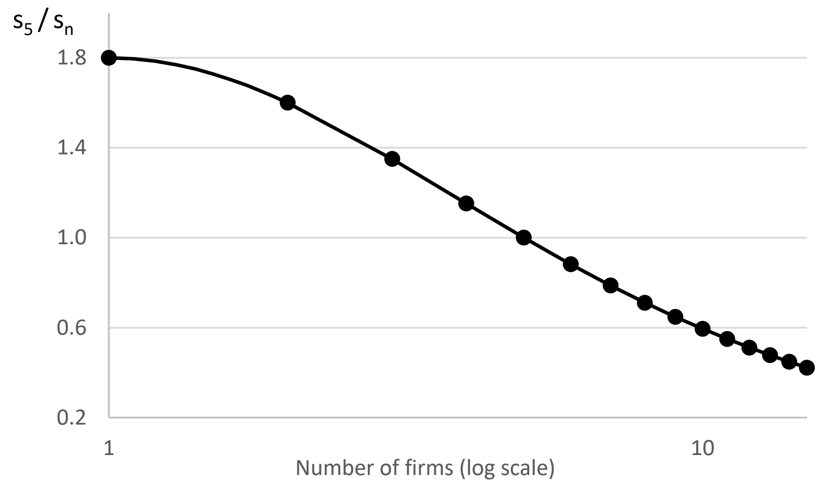
only a second-order effect if we deviate from $n = 1$ and from Q^*_1. The marginal effect of further increases in total quantity on industry profits becomes more and more negative as we move further away from the profit maximizing situation.

The vertical (dashed) lines on the graph show the integer values for the number of active firms, which correspond to the different lines in Table 1. Industry profit declines the most when the number of active firms increases from 2 to 3. For additional entrants, the rate of decline in profits is steeper, but this is more than compensated for by a smaller boost to aggregate quantity for each additional firm. As a result, industry profits decline by a lower amount for each additional entrants, but eventually the change stabilizes to a linear decline in the number of firms. The only deviation from this pattern is for the initial increase in n from the monopoly situation. Profits change only slightly when going from $n = 1$ to $n = 2$ as the decline in markups is compensated by a relatively large increase in output.

A possible reason why the ambiguous relationship between changes in competition and changes in the ETRs has not been noted before is that the numerical illustration in the original paper, in Table 1 of Bresnahan and Reiss (1991), shows ETRs not normalized by the number of firms. The statistics correspond to the S_{n+1}/S_n ratio, while the table heading mistakenly indicates the normalized ratio s_{n+1}/s_n. Note that Berry and Reiss (2007, p. 1858) use the correct statistics when discussing the same example. Moreover, Figure 4 in Bresnahan and Reiss (1991) shows the evolution of estimated ETR ratios normalized by the ETR for $n = 5$, i.e., s_5/s_n rather than s_{n+1}/s_n, while the latter has become a focal point in most of the applications of the framework.

Given that the entry thresholds always increase with n, as shown in Figure 1, the s_5/s_n ratio always declines with n. But importantly, the rate of decline is not monotonic. Figure 3 shows the evolution of the normalized inverse ratio against the number of active firms, using a logarithmic scale on the horizontal axis. This highlights the concave decline over the initial range and the convex decline for higher values of n that is responsible for the hump-shape in the ETR. The decline in the entry threshold is unusually small going from one to two active firms, in spite of the price-cost markup experiencing the largest decline, by approximately 40%, for this change in market structure. The implication is an imperfect relationship between the rate of decline of the entry thresholds and the increase in strength of competition.

Figure 3: Evolution of the (inverse) entry thresholds normalized by the value for $n = 5$



The surprising aspect of Proposition 1 is that it holds for any linear demand model, i.e., the pattern is independent of the intercept a, slope b, marginal costs c, and fixed costs F. This raises the question to what extend the result can be generalized to other demand functions. In the next section, we show that the hump shape also occurs for other demand functions, but it is not always visible if one confines attention to integer number of firms.

3 Constant Elasticity Demand

We consider the same oligopoly model as in the previous section, but with a constant elasticity demand function. The aggregate demand function again simply multiplies the per-consumer demand by the market size and is given by $Q = \alpha S p^{-\beta}$, where $\alpha > 0$ and β is the constant price elasticity of demand parameter with $\beta > 1$. The inverse demand function is then

$$p = \left(\frac{\alpha S}{Q}\right)^{\frac{1}{\beta}}. \tag{4}$$

Firm i chooses its quantity q_i to maximize its profit

$$\pi_i = \left(\frac{\alpha S}{Q}\right)^{\frac{1}{\beta}} q_i - c q_i - F.$$

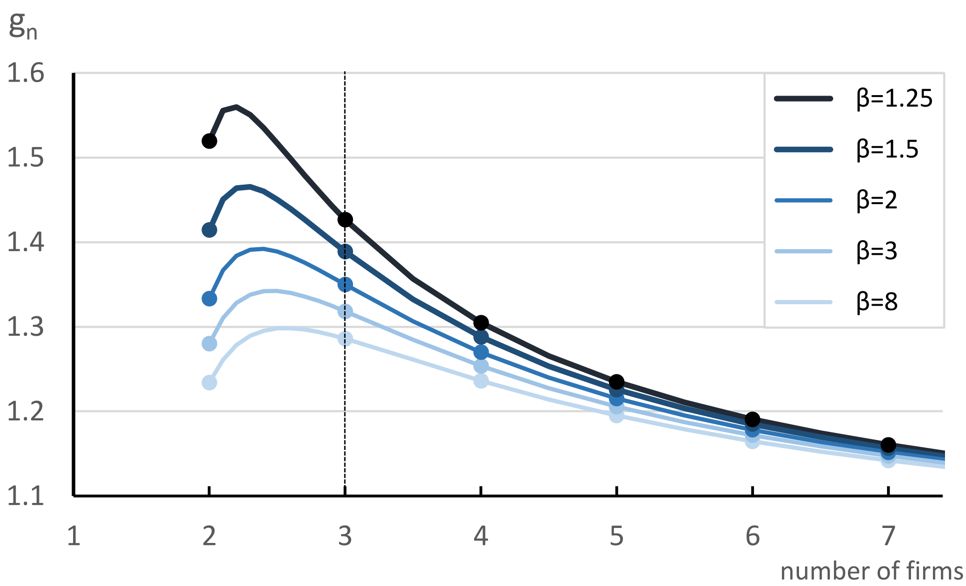
The unique symmetric equilibrium is characterized by the following values:

$$\begin{aligned}
\text{quantity per firm:} &\quad q_n^* = \frac{\alpha S}{n}\left(1 - \frac{1}{\beta n}\right)^{\beta} \frac{1}{c^{\beta}} \\
\text{total quantity:} &\quad Q_n^* = S\alpha \left(\frac{\beta n - 1}{\beta n}\right)^{\beta} \frac{1}{c^{\beta}} \\
\text{equilibrium price:} &\quad p_n^* = \frac{\beta n c}{\beta n - 1} \\
\text{markup per unit:} &\quad p_n^* - c = \frac{c}{\beta n - 1} \\
\text{industry gross profit:} &\quad n \times q_n^* \times (p_n^* - c) = \frac{\alpha S}{c^{\beta-1}} \frac{(\beta n - 1)^{\beta-1}}{(\beta n)^{\beta}} \\
\text{firm profit:} &\quad q_n^* \times (p_n^* - c) - F = \frac{\alpha S}{n c^{\beta-1}} \frac{(\beta n - 1)^{\beta-1}}{(\beta n)^{\beta}} - F
\end{aligned}$$

We again examine the evolution of the firm entry threshold ratio $g_n = s_n/s_{n-1}$. Consider the factor $H(n, \beta) = (\beta n - 1)^{\beta-1}/(\beta n)^{\beta}$. It scales industry profits with respect to the number of firms and defines the entry threshold ratio, i.e., $g_n = H(n-1, \beta)/H(n, \beta)$. If the drop in profits is largest when the number of firms increases from $n = 2$ to $n = 3$, we will again obtain our hump-shaped result. Unlike the linear demand case, the entry threshold ratio now depends on a parameter of the demand function.

In Figure 4 we show the evolution of the ETRs for a range of demand curves that vary in terms of elasticity: lighter colors correspond to higher elasticities. Our familiar hump-shaped pattern appears for each curve, but the value of n at which the ETR curve reaches its maximum increases with the demand elasticity. The ETR starts to decline especially rapidly for relatively less elastic demand curves.

Figure 4: Entry threshold ratios for various constant elasticity demand curves



Note that for $\beta \to 1$, the industry profit converges to $\alpha S/n$ and this expression is a function that declines with n in a convex manner over its entire range. In that extreme case, the hump disappears entirely as the drop in profits is largest when the number of firms increases from $n = 1$ to $n = 2$. For low values of β, for example Figure 4 shows the ETRs for $\beta = 1.25$ or 1.5, there is still a hump, but it is situated entirely before $n = 2$. For integer number of firms, which are indicated by the solid markers, it holds that $g_3 < g_2$, and the hump is not empirically relevant. Only when the price elasticity of demand β is large enough, we again find that $g_2 < g_3$ and $g_n > g_{n+1}$ for all $n \geq 3$, as in the linear demand case.[4]

Thus, we obtain the following result.

Proposition 2 *Consider the canonical oligopoly model of competition in quantities with n firms, constant marginal costs, and constant elasticity demand. There is a threshold $\beta^* \approx 1.723$ such that the following holds: If $\beta > \beta^*$, the firm entry threshold ratio g_n is hump-shaped in n and we have $g_2 < g_3$ and $g_n > g_{n+1}$ for all $n \geq 3$; if $\beta \leq \beta^*$ it is not hump-shaped for integer values of n and we have $g_n > g_{n+1}$ for all $n \geq 2$.*

[4]Numerically, we can show that the critical threshold for β is approximately 1.723, in which case g_3 exactly equals g_2.

The intuition for the threshold is as follows. If β is close to 1, the profit maximizing strategy for a monopolist is to sell few units for a very high price. Note that $Q_1^* \to 0$ and $p_1^* - c \to \infty$ for $\beta \to 1$. With a second firm in the market, this strategy is no longer profitable. The quantity produced will be too large to charge very high prices. So conduct and industry profits change significantly when the number of firms grows from $n = 1$ to $n = 2$. In contrast, if β is large, then the monopolist already produces a relatively large quantity. Note that $p_1^* - c \to 0$ for $\beta \to \infty$. Hence, the change in conduct and firm profits is less pronounced when the number of firms grows from $n = 1$ to $n = 2$ in this case.

As can be seen from Figure 4, the mechanism that produces the hump-shaped result operates for all values of β. It is the negligible impact of an increase in n on industry profit at $n+\epsilon$ that can make the ETR for the second entry unusually small. However, for highly inelastic demand curves, entry very quickly lowers industry profits. The second firm already has such a large impact on equilibrium behavior that the ETR is highest at g_2 (if we limit the comparison to integer values of n). When demand is more elastic, industry behavior only changes more gradually with entry, and the absence of first-order effects on industry profits at $n + \epsilon$ still shows up in an unusually low entry threshold for the second entrant, leading to the hump-shaped pattern.

It is not that clearly visible on Figure 4, but for the most elastic demand curve shown, the hump shape even extends to the fourth entrant. For $\beta = 8$, not only $g_2 < g_3$, but also $g_2 < g_4$. Entry of the fourth firm also requires a larger increase in market size compared to the market that can support three firms, than the relative change in market size needed to go from one to two firms. It is however the case that $g_3 > g_4$, such that the evolution of ETRs from $n = 3$ onwards straightforwardly maps into the change in competition.

4 Implications

The main message from our analysis is that care is warranted when ETRs are calculated for markets with few firms. There is no problem when comparisons are restricted to g_3 and up, i.e., comparing the s_3/s_2 ratio to s_4/s_3, etc. For $n \geq 3$, there is a correspondence between a lower value for the ETR and an increase in the strength of market competition or a reduction in price-cost margin. In contrast, the absence of a decline from g_2 to g_3 cannot be interpreted as evidence of a third entrant not leading to stronger competition and having no impact on the incumbents' pricing behavior. In some empirical applications the number of firms observed in the market never exceeds three, for example in Feinberg (2008), Manuszak (2002), or Pfann and Van Kranenburg (2003). In such a case it is still informative to know whether ETRs are estimated to be larger than unity or not, as such a value implies that an additional entrant strengthens competition. However, the absolute magnitude of g_3 or the difference between g_2 and g_3 is not necessarily a reliable gauge of how this competitive effect changed from the second to the third entrant. In particular, an increase in ETR for the third entrant should not be interpreted as a more substantial increase in competition.

In other applications, for example Dranove et al. (2003) or Cleeren et al. (2010), the observed firms can be classified into two distinct types—implicitly defining two market segments—and competition is conjectured to be stronger between firms of the same type. As each segment necessarily contains only a subset of the total number of firms, the ETRs for the first few entrants tend to receive most attention. For example, Cleeren et al. (2010) calculate a separate ETR for within-type competition, keeping the number of other type competitors constant. Their markets contain up to 7 retail stores, discounters or supermarkets, but they can only calculate ETRs up $n = 5$, the maximum number of discounters in a market.

One solution to the ambiguous implication of a change or absence of change in the ETR would be to impose more structure on the reduced form model for profits. Bresnahan and Reiss (1991) illustrate how to distinguish the impact of market size from differences in variable profits per consumer or fixed costs using a judicious choice of explanatory variables. Toivanen and Waterson (2005) show how one can further distinguish whether the presence of rival firms merely indicates stronger competition or can be a signal of higher unobservable demand shocks. Both extensions already require some reliance on functional form assumptions. Distinguishing the independent effect of rivals on the price-cost margin and firm output would require even more assumptions, for example on the exact shape of the demand equation. Such a solution seems unattractive as the strength of the framework lies exactly in the weak assumptions needed to calculate the ETRs.

While we have shown that in the standard oligopoly model the ETRs are hump-shaped in the number of active firms, this is not necessarily the case when some assumptions are generalized. For example, if marginal costs increase with quantity, entry would generate an additional downward effect on the markup as it leads to higher output per firm. Industry profits would decline more rapidly with entry and this effect would be increasing for successive entrants. Whether this eliminates the hump or not would depend on the exact shape of the marginal cost function as it is the relative impact on the entry thresholds at different entry points that matters.[5]

5 Conclusion

We have shown that the entry threshold ratio, i.e., the increase in the minimum market size needed per firm to sustain one additional firm in the market, does not fall monotonically for additional entrants. Even though the first entrant in a monopoly market has the largest impact on the price-cost margin—which is one way to define the strength of the competitive effect of entry—it does not translate into the highest ETR. From the third entrant onwards, the ETRs decline monotonically for each additional entrant, but for the third entrant itself, the (relative) increase in the required market size is larger than the increase needed to sustain the second entrant. As a result, the ETRs display a hump-shaped pattern; they first rise with the number of active firms, but after this initial increase they decline monotonically and converge to one. We show that this pattern is robust for different demand functions.

This finding is unexpected and interesting from a theoretical perspective. The intuition is that starting from the monopoly situation which maximizes industry profits, initial entry has only second order effects on aggregate profit. It makes entry of the second firm particularly easy, requiring an unusually small increase in the necessary market size for break-even. Only from the third entrant onwards does the evolution of the ETRs corresponds to the intuitive underlying pattern, namely that each successive entrant has a gradually smaller effect in terms of strengthening competition.

The finding is also relevant for applied work as it calls for caution when interpreting changes in ETRs. Comparing the increases in market size to support the second and third entrant, a small increase in the entry threshold cannot be interpreted as entrants having only a limited effect on competition or price-cost margins. Only from later entrants onwards (limiting the comparison to $n \geq 3$) is a lower ETR an

[5] If potential entrants differed in fixed costs and they entered in reverse order, i.e., the firm with lowest costs entered first, the change would intuitively be similar. Industry profits would decline more rapidly with entry, but the exact impact on the rate of change of ETRs would depend on the difference in fixed costs for successive entrants.

indication of a reduced effect of entry on the price-cost margin.

References

Abraham, Jean Marie, Coleman Drake, Jeffrey S. McCullough, and Kosali Simon, "What Drives Insurer Participation and Premiums in the Federally-Facilitated Marketplace?," *International Journal of Health Econonomics Management*, 2017, *17*, 395–412.

_ , Martin Gaynor, and William B. Vogt, "Entry and Competition in Local Hospital Markets," *Journal of Industrial Economics*, 2007, *55* (2), 265–288.

Asplund, Marcus and Rickard Sandin, "The number of firms and product capacity in relation to market size," *Journal of Industrial Economics*, 1999, *47* (1), 69–85.

Berry, Steven and Peter Reiss, "Empirical Models of Entry and Market Structure," in Mark Armstrong and Robert Porter, eds., *Handbook of Industrial Organization*, Vol. 3, North-Holland, 2007, pp. 1845–1886.

Bresnahan, Timothy F. and Peter C. Reiss, "Entry and Competition in Concentrated Markets," *Journal of Political Economy*, 1991, *99* (5), 977–1009.

Carree, Martin and Marcus Dejardin, "Entry Thresholds and Actual Entry and Exit in Local Markets," *Small Business Economics*, 2007, *29*, 203–2012.

Chevalier, Judith, David E. Harrington, and Fiona Scott Morton, "Differentiated to Death?," 2009. Working Paper.

Cleeren, Kathleen, Frank Verboven, Marnik G. Dekimpe, and Katrijn Gielens, "Intra- and Interformat Competition Among Discounters and Supermarkets," *Marketing Science*, 2010, *29* (3), 456–473.

Dranove, David, Anne Gron, and Michael J. Mazzeo, "Differentiation and Competition in HMO markets," *Journal of Industrial Economics*, 2003, *51* (4), 433–454.

Feinberg, Robert M., "Explaining the Credit Union Entry Decision, and Implications for Performance," *Review of Industrial Organization*, 2008, *33*, 81–91.

_ and Kara M. Reynolds, "An Examination of Entry and Competitive Performance in Rural Banking Markets," *Southern Economic Journal*, 2010, *76* (3), 624–637.

Gayle, Philip G., Teresa D. Harrison, and Jeremy Thornton, "Entry, donor market size, and competitive conduct among nonprofit firms," *International Journal of Industrial Organization*, 2017, *50*, 294–318.

Gil, Ricard and Justin Marion, "Residential Segregation, Discrimination, and African-American Theater Entry during Jim Crow," *Journal of Urban Economics*, 2018, *108*, 18–35.

Itin-Shwartz, Beata, "Competition and Market Power in Deregulated Fertilizers in India," 2017. Working Paper.

Lee, Gabriel S., "Germany: Entry and Competition for Bavaria, Germany Notary Profession," in Christoph U. Schmid, Steffen Sebastian, Gabriel S. Lee, Marcel Fink, and Iain Paterson, eds., *Conveyancing Services Market*, Bremen: Zentrum für Europäische Rechtspolitik, 2007.

Manuszak, Mark D., "Endogenous Market Structure and Competition in the 19th Century American Brewing IInternational Journal of Industrial Organizationndustry," *International Journal of Industrial Organization*, 2002, *20*, 673–692.

Nishida, Mitsukuni and Ricard Gil, "Regulation, Enforcement, and Entry: Evidence from the Spanish Local TV Industry," *International Journal of Industrial Organization*, 2014, *32*, 11–23.

Pfann, Gerard A. and Hans Van Kranenburg, "Tax Policy, Location Choices, and Market Structure," *Journal of Law and Economics*, 2003, *46* (61-83).

Schaumans, Catherine and Frank Verboven, "Entry and Competition in Differentiated Product Markets," *Review of Economics and Statistics*, 2015, *97* (1), 195–209.

Toivanen, Otto and Michael Waterson, "Market Structure and Entry: Where's the Beef?," *RAND Journal of Economics*, 2005, *36* (3), 380–699.

Varela, Mauricio J., "The Costs of Growth: Accelerated Growth and Crowd-out in the Mexican Supermarket Industry," *International Journal of Industrial Organization*, 2018, *61*, 1–52.

Xiao, Mo and Peter F. Orazem, "Does the Fourth Entrant Make any Difference? Entry and Competition in the early U.S. Broadband Market," *International Journal of Industrial Organization*, 2011, *29*, 547–561.