

# Entry and Competition in Differentiated Products Markets

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## Abstract

We propose a methodology for estimating the competition effects from entry when firms sell differentiated products. We first derive precise conditions under which Bresnahan and Reiss' entry threshold ratios (ETRs) can be used to test for the presence and to measure the magnitude of competition effects. We then show how to augment the traditional entry model with a revenue equation. This revenue equation serves to adjust the ETRs by the extent of market expansion from entry, and leads to unbiased estimates of the competition effects from entry. We apply our approach to seven different local service sectors. We find that entry typically leads to significant market expansion, implying that traditional ETRs may substantially underestimate the competition effects from entry. In most sectors, the second entrant reduces markups by at least 30%, whereas the third or subsequent entrants have smaller or insignificant effects. In one sector (bakeries), we find that even the second entrant does not reduce markups, which is consistent with the competition authority's recent finding of price fixing in this sector.

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# 1 Introduction

An important question in industrial organization is how market structure affects the intensity of competition. To address this question a variety of empirical approaches have been developed, each with different strengths and weaknesses depending on the available data.<sup>1</sup> Bresnahan and Reiss (1991) developed an innovative approach applicable to local service sectors: they infer the effects of entry on competition from the relationship between the number of entrants and market size. The intuition of their approach is simple. If market size has to increase disproportionately to support additional firms, entry can be interpreted to intensify the degree of competition. Conversely, if market size increases proportionally with the number of firms, then additional entry is interpreted to leave the degree of competition unaffected. To implement their approach, Bresnahan and Reiss propose the concept of the entry threshold ratio (henceforth ETR). The ETR is the percentage per-firm market size increase that is required to support an additional firm. An estimated ETR greater than 1 indicates that entry leads to stronger competition, whereas an ETR equal to 1 indicates that entry does not intensify competition.

A major strength of Bresnahan and Reiss' methodology is that it can be applied with relatively modest data requirements. One basically needs data on a cross-section of local markets, with information on the number of firms per market, population size and other market demographics as control variables. No information on prices or marginal costs is required. This also makes their approach potentially appealing from a competition policy perspective. It can be used as a first monitoring tool to assess which sectors potentially face competition problems and require more detailed investigation.

A central assumption of Bresnahan and Reiss' methodology is that firms produce homogeneous products: holding prices constant, an additional entrant only leads to business stealing and does not create market expansion. This assumption is potentially problematic since new entrants may be differentiated from existing firms, either because they offer different product attributes or because they are located at a different place. In both cases, additional entry would raise demand (holding prices constant).

In this paper we develop a more general economic model to assess the competition effects from entry. The model allows for the possibility that firms sell differentiated products, i.e. additional entry can create market expansion. We first derive precise conditions under which Bresnahan and Reiss' ETRs can be used as a test for the *presence* of competition effects from entry. We find that this is only possible if products are homogeneous, i.e. additional

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<sup>1</sup>For detailed overviews see, for example, Bresnahan (1989), Akerberg, Benkard, Berry and Pakes (2007) and Reiss and Wolak (2007).

entry only entails business stealing and no market expansion. We then ask when ETRs can be used as a measure for the *magnitude* of competition entry effects. We show that ETRs are generally a biased measure for the percentage markup effect due to entry, except in the special case where products are homogeneous and the price elasticity of market demand is unity. More generally, if products are sufficiently differentiated, ETRs typically tend to underestimate the percentage markup effects from competition.

Our theoretical framework also provides a natural way to extend the Bresnahan and Reiss approach to obtain an unbiased measure for the magnitude of the markup effects due to entry. We propose to augment the traditional ordered probit entry model with a revenue equation. The entry model specifies the equilibrium number of firms that can be sustained under free entry. The revenue equation specifies per firm revenues as a function of the number of firms and enables one to estimate the total market expansion effects (consisting of both the direct effects from increased product differentiation and any indirect effects through possible price changes). To obtain an unbiased estimate of the markup effects from entry, the traditional ETRs from the entry model should be suitably adjusted by the total market expansion effects estimated from the revenue equation.

To implement our approach, we study a variety of local service sectors, for which revenue data are increasingly becoming available.<sup>2</sup> More specifically, we consider architects, bakeries, butchers, florists, plumbers, real estate agents and restaurants. For each sector, we constructed a cross-section dataset of local markets (towns) in Belgium, with information on market revenues, the number of entrants, market size (population) and market demographics. Estimating the single-equation entry model yields the traditional ETRs, and we estimate these to be close to 1. This would seem to indicate that entry does not lead to intensified competition. In fact, we even estimate some ETRs to be below 1, which would be inconsistent with the hypothesis of increased competition. However, estimation of the revenue equation shows that entry may often lead to important total market expansion, especially for architects, florists and real estate agents. This implies that the traditional ETRs underestimate the competition effects from entry. Accounting for the estimated total market expansion effects leads to stronger competition effects, especially from the second entrant. Third and subsequent entrants have more limited or insignificant competition effects. In one

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<sup>2</sup>The increased access to revenue data has recently also been exploited in a variety of other settings. For example, Syverson (2004) uses plant-level revenue data in the ready-mixed concrete industry, to assess how demand factors affect the distribution of productivity. Campbell and Hopenhayn (2005) consider the relationship between market size and the size distribution of establishments. They find that establishments tend to be larger in large markets, consistent with models of large-group competition. Konings, Van Cayseele and Warzynski (2005) and De Loecker and Warzynski (2010) extend Hall's (1988) approach to estimate markups using plant-level data on revenues in combination with variable input expenditures.

sector, bakeries, we find no significant competition effects, not even from the second entrant. Incidentally, this sector has recently been investigated by the local competition authority because of price fixing concerns.

Our paper relates to the growing empirical literature on static entry models. Bresnahan and Reiss (1991) proposed their ordered probit model of free entry to infer competition effects from entry by doctors, dentists, car dealers and plumbers. They actually recognize the possibility that “product differentiation offsets competitive decreases in margins, thereby leaving entry threshold ratios constant” (p. 997), but they do not explore this further. Asplund and Sandin (1999) and Manuszak (2002) are examples of applications of the Bresnahan and Reiss entry model. Berry (1992) considered a more general model of entry with heterogeneous firms. Mazzeo (2002), Seim (2006) and Schaumans and Verboven (2008) allow for multiple types of firms or endogenize the choice of type. Other recent work on static entry models has focused on different ways of addressing the multiplicity problem in entry games with firm heterogeneity; see Berry and Reiss (2007) for a recent overview of the literature. In contrast with this recent literature, we maintain the basic entry model that can be applied to market-level data and we focus on the interpretation of ETRs. We show how to augment the entry model with a revenue equation to draw more reliable inferences about the competition effects from entry.

Section 2 presents the theoretical framework, showing under which conditions ETRs can be used as a test for the presence and a measure for the magnitude of competition effects. Section 3 presents the econometric model and Section 4 the empirical analysis. Finally, Section 5 concludes.

## 2 Theoretical framework

We first describe the model. We then introduce the concept of the ETR, and derive conditions under which ETRs can be used to test for the *presence* of competition effects from entry. Finally, we show how to incorporate revenue data to adjust ETRs to measure the *magnitude* of competition effects from entry in an unbiased way.

### 2.1 The model

There are  $N$  firms, competing in a local market with a population size  $S$ . Each firm has the same constant marginal cost  $c > 0$  and incurs a fixed cost  $f > 0$  (independent of the number of firms).

**Demand** Firms do not necessarily produce homogeneous products, but in equilibrium they charge the same industry price  $p$ . The demand per firm and per capita as a function of this common price  $p$  and the number of firms  $N$  is  $q(p, N)$ . This is the traditional Chamberlinian  $DD$  curve (in per capita terms). Similarly, industry demand per capita is  $Q(p, N) = q(p, N)N$ . Denote the price elasticity of industry demand by  $\varepsilon = -Q_p \frac{p}{Q} = -q_p \frac{p}{q}$ . We ignore the fact that  $N$  can only take integer values here, but we take this into account in the empirical analysis.

We make the following three assumptions about demand.

**Assumption 1**  $q_p \leq 0$ , or equivalently,  $Q_p = q_p N \leq 0$ .

**Assumption 2**  $q_N \leq 0$ .

**Assumption 3**  $Q_N = q + q_N N \geq 0$ .

The first assumption simply says that per-firm or industry demand is weakly decreasing in the common industry price  $p$ . The second assumption says that per-firm demand is weakly decreasing in the number of firms  $N$ : holding prices constant, additional entry either leads to business stealing (if products are substitutes) or does not affect per-firm demand (if products are independent). Finally, the third assumption says that industry demand is weakly increasing in  $N$ : holding prices constant, entry either leads to market expansion because of product differentiation, or leaves industry demand unaffected if products are homogeneous.

These assumptions clearly cover the special case in which products are homogeneous, as in Bresnahan and Reiss (1991). In this case, industry demand per capita can be written as  $Q(p, N) = D(p)$ , so that  $q(p, N) = \frac{D(p)}{N}$ . It immediately follows that  $q_N = -q/N < 0$  and  $Q_N = q + q_N N = 0$ . Hence, with homogeneous products entry leads to full business stealing and no market expansion (holding prices constant).

More generally, the assumptions allow for product differentiation with symmetric firms. To illustrate, consider Berry and Waldfogel's (1999) symmetric nested logit model used to study product variety: the first nest includes all firms' products, and the second nest contains the outside good or no-purchase alternative. With identical firms and identical prices, the nested logit per firm and per capita demand function is:

$$q(p, N) = \frac{N^{-\sigma}}{e^{\alpha p} + N^{1-\sigma}},$$

where  $\alpha > 0$  is the price parameter and  $0 \leq \sigma \leq 1$  is the nesting parameter. It can easily be verified that:

$$\begin{aligned} q_p &= -\alpha(1 - Nq) < 0 \\ q_N &= -(\sigma + (1 - \sigma)q) \frac{q}{N} < 0 \\ Q_N &= (1 - \sigma)q(1 - q) \leq 0. \end{aligned}$$

If  $\sigma = 1$ , then  $q_N = -q/N$  and  $Q_N = 0$ , so all firms' products are perceived as homogeneous (relative to the outside good).

**Profits and prices** Now consider profits and the symmetric equilibrium price in the market. For a common industry price  $p$  a firm's profits are

$$\pi = (p - c)q(p, N)S - f.$$

Suppose first that all  $N$  firms behave as a cartel. In this case, the equilibrium price as a function of  $N$  is  $p^m(N)$ , defined by the first-order condition

$$q(p, N) + (p - c)q_p(p, N) = 0.$$

More generally, let the symmetric equilibrium price as a function of the number of firms  $N$  be given by  $p(N) \leq p^m(N)$ . In many oligopoly models, including the Cournot and Bertrand models, this equilibrium price is weakly decreasing in  $N$ ,  $p' \leq 0$ . We can then write a firm's equilibrium profits as a function of the number of firms  $N$  as:

$$\pi(N) = (p(N) - c)q(p(N), N)S - f. \tag{1}$$

In the next two subsections we will decompose profits in two different ways. Define the variable profits per firm and per capita by  $v(N) \equiv (p(N) - c)q(p(N), N)$ , the revenues per firm and per capita by  $r(N) \equiv p(N)q(p(N), N)$ , and the Lerner index or percentage markup by  $\mu(N) \equiv \frac{p(N) - c}{p(N)}$ . We can then write

$$\pi(N) = v(N)S - f. \tag{2}$$

$$= \mu(N)r(N)S - f. \tag{3}$$

The expression on the first line contains variable profits per firm and per capita, similar to Bresnahan and Reiss (1991). The expression on the second line rewrites variable profits as markups times revenue per firm and per capita. As we will show in the next two subsections, this second expression provides useful additional information to assess the effects of competition on markups, provided that data on revenues are available.

Although the above framework generalizes Bresnahan and Reiss' model to account for product differentiation, it still assumes that firms are in a symmetric price equilibrium.<sup>3</sup> This will enable us to obtain clear expressions for biases of entry thresholds as competition measures. To incorporate asymmetries between firms, a natural first step would be to model observed firm heterogeneity, as in Mazzeo's (2002) set-up with multiple types of firms (low-quality and high-quality hotels); see also Ciliberto and Tamer (2009) for an application to large airlines and low-cost carriers. We come back to this generalization in the concluding section.

## 2.2 ETRs to test for the presence of competition effects

Bresnahan and Reiss (1991) introduce the concept of the entry threshold and entry threshold ratio as a test for the presence of competition effects from entry. The entry threshold is the critical market size required to support a given number of firms, and is derived from the zero-profit condition  $\pi(N) = 0$ . Using (2), this gives

$$S = \frac{f}{v(N)} \equiv S(N).$$

Bresnahan and Reiss argue that entry does not lead to increased competition if the entry threshold increases proportionally with the number of firms. For example, entry would not lead to more competition if a doubling of the market size is required to support twice as many firms. Conversely, entry creates intensified competition if the entry threshold increases disproportionately with the number of firms. For example, competition intensifies if a tripling of the market size would be required to support twice as many firms.

Based on this intuition, Bresnahan and Reiss propose the entry threshold *ratio*, or ETR, as a unit-free measure to test for the presence of competition effects. The ETR is defined as the per-firm entry threshold required to support  $N$  firms, relative to the per-firm entry threshold to support  $N - 1$  firms, i.e.

$$ETR(N) \equiv \frac{S(N)/N}{S(N-1)/(N-1)}. \quad (4)$$

One can then test the null hypothesis,  $ETR(N) = 1$ , that the  $N$ -th entrant does not lead to more competition.

We now assess this interpretation formally, starting from our more general model where products are not necessarily homogeneous, i.e. allowing for market expansion upon entry.

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<sup>3</sup>It also assumes that firms obtain equal market shares, but this assumption may be easily relaxed, for example by modeling different capacity levels.

Substituting  $S(N) \equiv \frac{f}{v(N)}$  in (4), we can write the ETR in a simple form:

$$\begin{aligned} ETR(N) &= \frac{v(N-1)(N-1)}{v(N)N} \\ &\equiv \frac{V(N-1)}{V(N)}. \end{aligned} \tag{5}$$

where  $V(N) = v(N)N$  is per capita industry variable profits. The ETR is therefore just the ratio of industry variable profits with  $N$  and  $N-1$  firms.

It follows immediately from (5) that the  $ETR(N) > 1$  if and only if  $V'(N) < 0$ , i.e. if and only if industry variable profits are strictly decreasing in  $N$ . To see under which circumstances this is the case, differentiate  $V(N) = v(N)N$  using (1), and rearrange to obtain

$$\begin{aligned} V' &= (q + (p-c)q_p)p'N + (p-c)(q + q_NN) \\ &= (1 - \mu\varepsilon)p'Nq + (p-c)(q + q_NN). \end{aligned} \tag{6}$$

Suppose first that products are homogeneous, which is the special case considered by Bresnahan and Reiss. In this case,  $q + q_NN = 0$  so that the second term in (6) vanishes. Since  $1 - \mu\varepsilon \geq 0$ , it follows that  $V' < 0$  (and hence  $ETR(N) > 1$ ) if and only if  $p' < 0$ . Similarly,  $V' = 0$  if and only if  $p' = 0$ . We can therefore confirm, and make more precise, Bresnahan and Reiss' justification for using ETRs as a test for the presence of competition effects from entry, when products are homogeneous:

**Proposition 1** *Suppose that products are homogenous.  $ETR(N) > 1$  if and only if entry leads to a price decrease ( $p' < 0$ ).  $ETR(N) = 1$  if and only if entry does not affect the price ( $p' = 0$ ).*

Bresnahan and Reiss also provide examples from oligopoly models to argue that the ETRs are declining in  $N$ . Intuitively, entry may be expected to have larger effects on competition if one starts off from few firms with strong market power, as can be confirmed from examples such as the Cournot model. Formally, it follows from (5) that the ETRs are declining if and only if the industry variable profits are convex in  $N$ ,  $V'' > 0$ . While this may often be the case, it is not generally true, not even if products are homogeneous. A simple counterexample is a repeated game with price setting firms: profits are monopoly profits for sufficiently low  $N$ , and then drop to zero above a critical level for  $N$ .<sup>4</sup>

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<sup>4</sup>In fact, with homogeneous products one can verify that for small  $N$  the function  $V$  is concave ( $V'' < 0$ ), while for sufficiently large  $N$  the function  $V$  is convex. In a linear demand Cournot model, the function is convex for  $N \geq 2$ . So ETRs appear to be increasing for  $N$  very small. Yet accounting for the fact that  $N$  is an integer, the ETR already drops when moving from 1 to 2 firms.



Suppose now that products are differentiated. This means that additional entry implies market expansion (holding prices constant), i.e.  $q + q_N N > 0$ , so that the second term in (6) becomes positive. It follows immediately that  $V' > 0$  (and hence  $ETR(N) < 1$ ) if  $p' = 0$ . Furthermore,  $V' > 0$  is also possible if  $p' < 0$ , provided products are sufficiently differentiated (since then  $p$  approaches  $p^m$  or  $\mu$  approaches  $1/\varepsilon$ , so that the first term in (6) vanishes and the second term dominates). We can conclude the following about the use of entry thresholds when products are differentiated:

**Proposition 2** *Suppose products are differentiated.  $ETR(N) < 1$  if entry does not affect the price ( $p' = 0$ ) or even if entry leads to a price decrease ( $p' < 0$ ) provided products are sufficiently differentiated.*

Product differentiation can thus explain occasional findings in applied work of ETRs less than 1. (For example, Bresnahan and Reiss report  $ETR(3) = 0.79$  for dentists.) Intuitively, if entry leads to substantial market expansion and does not intensify competition by very much, it is possible that market size increases less than proportionately with the number of firms.

To summarize, Propositions 1 and 2 identify conditions under which the null hypothesis  $ETR(N) = 1$  is reasonable as a test for the presence of competition effects. It turns out that this approach is reasonable only if products are homogeneous, but not more generally if products are differentiated.

### 2.3 ETRs to measure the magnitude of competition effects

Having identified conditions under which ETRs form a reasonable basis to test for the presence of the competition effects from entry, we now ask under which conditions ETRs provide an unbiased measure for the magnitude of the competition effects. Define this magnitude as the percentage drop in the Lerner index,  $\mu(N-1)/\mu(N)$ .

To address this question, we now start from (3) instead of (2) to rewrite the entry threshold as

$$S(N) = \frac{f}{\mu(N)r(N)}.$$

This can be substituted in the definition of the ETR (4) to rewrite it as:

$$\begin{aligned} ETR(N) &= \frac{\mu(N-1)}{\mu(N)} \frac{r(N-1)(N-1)}{r(N)N} \\ &\equiv \frac{\mu(N-1)}{\mu(N)} \frac{R(N-1)}{R(N)} \end{aligned} \tag{7}$$

where  $R(N) = r(N)N$  is the per capita industry revenue function.

It immediately follows that the ETR is an exact measure for the magnitude of the percentage markup drop if and only if industry revenues do not vary with the number of firms,  $R(N) = R(N - 1)$ , i.e. if and only if  $R' = 0$  (ignoring that  $N$  only takes integer values). Similarly, the ETR underestimates (overestimates) the percentage markup drop if and only if  $R' > 0$  ( $R' < 0$ ). To see when this is the case, use  $R(N) = p(N)q(p(N), N)N$  to compute

$$\begin{aligned} R' &= (q + pq_p)p'N + p(q + q_NN) \\ &= (1 - \varepsilon)p'Nq + p(q + q_NN). \end{aligned} \tag{8}$$

As before, suppose first that the products are homogeneous, as in Bresnahan and Reiss. We have that  $q + q_NN = 0$ , so that the second term in (8) vanishes. For  $p' < 0$ , we then obtain that  $R' < 0$  if  $\varepsilon < 1$ ,  $R' = 0$  if  $\varepsilon = 1$  and  $R' > 0$  if  $\varepsilon > 1$ . We can conclude the following:

**Proposition 3** *Suppose that products are homogeneous. The ETR is a correct measure of the percentage markup drop due to entry,  $ETR(N) = \mu(N - 1)/\mu(N)$ , if and only if  $\varepsilon = 1$ . It underestimates (overestimates) the percentage markup drop if and only if  $\varepsilon > 1$  ( $\varepsilon < 1$ ).*

For example, consider an estimated  $ETR = 1.3$ , as roughly found for entry by the second and third firm in Manuszak's study of the 19th century U.S. brewery industry. Assuming homogeneous products, this can be interpreted as a markup drop by 30% following the introduction of a second and third competitor, if and only if the price elasticity of market demand is unity.

Proposition 3 shows that it is difficult to draw general conclusions about the direction of bias, since one needs to know the level of the price elasticity of industry demand. But the direction of bias is clear in the special case where industry behaves close to a perfect cartel. In this case, we have that  $\varepsilon > 1$  (since marginal cost  $c > 0$ ). Hence, if the industry behaves close to a perfect cartel, the entry threshold would underestimate the magnitude of the markup drop following entry.

Now suppose that products are differentiated,  $q + Nq_N > 0$ . The second term in (8) is then positive, so that the ETR is more likely to underestimate the markup drop. More precisely, define  $\varepsilon^*$  as the critical elasticity such that  $R' = 0$ , i.e.

$$\varepsilon^* \equiv 1 + \frac{q + q_NN}{p'Nq/p}$$

For  $q + q_NN > 0$  and  $p' < 0$ , we have that  $\varepsilon^* < 1$ , so that the ETR would also underestimate the markup drop for an elasticity below 1 but sufficiently close to 1. More precisely, we have:

**Proposition 4** *Suppose products are differentiated. The ETR underestimates (overestimates) the percentage markup drop  $\mu(N - 1)/\mu(N)$  if and only if  $\varepsilon > \varepsilon^*$  ( $\varepsilon < \varepsilon^*$ ), where  $\varepsilon^* < 1$ .*

To summarize, Propositions 3 and 4 imply that the ETR is more likely to underestimate the percentage markup drop from entry if the industry behaves close to a cartel (so that  $\varepsilon > 1$ ) and/or if products are strongly differentiated (substantial market expansion from entry).

To obtain this conclusion we made use of the (per capita) industry revenue function. Provided that revenue data are available, it also suggests a natural way to obtain an unbiased measure of the competition effect from entry. Indeed, using (7) we can write the percentage markup drop as

$$\frac{\mu(N - 1)}{\mu(N)} = ETR(N) \frac{R(N)}{R(N - 1)}.$$

The markup drop due to entry is thus equal to Bresnahan and Reiss' ETR, multiplied by the percentage industry revenue effects from entry. In the next section, we develop an empirical model that augments the traditional entry model with a revenue function. This leads to the "adjusted ETR" as an unbiased estimate of the competition effects from entry. The approach requires market-level revenue data, in addition to data on the number of entrants and market demographics used in standard entry models.

**Remark: absolute margins** The above discussion focused on how to obtain an unbiased measure for the magnitude of the competition effect from entry as defined by percentage drop in the Lerner index (or percentage margin),  $\mu(N - 1)/\mu(N)$ . One may also ask this question for the percentage drop in the *absolute* margin,  $(p(N - 1) - c) / (p(N) - c)$ .<sup>5</sup> One can easily verify that (7) can be rewritten as

$$ETR(N) = \frac{p(N - 1) - c}{p(N) - c} \frac{Q(N - 1)}{Q(N)}.$$

The bias of the ETR as a competition measure now depends on the reduced form demand function  $Q(N)$  instead of the reduced form revenue function  $R(N)$ . The ETR is an unbiased measure of the percentage drop in absolute margins if and only if  $Q_N = 0$ . Similarly, the ETR underestimates (overestimates) the percentage drop in absolute margins if and only if  $Q_N > 0$  ( $Q_N < 0$ ). We can use  $Q(N) = q(p(N), N)N$  to compute

$$Q_N = -\varepsilon p' N q / p + (q + q_N N).$$

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<sup>5</sup>We thank Johan Stennek for suggesting us to also look at this measure.

The counterparts of Proposition 3 and 4 are simple. The ETR is an unbiased estimated of the percentage drop in absolute margins only if products are homogeneous ( $q + q_N N = 0$ ) and demand is perfectly inelastic ( $\varepsilon = 0$ ). If either condition is violated, we have  $Q_N > 0$ , so that the ETR will generally underestimate the percentage drop in absolute margins.

This discussion also shows that the appropriate measure of competition depends on data availability. With revenue data (as in most applications) it is natural to focus on the percentage drop in the Lerner index  $\mu(N)$ . With quantity data it is natural to focus on the percentage drop in the absolute margin  $p(N) - c$ .

### 3 Econometric model

We first specify a standard empirical entry model without revenue data in the spirit of Bresnahan and Reiss (1991). We show how to estimate this model and compute ETRs, based on a dataset with the number of firms and market characteristics for a cross-section of local markets. We then show how to extend the standard entry model with a revenue equation, and how to compute adjusted ETRs as an unbiased measure of competition effects from entry.

In both cases the empirical entry model assumes that firm profits are an unobserved, latent variable. But bounds can be inferred based on the assumption that there is free entry, i.e. firms enter if and only if this is profitable.

#### 3.1 Simple entry model

If revenue data are not available, we start from the profit function (2)

$$\pi(N) = v(N)S - f,$$

where  $v' < 0$ . Both the (per capita) variable profits and the fixed costs component are unobserved. However, bounds can be inferred based on the assumption that there is free entry. Upon observing  $N$  firms, we can infer that  $N$  firms are profitable, whereas  $N + 1$  firms are not:

$$v(N + 1)S - f < 0 < v(N)S - f,$$

or equivalently

$$\ln \frac{v(N + 1)}{f} + \ln S < 0 < \ln \frac{v(N)}{f} + \ln S. \quad (9)$$

Consider the following logarithmic specification for the ratio of variable profits over fixed costs

$$\ln \frac{v(N)}{f} = X\lambda + \theta_N - \omega, \quad (10)$$

where  $X$  is a vector of observable market characteristics  $X$ ,  $\theta_N$  represents the fixed effect of  $N$  firms, and  $\omega$  is an unobserved error term.<sup>6</sup> Assume that  $\theta_{N+1} < \theta_N < \dots$ , i.e. additional firms reduce the variable profits over fixed cost ratio (because of reduced demand and/or reduced markup). We can write the entry conditions as

$$X\lambda + \theta_{N+1} + \ln S < \omega < X\lambda + \theta_N + \ln S.$$

**Estimation** To estimate the model by maximum likelihood, assume  $\omega$  is normally distributed  $\mathcal{N}(0, \sigma)$ . The probability of observing  $N$  firms is

$$P(N) = \Phi\left(\frac{X\lambda + \ln S + \theta_N}{\sigma}\right) - \Phi\left(\frac{X\lambda + \ln S + \theta_{N+1}}{\sigma}\right). \quad (11)$$

This is a standard ordered probit model, where the  $\theta_N$  are the “cut-points” or entry effects. Note that the variance is identified because of the assumption that variable profits increase proportionally with market size  $S$ .<sup>7</sup> See Berry and Reiss (2008) for a more general discussion on identification in entry models.

**Constructing ETRs** Based on the estimated parameters one can compute the entry threshold, i.e. the critical market size to support  $N$  firms. Using (9) and (10), evaluated at  $\omega = 0$ , the entry threshold to support  $N$  firms is

$$S(N) = \exp(-X\lambda - \theta_N). \quad (12)$$

The ETR is the ratio of the per-firm market size to support  $N$  versus  $N - 1$  firms. Using (4), this is

$$ETR(N) = \exp(\theta_{N-1} - \theta_N) \frac{N-1}{N}. \quad (13)$$

So in our logarithmic specification the ETRs only depend on the differences in the consecutive “cut-points” of the ordered probit model; they do not depend on the market characteristics  $X$ .

As shown in the previous section, the ETRs are no good measure of the competitive effects from entry if products are differentiated. Furthermore, even if products are homogenous, ETRs can only be used to test the null hypothesis of no competition effects, but not to measure the magnitude of the competition effects. These considerations motivate augmenting the entry model to include revenue data in the analysis. We turn to this next.

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<sup>6</sup>To avoid possible confusion, in the empirical specification we use the subscript  $N$  to denote the fixed effect for the  $N$ -th firm (as in  $\theta_N$ ). This differs from the previous section where we used the subscript  $N$  for the partial derivative with respect to  $N$  (as in  $q_N$ ).

<sup>7</sup>Our specification differs from Bresnahan and Reiss (1991) and more closely resembles Genesove (2000). In contrast with Bresnahan and Reiss, our specification only identifies the ratio of variable profits over fixed costs and not the levels. However, we also identify the variance of the error term.

### 3.2 Simultaneous entry and revenue model

If we observe revenues per firm and per capita  $r = r(N)$ , we can disentangle the variable profits per capita into a percentage markup and a revenue component,  $v(N) = \mu(N)r(N)$ . We can then start from the profit function (3):

$$\pi(N) = \mu(N)r(N)S - f,$$

Upon observing  $N$  firms, we can now infer that

$$\mu(N+1)r(N+1)S - f < 0 < \mu(N)r(N)S - f,$$

or equivalently

$$\ln \frac{\mu(N+1)}{f} + \ln r(N+1) + \ln S < 0 < \ln \frac{\mu(N)}{f} + \ln r(N) + \ln S. \quad (14)$$

This again gives rise to the ordered probit model. But since we observe per-firm revenues  $r = r(N)$ , we can separately specify an equation for revenues and markups (rather than only for variable profits).

We specify revenues per capita to depend on observed market characteristics  $X$ , the number of firms  $N$  and an unobserved market-specific error term  $\xi$ . We consider both a constant elasticity and a fixed effects specification:

$$\ln r = \ln r(N) = X\beta + \alpha \ln N + \xi \quad (15)$$

$$\ln r = \ln r(N) = X\beta + \alpha_N + \xi \quad (16)$$

where  $X$  are observed market demographics,  $\alpha$  is the (constant) elasticity of per-firm revenues  $r$  with respect to  $N$ , and  $\alpha_N$  are fixed entry effects. The error term  $\xi$  captures market-specific revenue shocks. It may also capture unobserved reputation or quality of firms, to the extent that these are correlated across firms within a market.

To interpret the effect of  $N$  on  $r$ , one should bear in mind that  $r(N) \equiv p(N)q(p(N), N)$ . Hence, the elasticity  $\alpha$  or the fixed effects  $\alpha_N$  capture both the direct effect through increased product differentiation and the indirect effect through a possible price change. More formally, using (8) we can write the elasticity of  $r$  with respect to  $N$  as:

$$r' \frac{N}{r} = (1 - \varepsilon) p' \frac{N}{p} + q_N \frac{N}{q}.$$

The second term  $q_N(N/q)$  is the direct effect through increased product differentiation. By assumptions 2 and 3,  $q_N(N/q) \in (-1, 0)$ : if  $q_N(N/q) = -1$ , products are homogeneous and

there is only business stealing. If  $q_N(N/q) = 0$ , products are independent and there is only market expansion. The first term is the indirect effect through a possible price change. If the first term is small (because of a modest price effect  $p'(N/p)$  and  $\varepsilon$  relatively close to 1), then we can interpret our estimate of  $r'(N/r)$  as the extent of business stealing versus market expansion. For example, in the constant elasticity specification, an estimate of  $\alpha$  close to  $-1$  would indicate that entry mainly involves business stealing (homogeneous products), and  $\alpha$  close to 0 would indicate that entry mainly involves market expansion (independent products). It will be convenient to follow this interpretation when discussing the empirical results. However, we stress that this interpretation only holds approximately, since  $\alpha$  also captures indirect revenue effects through price changes.

Next, we specify the ratio of markups over fixed costs as a function of observed market characteristics  $X$ , the number of firms and an unobserved market-specific error term  $\eta$ :

$$\ln \frac{\mu(N)}{f} = X\gamma + \delta_N - \eta. \quad (17)$$

where  $\delta_N > \delta_{N+1} > \dots$ , i.e. markups are decreasing in the number of firms.

Substituting the revenue specification (15) or (16) and the markup specification (17) in (14), we can write the entry conditions as

$$X\lambda + \ln S + \theta_{N+1} < \omega < X\lambda + \ln S + \theta_N,$$

where we define

$$\begin{aligned} \lambda &\equiv \beta + \gamma \\ \omega &\equiv \eta - \xi, \\ \theta_N &\equiv \alpha \ln N + \delta_N \quad (\text{constant elasticity revenue specification}) \\ &\equiv \alpha_N + \delta_N \quad (\text{fixed effects revenue specification}) \end{aligned}$$

This gives rise to the following simultaneous model for revenues and the number of firms:

$$\begin{aligned} \text{for } N = 0: & & r & \text{ unobserved} \\ & & X\lambda + \ln S + \theta_1 & < \omega \\ \\ \text{for } N > 0: & & \ln r & = X\beta + \alpha_N + \xi \\ & & X\lambda + \ln S + \theta_{N+1} & < \omega < X\lambda + \ln S + \theta_N. \end{aligned}$$

**Estimation** This is a simultaneous ordered probit and demand model. It has a similar structure as in Ferrari, Verboven and Degryse (2010), although they derive it from a rather

different setting with coordinated entry. The model has the following endogeneity problem. We want to estimate the causal effect of  $N$  on  $r$ , but  $N$  is likely to be correlated with the demand error  $\xi$ . Econometrically, the error terms  $\xi$  and  $\omega \equiv \eta - \xi$  are correlated because they contain the common component  $\xi$ . Intuitively, firms are more likely to enter in markets where they expect demand to be high, leading to spurious correlation between the number of firms and total revenues per capita  $N \cdot r$ , or a bias towards too much market expansion and too little business stealing. Since we will use the estimated market expansion effects to obtain a proper estimate of the competition effects, it is crucial that we do not overestimate market expansion. Fortunately, population size  $S$  serves as a natural exclusion restriction to identify the causal effect of  $N$  on  $r$ . It does not directly affect per capita revenues, yet it is correlated with  $N$ , since firms are more likely to enter and cover their fixed costs in large markets. In different contexts, Berry and Waldfogel (1999) and Ferrari, Verboven and Degryse (2010) have used similar identification strategies.

To estimate the model by maximum likelihood, suppose that  $\xi$  and  $\eta$  are normally distributed, so that  $\omega \equiv \eta - \xi$  is also normally distributed. We then obtain the following likelihood contributions. For markets with  $N = 0$  we have

$$P(0) = 1 - \Phi \left( \frac{X\lambda + \ln S + \theta_1}{\sigma_\omega} \right),$$

and for markets with  $N > 0$  we have

$$f(\ln r)P(N|\ln r) = \frac{1}{\sigma_\xi} \phi \left( \frac{\xi}{\sigma_\xi} \right) \times \left( \Phi \left( \frac{X\lambda + \ln S + \theta_N - (\sigma_{\omega\xi}/\sigma_\xi^2) \xi}{\sqrt{\sigma_\omega^2 - \sigma_{\omega\xi}^2/\sigma_\xi^2}} \right) - \Phi \left( \frac{X\lambda + \ln S + \theta_{N+1} - (\sigma_{\omega\xi}/\sigma_\xi^2) \xi}{\sqrt{\sigma_\omega^2 - \sigma_{\omega\xi}^2/\sigma_\xi^2}} \right) \right), \quad (18)$$

where  $\xi = \ln r - X\beta - \alpha_N$ .

**Constructing ETRs and percentage markup drops** When the entry model is augmented with revenue data, we can still compute the ETR as before. It is given by

$$ETR(N) = \exp(\theta_{N-1} - \theta_N) \frac{N-1}{N}.$$

Furthermore, it is now also possible to directly compute the percentage markup drop following entry. Using (17), we can write this percentage markup drop as

$$\frac{\mu(N-1)}{\mu(N)} = \exp(\delta_{N-1} - \delta_N).$$



To express this in terms of the estimated parameters for the fixed effects revenue specification, we can substitute the definition  $\theta_N \equiv \alpha_N + \delta_N$  to obtain:

$$\begin{aligned} \frac{\mu(N-1)}{\mu(N)} &= \exp(\theta_{N-1} - \theta_N) \exp(-(\alpha_{N-1} - \alpha_N)) \\ &= ETR(N) \frac{N}{N-1} \exp(-(\alpha_{N-1} - \alpha_N)), \end{aligned} \quad (19)$$

where the second equality follows from the definition of the ETR. Similarly, for the constant elasticity revenue equation, we can substitute the definition  $\theta_N \equiv \alpha \ln N + \delta_N$  to obtain

$$\begin{aligned} \frac{\mu(N-1)}{\mu(N)} &= \exp(\theta_{N-1} - \theta_N) \left(\frac{N-1}{N}\right)^{-\alpha} \\ &= ETR(N) \left(\frac{N}{N-1}\right)^{1+\alpha}. \end{aligned} \quad (20)$$

Consistent with the discussion in Section 2, this shows for both specifications how the ETRs should be adjusted by the estimated revenue parameters to obtain an unbiased estimate for the markup drop after entry. The simple ETRs can only be used as an unbiased measure in the special case where

$$\exp(-(\alpha_{N-1} - \alpha_N)) = \frac{N-1}{N},$$

in the flexible specification, and  $\alpha = -1$  in the restricted specification. Intuitively, in both cases this requires that entry only leads to business stealing and not to any market expansion.

## 4 Empirical analysis

We organize the discussion of the empirical analysis as follows. We first present the dataset for the various local service sectors. Next, we discuss the results from estimating the entry model and the revenue model separately. This leads to the construction of traditional Bresnahan and Reiss entry threshold ratios. They do not yet take into account the existence of market expansion from entry, and can be used as a benchmark for our subsequent results. Finally, we present the results for the simultaneous model of entry and demand, leading to estimates of competition effects or “adjusted entry threshold ratios” that take into account market expansion effects.

### 4.1 Dataset

We analyze seven different local service sectors: architects, bakeries, butchers, florists, plumbers, real estate agents and restaurants. For each sector, we have constructed a cross-sectional data set of more than 800 local markets (towns) in Belgium in 2007. The main

variables are firm revenues per capita  $r$ , the number of firms  $N$ , population size  $S$  and other market demographics  $X$ .<sup>8</sup>

**Selection of sectors** Based on our research proposal, the Belgian Federal Ministry of Economic Affairs made available a list of local service sectors at the 4-digit or 5-digit NACE code for empirical analysis. From this list we first eliminated sectors where the relevant market is clearly not local, such as TV-production houses. Furthermore, to avoid possible complications stemming from multi-market competition, we restricted attention to sectors where the average number of establishments per firm is less than 3. Sectors with many chains, such as travel agencies and clothes stores, were therefore also eliminated from the analysis. This resulted in a list of seven local service sectors: architects, bakeries, butchers, florists, plumbers, real estate agents and restaurants. For all these sectors the median number of establishments per company is 1, the 75-percentile is no larger than 2 and the 90-percentile is no larger than 5.

**Market definition** For each sector, we define the geographic market at the level of the ZIP-code. This roughly corresponds to the definition of a town in Belgium, and it is more narrow than the administrative municipality, which on average consists of about 5 towns. The market definition appears reasonable for the considered sectors. Most sectors are frequently purchased goods and small ticket items. Two exceptions are real estate agents and architects, but here local information is important. Real estate agents make use of their local networks to act as intermediaries between buyers and sellers. Architects also rely on their local reputation. Furthermore, they may incur significant transportation costs when monitoring the yards, and thus have a competitive advantage in serving local customers. In sum, for all professions distance matters and consumers may be expected not to travel far. The extent of the geographic market may of course vary somewhat across sectors. Nevertheless, for simplicity and consistency we decided to use the same market definition for all sectors.

Since the market definition roughly corresponds to the town, most of the population tends to be clustered around the center. But the country is densely populated, so that markets show overlap. To mitigate problems with overlapping markets, we only retain the non-urban areas, i.e. towns with a population density below 800 inhabitants per km<sup>2</sup> and a market size lower than 15,000 inhabitants. We also performed a sensitivity analysis with other selection criteria on population density and obtained similar results.<sup>9</sup>

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<sup>8</sup>Firm revenues and the number of firms come from V.A.T. and Business register data from the sectoral database, set up by the Federal Public Service Economy (Sector and Market Monitoring Department). Population size and other market demographics are census data from the FPS Economy (Statistics Belgium).

<sup>9</sup>In particular, we considered a sample with a stricter definition on non-urban areas (population density

Two of the considered sectors, bakeries and butchers, are to some extent subject to competition from supermarkets. According to the Belgian Enterprise Federation, Unizo, the market share of both professions is declining, but they still have strong prospects.<sup>10</sup> They have a much stronger geographical coverage in rural areas (our sample), and they are differentiated from supermarkets because of their artisanal production, and different opening hours. This is especially the case for bakeries which offer a much broader variety of fresh bread and pastries than supermarkets.

**Construction of the variables and summary statistics** The number of firms  $N$  is the number of companies in the market, as constructed from the business registry database. Revenues per firm and per capita  $r$  are computed at the company level from the V.A.T. sectoral database. Ideally, we would want to use data at the establishment level but this information is incomplete. As discussed above, we therefore focus on sectors with a low number of establishments per firm (no chains). Furthermore, we restrict attention to companies with at most two establishments in the country.<sup>11</sup>

The data on the number of firms  $N$  and revenues  $r$  are specific to each of the seven different sectors. In addition to these endogenous variables, we also observe the common variables population size  $S$  and a vector of other market demographics  $X$ . This vector consists of the market surface, personal income/capita, the demographic composition of the population (% women, % foreigners, % unemployed and % in various age categories), and a regional dummy variable for Flanders. The vector  $X$  enters both the revenue and entry equation. In contrast, population size  $S$  only enters the entry equation and therefore serves as an exclusion restriction for the revenue equation to identify the causal effect of  $N$  on  $r$ .

Table 1 gives a complete list of the variables and their definitions, and presents basic summary statistics for the common variables  $S$  and  $X$ , as observed for the cross-section of 835 non-urban markets. Table 2 provides more detailed summary statistics for the sector-specific variables, revenues per firm and per capita  $r$  and the number of firms  $N$ . The top panel shows the number of markets with 0, 1, 2, 3, 4, 5 or more firms. Most sectors have broad market coverage with a common presence of at least one firm per market. This is most notable for restaurants, since there are only 93 markets without a restaurant. The middle

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below 700 and population size less than 12,000). We also considered a sample that in addition excludes the 10% largest markets in terms of revenue per firm per capita, since these markets may contain agents with a particularly strong reputation.

<sup>10</sup>See newspaper article in De Standaard (13 November 2008), “Minder Bakkers en Slagers, Maar met Mooie Toekomst” (“Fewer Butchers and Bakeries, but with Bright Future”).

<sup>11</sup>The results of our analysis are robust when we use alternative selection criteria, e.g. retain companies with at most five establishments.

and bottom panels of Table 2 show the means and standard deviations for the number of firms  $N$  and revenues  $r$  across markets.

## 4.2 Preliminary evidence

We now discuss the results from estimating the entry model and the revenue model separately. This leads to traditional Bresnahan and Reiss entry threshold ratios. It also provides a first indication on the extent of market expansion (as opposed to business stealing) following entry, yet without accounting for endogeneity of  $N$  for now.

**Entry model** Table 3 shows the empirical results per sector from estimating the ordered probit entry model. Consistent with other work, population size  $\ln S$  is the most important determinant of firm entry, with a positive and highly significant parameter for all sectors.<sup>12</sup> Several variables of the age structure also tend to have a positive and significant effect across sectors, in particular the %young and %old, relative to the reference group of young adults with age between 25–40 years. The effect of several other variables differs across sectors, both in sign and magnitudes. For example, markets with a high income per capita tend to have more architects, florists and real estate agents, but fewer bakeries. Generally speaking, it is not straightforward to interpret these parameters, as the variables may capture several effects (variable profits, fixed costs) and may be collinear with other variables (e.g. income and unemployment). While the control variables are not of direct interest, it is still important to control for them to allow for different sources of variation across markets.

The ordered probit model also includes the entry effects or “cut-points”  $\theta_N$ . We transform these parameters to construct the entry thresholds (for a representative market with average characteristics) and the per firm entry threshold ratios (which are independent of the other characteristics). This is based on the expressions (12) and (13) derived earlier.

Table 4 shows the computed entry thresholds and entry threshold ratios. To illustrate, first consider butchers (third column). The entry threshold, i.e. the minimum population size to support one butcher in a town, is 1,166. It increases to 2,736 to support a second butcher and to 4,905 to support a third butcher. The pattern is slightly disproportional, i.e. the minimum population size to support a given number of firms increases disproportionately with the number of firms. This is reflected in the ETRs. For example,  $ETR(2) = 1.17$ , which means that the minimum population size per firm should increase by an extra 17% to support a second firm. Under the homogeneous goods assumption of the Bresnahan and Reiss model,

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<sup>12</sup>Based on (11), the parameter of  $\ln S$  can be interpreted as  $1/\sigma$ , and the parameters of the other demographics as  $\lambda/\sigma$ .

this can be interpreted as an indication that entry intensifies competition between butchers.

Now consider all sectors. Table 4 shows that the ETRs for the third, fourth or fifth entrant are significantly greater than 1 in about half of the cases, and insignificantly different from 1 in the remaining half. In the traditional Bresnahan and Reiss' framework, this would indicate mixed evidence on the competitive effects of entry from the third entrant onwards. Table 4 also shows that the ETR for the second entrant is only significantly greater than 1 for one sector, butchers; it does not differ significantly from 1 for four sectors; and it is even significantly less than 1 for the remaining two sectors, architects and real estate agents. The latter finding contradicts the competition interpretation of ETRs, as it would suggest that competition becomes weaker when a second firm enters the market. As we will show below, an alternative interpretation is the presence of significant market expansion when a second firm enters the market.

**Revenue model** Table 5 shows the empirical results per sector from simple OLS regressions of the restricted revenue specification (15), i.e. regressions of  $\ln r$  on  $\ln N$  and  $X$ . Since the model is estimated with OLS, we do not yet account for the endogeneity of  $N$  so we should be cautious at this point in drawing causal inferences on market expansion versus business stealing from entry. First, consider the control variables  $X$ . In contrast with the entry equation, the parameters are significant for most variables and usually have the same sign across the various sectors. Per capita revenues tend to be larger in markets with a low surface area, a low personal income, a low fraction of unemployed, and a high fraction of kids/young or old (relative to the base young adult group).

Now consider the parameter on  $\ln N$ . The parameter is negative and significant for five out of seven sectors, and insignificantly different from zero for the remaining two sectors (florists and real estate agents). For the five sectors where the parameter is negative, it is relatively small, varying between  $-0.15$  and  $-0.39$ . Overall, this preliminary evidence would suggest that additional entry implies some business stealing but more important market expansion. This would in turn indicate that the ETRs are not a good measure of competition, as this is only the case when entry only leads to business stealing (coefficient for  $\ln N$  of  $-1$ ). However, as already mentioned, we have not yet accounted for the endogeneity of  $N$ . Firms tend to locate in markets where they expect demand to be high, leading to a spurious correlation between the number of firms and total market demand and an overestimate of the extent of market expansion. Our full model accounts for this, by estimating the revenue model simultaneously with the entry model, using market size as an exclusion restriction to identify the market expansion effect.

### 4.3 Results from the full model

We now discuss the main empirical results, from estimating the entry and revenue model simultaneously. We first look at the case of butchers in detail, to give a comparison of the different specifications and methods. We then give a broader overview of all sectors, focusing on the estimated competition effects or adjusted ETRs, which take into account the market expansion effects from entry.

**Comparison of different specifications and methods: butchers** As discussed in section 3, we consider two specifications for the revenue equation. In the constant elasticity specification (15), the number of entrants appears logarithmically, so  $\alpha_N = \alpha \ln(N)$ . In the fixed effects specification (16), we estimate the effect of entry  $\alpha_N$  on revenues for each market configuration. For both specifications, we compare the results from simultaneous estimation of the demand and entry model with those from estimating the models separately. We focus the comparison on the revenue equation, since the results for the entry equation are very similar across specifications and methods (and given in Table 3 for the single equation estimation).

Table 6 shows the results. The estimated effects of the control variables  $X$  are very similar across different specifications, so we do not discuss them further. Our main interest is in the effects of entry on revenues. First consider the constant elasticity specification. When the revenue equation is estimated separately using OLS, we estimate  $\alpha = -0.24$  (as already reported in Table 5). In sharp contrast, when the revenue equation is estimated simultaneously with the entry equation, we estimate  $\alpha = -0.72$ . Hence, accounting for the endogeneity of  $N$  implies a considerably higher estimate of business stealing. The market expansion elasticity,  $1 + \alpha$ , correspondingly drops from 0.76 to 0.28. Intuitively, OLS gives a spurious finding of market expansion, since it does not take into account that entrants tend to locate in markets where the unobserved demand error is high.<sup>13</sup> Nevertheless, the simultaneous model still implies there is some market expansion: an increase in  $N$  by 10% tends to raise market revenues by 2.8%. The bottom part of Table 6 shows how  $\alpha$  translates into percentage revenue effects  $R(N)/R(N+1)$ . We see a declining pattern, where the effect on total revenue per capita is 21% for the second entrant, 12% for the third entrant, 8% for the fourth entrant and 6% for the fifth entrant. This smooth pattern is evidently driven by the restricted functional form of the logarithmic specification.

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<sup>13</sup>More formally, the simultaneous model differs from the single equation model because it accounts for the correlation between the demand and profit error. Table 5 shows that  $\sigma_{\omega\xi} = -0.43$ , which is negative as expected because the structural error in the entry equation contains the structural error in the demand equation.

Now consider the unrestricted fixed effects specification. We do not report the different  $\alpha_N$ , but immediately discuss the implied percentage revenue effects  $R(N)/R(N + 1)$ . As before, we find large market expansion effects from single equation estimation (e.g. 85% market expansion for the second entrant) and much lower effects when we account for the endogeneity of  $N$  (26% for the second entrant). Furthermore, the flexible specification no longer gives a smooth pattern for the entry effects. Only the second butcher leads to significant market expansion. For additional entrants, the extent of market expansion becomes insignificant.

In sum, this discussion shows that both the specification and the method are important to correctly estimate the extent of market expansion. First, it is necessary to account for the endogeneity of entry since otherwise the extent of market expansion will be overestimated. Second, it may be important to consider the possibility of a flexible specification for the entry effects, though this comes at the cost of reduced precision. These conclusions do not just hold for butchers but also for the other sectors we have studied. They will therefore be highly relevant when estimating the competition effects based on the adjusted ETRs.

**Competition effects from entry: all sectors** Table 7 shows the competition effects from additional entry, as estimated from the simultaneous entry and revenue model. As is clear from (19) and (20), the competition effects can be interpreted as adjusted ETRs: they adjust the traditional ETRs for the extent of market expansion induced by entry. Only if market expansion is small, the competition effects will be close to the traditional ETR's.

The top panel of Table 7 shows the results for the constant elasticity revenue specification. The first row shows the estimated business stealing effects  $\alpha$  from the revenue equation. For six out of seven sectors, the estimates are much closer to -1 than in the earlier OLS estimates of Table 5. This means that the necessary adjustments of the ETRs are much smaller, as earlier suggested. Nevertheless, the market expansion elasticity  $1 + \alpha$  is still important, varying from 0.08 for bakeries to 0.72 for florists.<sup>14</sup>

Based on (20), we can use the  $\alpha$ 's and the ETRs (very similar to those in Table 4) to compute the markup effects or "adjusted ETRs". For most sectors and market configurations we find significant competition effects from entry. The adjusted ETRs are typically significantly greater than 1, also for entry by the second firm, and they are never significantly below 1. For example, entry by a second restaurant reduces markups by 17% ( $\mu(1)/\mu(2) = 1.17$ ). This contrasts with our earlier estimated simple ETRs, which were often significantly less than 1 for the second entrant (e.g.  $ETR(2) = 0.87$  for restaurants). The reason is, of course,

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<sup>14</sup>Only for real estate agents  $\alpha$  is not significant. This suggests considerable market expansion, perhaps capturing that market definition is broader than the town level for this sector.

that we now adjust for the extent of market expansion. Bakeries are the only sector without significant competition effects from entry in the constant elasticity specification. We already found the traditional ETRs to be close to 1 in this sector. Moreover, it turns out that entry by bakeries largely entails business stealing ( $\alpha = -0.92$ ), so that the adjusted ETRs remain close to and not significantly different from 1.

The bottom panel of Table 7 shows whether these conclusions are confirmed using the more flexible fixed effects revenue specification. The estimated competition effects of the second entrant are broadly similar. In five out of seven sectors, the second entrant has a significant effect on competition. The two exceptions are bakeries (as before) and real estate agents where  $\mu(1)/\mu(2)$  does not differ significantly from 1. However, the conclusions regarding competition from the third, fourth or fifth entrant are different from the restricted specification. With the exception of restaurants, we no longer estimate significant competition effects from the third entrant onwards. Note, however, that the standard errors of the estimated  $\mu(N-1)/\mu(N)$  have become larger (because of the increased flexibility), so that the competition tests have less power.

Combining the results from the restricted constant elasticity specification (with more precise estimates) and the more flexible fixed effects specification (with larger standard errors), we conclude that in most sectors the second entrant appears to reduce markups by at least 30%, whereas further entrants may not necessarily promote competition further. Bakeries and real estate agents are exceptions to this conclusion. For real estate agents, the fixed effects specification does not estimate significant competition effects from the second entrant, though the standard errors are rather large here.<sup>15</sup> For bakeries, the lack of competition effects are estimated more precisely: both the constant elasticity and the fixed effects specification indicate that the second entrant does not promote competition. Incidentally, this is consistent with a recent decision by the Belgian Competition Council. In January 2008, the Council convicted the Association of Bakeries for continuing its price fixing policies after prices for bread had been liberalized in 2004.

**The case of bakeries** It is interesting to consider this case in more detail. Until July 2004, the prices of a large number of bread varieties were regulated and uniform across bakeries. The liberalization aimed to deregulate prices and promote competition. However, after a complaint from a consumer organization, the Belgian Competition Council started an investigation on price fixing.

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<sup>15</sup>A lack of competition effects from entry in the real estate sector is consistent with the common practice of more or less uniform percentage commissions. This has also been documented elsewhere, for example Hsieh and Moretti (2003), who draw implications for the efficiency of entry.



It found that the Association of Bakeries prepared detailed cost schemes and a bread price index, and published this information across its members. The Competition Council acknowledged that the Association could inform its members on the evolution of their cost structure. But it found that the system went too far, because it actively encouraged their members to raise their prices by passing through average cost increases. It was particularly concerned with the fact that the index was pegged to the last regulated bread price (before the 2004 liberalization), resulting in a uniform recommended price for all bakeries, a violation of competition law.

In sum, the estimated entry threshold ratio's for bakeries indicate a lack of competition in 2007, which is consistent with the Council's finding on price fixing after the deregulation in 2004. If entry adjusts slowly, our findings also indicate a lack of competition from entry before the price deregulation.

## 5 Conclusions

We have proposed a methodology for estimating the competition effects from entry in differentiated products markets, and illustrated how to implement it using datasets for seven different local service sectors. We started from Bresnahan and Reiss' ETRs, and provided conditions under which they can be used as a test for the presence and a measure for the magnitude of competition effects from entry. We subsequently showed how to augment the traditional entry model with a revenue equation. This revenue equation serves to adjust the traditional ETRs by the extent of market expansion due to entry, leading to an unbiased estimate of the competition effects from entry.

Our empirical results show that traditional ETRs are close to one, implying limited competition effects. In some cases they are even significantly below 1, suggesting entry would actually reduce competition. Furthermore, we find that entry leads to significant market expansion, which implies that the traditional ETRs underestimate the effects of entry on competition. Accounting for the estimated market expansion, we no longer find adjusted ETRs that are significantly below 1. In most sectors, the second entrant reduces markups by at least 30%, whereas the third or higher entrants have smaller or insignificant effects. In at least one sector, bakeries, we have found that even the second entrant does not create competition, which is consistent with a recent decision by the competition authority.

Our empirical analysis stressed the importance of several specific issues that should be taken into account. First, it is important to account for the endogeneity of the number of entrants in estimating market expansion effects from entry. Failure to do so would result in an overestimate of market expansion effects, and hence an overestimate of the competition

effects (adjusted ETRs), as opposed to an underestimate from the traditional ETRs. In our setting, population size arises as a natural instrument, and we found the bias from ignoring the endogeneity issue can be substantial.

Second, it is potentially important to consider a flexible revenue specification to estimate the market expansion effects. Our restricted constant elasticity specification (with  $\ln N$ ) imposes market expansion effects to be declining in  $N$ , whereas our more flexible fixed effects specification allows the effects to vary per consecutive entrant. The flexible specification suggested that the main market expansion effects (and hence the required adjustment to the ETRs) come from the second entrant, and less so from the additional entrants. However, this specification also entails less precise parameter estimates. Future research would be desirable to shed further light on this. For example, one may collect more data, or use alternative specifications with more structure from a specific model of product differentiation.

Our model introduced product differentiation in a simple way, by maintaining the assumption that firms are in a symmetric equilibrium. This had a number of advantages. First, the simplicity enabled us to compare quite a number of different local service sectors in an integrated framework. Nevertheless, more work on different sectors and different countries would be useful to further evaluate the benefits and limitations of our approach. Second, the symmetric model has the advantage of transparency: one can clearly see the biases from estimating competition effects with a traditional entry model, and how to correct for them by adding a revenue equation. In practice, a recent empirical literature has emphasized the relevance of firm heterogeneity, but typically without examining the implications of entry on markups. For example, in international trade, Eaton, Kortum, and Kramarz (2011) look at relationships between the number of firms and market size across destination markets, assuming constant markups. In future research, it would be interesting to investigate how to extend our model to allow for heterogeneous firms, so that entry may have asymmetric effects on markups across different firms. A natural first step would be to extend Mazzeo's (2002) entry framework with multiple types of firms, and introduce a revenue equation for each type, as a function of the number of competitors of each type. As in our simpler framework, these revenue functions would serve to account for market expansion effects when estimating the competition effects from entry of different types of firms.

Our model is one of static entry, as in Bresnahan and Reiss' (1991) original work. Bresnahan and Reiss (1993) already proposed a simple dynamic entry model with sunk costs. Abbring and Campbell (2010) provide structural foundations based on a "last-in first-out" assumption.<sup>16</sup> Their model includes uncertainty, where option value considerations make

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<sup>16</sup>This work is situated in a larger recent literature on estimating dynamic models of imperfect competition, e.g. Bajari, Benkard and Levin (2007).

firms more reluctant to exit. They show that both the dynamic and static entry threshold ratio's may be greater than 1, even when entry does not actually lower the firms' profit margins. This is largely due to uncertainty; without uncertainty the entry threshold ratio's do not show strong biases in their examples. In future research, it would be interesting to extend this or related dynamic entry models with a revenue equation as in our framework, to further explore the effects of entry on competition.

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Table 1: Definition of variables

Name	Definition	Mean	St. Dev.
$N$	Number of firms with at least one establishment	See Table 2	
$r$	Revenues per firm and per capita (in €)	See Table 2	
$S$	Population size or number of inhabitants (in 1,000)	4.53	3.89
Surface	logarithm of surface area (in km <sup>2</sup> )	2.71	2.76
GDP	GDP per capita (in 1,000 Euro)	11.15	2.03
%women	Percentage of women	.506	.013
%foreigners	Percentage of foreigners	.043	.057
%unemployed	Percentage unemployed	.057	.028
%kid	Percentage under age of 10 years	.121	.018
%young	Percentage between age of 10 and 25 years	.187	.019
%adult	Percentage between age of 40 and 65 years	.323	.027
%old	Percentage over age of 65	.163	.028
Flanders	Dummy variable equal to 1 for market in Flanders	.398	.490

Notes: The number of observations (markets) is 835. The number of firms  $N$  and revenues per firm  $r$  are constructed from V.A.T. and Business register data from the sectoral database, set up by the Federal Public Service Economy (Sector and market Monitoring Department). The demographics are census data from the FPS Economy (Statistics Belgium), except for %unemployed which comes from Ecodata.

Table 2: Summary statistics for number of firms and firm revenues

Sector NACE code	Archit. 7111	Baker. 1071	Butch. 4722	Florists 47761	Plumb. 4322	Real Est. 6831	Restaur. 5610
	Number of markets with						
$N = 0$	144	242	236	260	139	278	93
$N = 1$	83	148	169	147	112	106	74
$N = 2$	76	126	122	130	94	95	65
$N = 3$	79	94	97	85	68	57	57
$N = 4$	68	63	71	62	68	56	37
$N = 5$	39	41	39	44	43	26	37
$N > 5$	337	111	93	94	303	168	472
	Number of firms (sample of all markets)						
mean	6.2	2.5	2.4	2.3	5.1	3.4	11.1
st.dev	7.0	2.8	2.7	2.6	5.1	5.6	12.3
	Revenues per firm and per capita (sample of markets with $N > 0$ )						
mean	27.79	65.56	82.09	51.96	108.26	31.68	64.18
st.dev	51.98	76.70	117.8	106.14	231.3	63.32	132.5

Notes: The number of observations (markets) is 835.

Table 3: Ordered probit entry model

	Archit.	Baker.	Butch.	Florists	Plumb.	Real Est.	Restaur.
	Ordered probit entry model (sample of all markets)						
$\ln S$	1.40*	1.62*	1.21*	1.29*	1.34*	1.35*	1.48*
Surface	0.12	-0.04	0.10	0.06	0.15*	-0.09	0.24*
GDP	2.63*	-0.73*	-0.48	0.81*	0.59	2.11*	-0.28
%women	9.27*	-8.58	-0.16	-2.16	-3.57	-0.40	3.63
%foreigners	-0.91	-2.08*	-2.53*	0.18	-1.59*	0.40	-0.04
%unemployed	-4.18*	-2.85	-2.45	-2.36	-2.85	-6.34*	4.95*
%kid	7.41	0.02	-6.69	-7.07	2.44	12.99*	1.29
%young	11.49*	6.99*	7.99*	0.01	1.55	13.20*	9.05*
%adult	2.69	-3.13	-3.75	-7.93*	-0.27	7.55*	9.50*
%old	4.79	10.57*	7.70*	-1.87	-0.10	13.06*	7.08*
Flanders	-0.49*	0.01	0.28*	0.04	-0.05	-0.28	0.59*
$\theta_N$	yes	yes	yes	yes	yes	yes	yes
$R^2$	0.25	0.29	0.26	.27	0.24	0.25	0.25

Notes: The parameter estimates are based on maximum likelihood estimation of the ordered probit model (11), where the parameters are all multiplied by the standard deviation  $\sigma$ . Hence, the parameter of  $\ln S$  can be interpreted as  $1/\sigma$ , and the parameters of the other demographics as  $\lambda/\sigma$ . A “\*” indicates that the parameter differs significantly from 0 at the 5% level.

Table 4: Entry thresholds and entry threshold ratios

	Archit.	Baker.	Butch.	Florists	Plumb.	Real Est.	Restaur.
	Entry thresholds						
<i>ET</i> (1)	692	1387	1166	1405	650	1699	445
<i>ET</i> (2)	1137	2610	2736	2873	1251	2818	773
<i>ET</i> (3)	1706	4326	4905	5198	2041	4458	1132
<i>ET</i> (4)	2527	6446	8027	7864	2845	5896	1572
<i>ET</i> (5)	3542	8656	12360	11171	3979	7852	1924
	Entry threshold ratios						
<i>ETR</i> (2)	0.82*	0.94	1.17*	1.02	0.96	0.83*	0.87
<i>ETR</i> (3)	1.00	1.11*	1.20*	1.21*	1.09	1.06	0.98
<i>ETR</i> (4)	1.11*	1.12*	1.23*	1.14*	1.05	0.99	1.04
<i>ETR</i> (5)	1.12*	1.07	1.23*	1.14*	1.12*	1.07	0.98

Notes: The entry thresholds (ET) are based on the cut-points  $\theta_N$  and the other parameter estimates of Table 3, using expression (12) evaluated at the sample means of the variables. The entry threshold ratios (ETR) are based on the cut-points  $\theta_N$ , using expression (13). All ETs are significant with standard errors varying around 150. For the ETRs, a “\*” indicates that the ETR differs significantly from 1.



Table 5: Preliminary regressions for the revenue equation

	Archit.	Baker.	Butch.	Florists	Plumb.	Real Est.	Restaur.
	OLS revenue model (sample of markets with $N > 0$ )						
Constant	3.82	11.89*	18.05*	19.57*	16.34*	5.20	11.20*
$\ln N$	-0.15*	-0.39*	-0.24*	-0.02	-0.15*	0.10	-0.25*
Surface	-0.57*	-0.36	-0.53*	-0.43*	-0.50*	-0.52*	-0.45*
GDP	-0.24	-0.69*	-0.86*	-0.75	-1.23*	0.05	-0.81*
%women	-3.10	-9.97*	-15.23*	-15.6*	-11.09*	-11.16	-10.28*
%foreigners	-1.81*	-0.76	-1.50*	-1.89	-1.09	-1.20	-1.48*
%unemployed	-8.74*	-5.95*	-9.66*	-7.70*	-5.61*	-4.19	-5.09*
%kid	13.71*	6.48	7.10	5.53	11.48*	17.80*	10.24*
%young	7.78*	11.63*	6.34*	2.78	13.62*	1.33	11.61*
%adult	1.68	2.95	1.23	-4.03	3.91	2.75	6.81*
%old	10.72*	8.95*	11.42*	3.02	9.76*	6.90	10.45*
Flanders	-0.51*	-0.28*	-0.53*	-0.16	-0.12	-0.19	-0.24*
$R^2$	.33	.33	.37	.13	.27	.09	.40

Notes: The parameter estimates are based on OLS estimation of the restricted revenue specification (15). A “\*” indicates that the parameter differs significantly from 0 at the 5% level.

Table 6: Detailed estimation results for the revenue equation: illustration with butchers

	Constant elasticity model				Fixed effects model			
	Single equation		Simultaneous		Single equation		Simultaneous	
Constant	18.05*	(2.94)	9.76	(3.40)	–		–	
$\ln N$ ( $\alpha$ )	-0.24*	(0.06)	-0.72*	(0.09)	(fixed effects)		(fixed effects)	
Surface	-0.53*	(0.05)	-0.18	(0.07)	-0.54*	(0.05)	-0.02	(0.08)
GDP	-0.86*	(0.28)	-0.30	(0.36)	-0.89*	(0.28)	-0.12	(0.40)
%women	-15.23*	(3.83)	-6.78	(3.83)	-15.35*	(3.85)	-3.15	(4.24)
%foreigners	-1.50*	(0.71)	-1.17	(0.88)	-1.56*	(0.72)	-1.15	(0.97)
%unemployed	-9.66*	(1.87)	-7.81*	(2.19)	-9.63*	(1.88)	-7.12*	(2.42)
%kid	7.10	(3.68)	-0.16	(4.11)	7.41*	(3.70)	-3.09	(4.49)
%young	6.34*	(2.67)	5.47	(2.83)	6.51*	(2.69)	5.01	(3.12)
%adult	1.23	(2.47)	-1.72	(3.14)	1.30	(2.48)	-2.99	(3.40)
%old	11.42*	(2.22)	9.53*	(2.41)	11.38*	(2.23)	8.48*	(2.61)
Flanders	-0.53*	(0.11)	-0.14	(0.14)	-0.53*	(0.12)	0.06	(0.16)
$\sigma_{\omega\xi}$	0	(–)	-0.43*	(0.06)	0	(–)	-0.60	(0.08)
$R(2)/R(1)$	1.78*	(0.10)	1.21*	(0.07)	1.85*	(0.20)	1.26*	(0.13)
$R(3)/R(2)$	1.40*	(0.05)	1.12*	(0.04)	1.38*	(0.18)	1.05	(0.13)
$R(4)/R(3)$	1.27*	(0.03)	1.08*	(0.03)	1.29	(0.19)	1.00	(0.14)
$R(5)/R(4)$	1.20*	(0.02)	1.06*	(0.02)	1.04	(0.24)	0.82	(0.17)

Notes: Both the single equation and the simultaneous equation models are estimated by maximum likelihood of the full model (18). The single equation models are the special case in which we set  $\sigma_{\omega\xi}^2 = 0$ , reducing to the earlier ordered probit entry equation and OLS revenue equation. In the restricted constant elasticity model,  $N$  enters the revenue equation through  $\ln N$ , in the flexible fixed effects model it enters through a set of fixed effects  $\alpha_N$ . Parameter estimates and standard errors (in parentheses) are only shown for the revenue equation. For the entry equation, they are very similar to the single equation ordered probit results of Table 3. A “\*” indicates that the parameter differs significantly from 0 at the 5% level.

Table 7: Markup effects or adjusted entry threshold ratios

	Archit.	Bakeries	Butchers	Florists	Plumbers	Real Est.	Restaur.
	constant elasticity model						
$\alpha$	-0.48*	-0.92*	-0.72*	-0.28*	-0.53*	0.07	-0.53*
	(0.05)	(0.09)	(0.09)	(0.11)	(0.08)	(0.09)	(0.05)
$\mu(1)/\mu(2)$	1.20*	1.02	1.42*	1.57*	1.35*	1.70*	1.17*
	(0.07)	(0.06)	(0.11)	(0.16)	(0.10)	(0.14)	(0.07)
$\mu(2)/\mu(3)$	1.24*	1.17*	1.33*	1.58*	1.32*	1.58*	1.22*
	(0.06)	(0.05)	(0.07)	(0.10)	(0.07)	(0.09)	(0.06)
$\mu(3)/\mu(4)$	1.26*	1.14*	1.28*	1.37*	1.19*	1.33*	1.21*
	(0.05)	(0.04)	(0.06)	(0.07)	(0.05)	(0.06)	(0.05)
$\mu(4)/\mu(5)$	1.22*	1.07	1.24*	1.31*	1.23*	1.34*	1.08*
	(0.04)	(0.04)	(0.06)	(0.06)	(0.05)	(0.06)	(0.04)
	fixed effects model						
$\mu(1)/\mu(2)$	2.01*	1.19	1.53*	1.73*	1.82*	1.31	1.35*
	(0.19)	(0.11)	(0.16)	(0.26)	(0.25)	(0.25)	(0.13)
$\mu(2)/\mu(3)$	0.99	1.21	1.25	1.40	1.25	0.98	1.40*
	(0.11)	(0.11)	(0.15)	(0.22)	(0.18)	(0.22)	(0.16)
$\mu(3)/\mu(4)$	1.14	1.13	1.21	1.24	1.08	1.55	1.15
	(0.14)	(0.12)	(0.17)	(0.23)	(0.17)	(0.38)	(0.19)
$\mu(4)/\mu(5)$	1.09	0.98	1.01	1.02	1.63*	1.75	0.92
	(0.17)	(0.13)	(0.21)	(0.22)	(0.29)	(0.55)	(0.17)

Notes: The markup effects  $\mu(N - 1)/\mu(N)$  are computed from (20) for the restricted constant elasticity revenue equation, and from (19) for the more flexible fixed effects revenue specification. For the constant elasticity specification, Table 7 also shows the business stealing effect  $\alpha$ , used to adjust the ETR. A “\*” indicates that the markup effect differs significantly from 1.