Estimating Market Entry With Observed Fixed Costs: Radio Stations in Canada

Jules Boudreau

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Since the publication of the influential entry model of Bresnahan and Reiss (1991, BR henceforth), market entry thresholds have been estimated for a myriad of industries. The ubiquity of market entry estimation in IO is due to the convenience of the estimation methods. They do not require hard-to-obtain firm-level data, but rather rely solely on market-level observations: number of firms in a market, exogenously-treated demographic and geographic variables. While this low data requirement allows the application of the BR entry model to many industries, it relies on strong distributional assumptions and confuses the effect of market structure (competition) on entry thresholds with the effect of changing costs.

I am able to relax these assumptions by exploiting data sources on the Canadian radio industry that to my knowledge have not been used in empirical IO to date. By combining radio listening data from Numeris consumer surveys with market-level financial data from the Canadian Radio-television and Telecommunications Commission (CRTC), I can add to the entry model observables for fixed costs, price and quantity, in addition to a higher quality measure of market size. The particularities of the radio market – zero marginal costs – also simplify the model. In addition, the estimation of the entry model will allow me to evaluate the impact of an increase in firm homogeneity on competition. The Canadian Content law of 1999 arguably increased homogeneity in station programming by requiring that 40% of music aired be Canadian.

1 Related Literature

BR's model relates the observed number of firms N_m in a market of size S to firms' unobserved profits. In a homogeneous industry, the profit of the N^{th} entrant in a market is given by

$$\pi(N) = [p_N - AVC(q_N, \boldsymbol{W})]d_n \frac{S}{N} - F_N \tag{1}$$

where p_N is the per-unit price of the product, q_N is the quantity produced by the firm, $\boldsymbol{W}$ is a vector of cost-shifters, d_N is the demand of a representative consumer, and S is the size of the market. BR assume that profits are the same across all firms in a market, so the entry of the N^{th} also decreases profits for all other firms, through a decrease in p or an increase in AVC.

If the zero-profit condition holds, we can invert the profit function to get the per-firm entry threshold, i.e. the minimum market size per firm N necessary to support N firms in a market.

$$s_N = \frac{S_N}{N} = \frac{F_N}{(p_N - AVC_N)d_N} \tag{2}$$

We expect s_N to be increasing in N due to competition. The pool of customers necessary to sustain a monopolist is relatively small, as the monopolist can charge high prices p_N, thus increasing profits for a given number of customers. But in a perfectly competitive market, as $N \to \infty$, p_N is pressured downwards. More potential consumers per firm are needed for them to cover AVC and F.

By computing entry threshold ratios, you could in theory approximate how far a market is from perfect competition:

$$\frac{s_{N+1}}{s_N} = \frac{F_{N+1}}{F_N} \frac{(p_N - AVC_N)d_N}{(p_{N+1} - AVC_{N+1})d_{N+1}} \tag{3}$$

If a market has 4 firms, and $\frac{s_\infty}{s_4} = 1$, then it is at competitive equilibrium. If $\frac{s_\infty}{s_4} > 1$, then the firms are making oligopoly profits.

How do BR estimate this model considering they only observe N? Because they don't observe F, p_N, d_N, they use exogenous variables that are likely to determine demand and costs. Equation (1) becomes:

$$\pi(N) = S(\boldsymbol{Y}, \lambda)V_N(\boldsymbol{Z}, \boldsymbol{W}, \alpha, \beta) - F_N(\boldsymbol{W}, \gamma) + \epsilon \tag{4}$$

where $\boldsymbol{Y}$ are linear determinants of market size, $\boldsymbol{Z}$ is a vector of per-capita linear demand shifters, $\boldsymbol{W}$ is a vector of per-capita linear cost shifters and ϵ summarizes profits that the econometrician does not observe.

To identify the parameters – $\lambda, \alpha, \beta, \gamma$ – BR rely on the fact that the N^{th} firm will only enter the market if $\pi(N) \geq 0$ while the $(N+1)^{\text{th}}$ firm will not enter if $\pi(N+1) \leq 0$. Given an observed N, we can maximize the probability that this maximum-entry condition holds across markets. With the strong assumption that the unobserved profits ϵ are the same for all firms in a given market and $\epsilon \sim \mathcal{N}(0, \sigma^2)$, it implies finding the maximum likelihood of the ordered probit:

$$Pr(\pi_N \geq 0 \text{ and } \pi_{N+1} \leq 0) = \Phi(\pi_N - \epsilon) - \Phi(\pi_{N+1} - \epsilon) \tag{5}$$

As shown in Figure 1, BR find that estimated entry threshold ratios converge to 1 for markets with 3 firms or more. As explained above, they take this to imply that with 3 firms of more in a market, competition between firms pushes down p to competitive levels. But looking at equation (3), it is clear that falling threshold ratios don't necessarily imply that prices are converging to a competitive equilibrium. The falling threshold ratios observed in Figure 1 could be explained by p dropping as N increases, but also by increases in AVC or F (Berry and Reiss, 2007). For example, Figure 1 shows that the ratios for doctors falls from $\frac{s_5}{s_1} = 2$ to $\frac{s_5}{s_2} = 1$. Assume $AVC_N = AVC_{N+1} = 1$, $d_N = d_{N+1} = 1$. Then the fall in threshold could be explained by prices dropping from $p_1 = 3$ to $p_2 = 2$, consistent with BR's interpretation of increased competition. But it could also be explained by an increase in fixed costs from $F_1 = 1$ to $F_2 = F_5 = 2$.

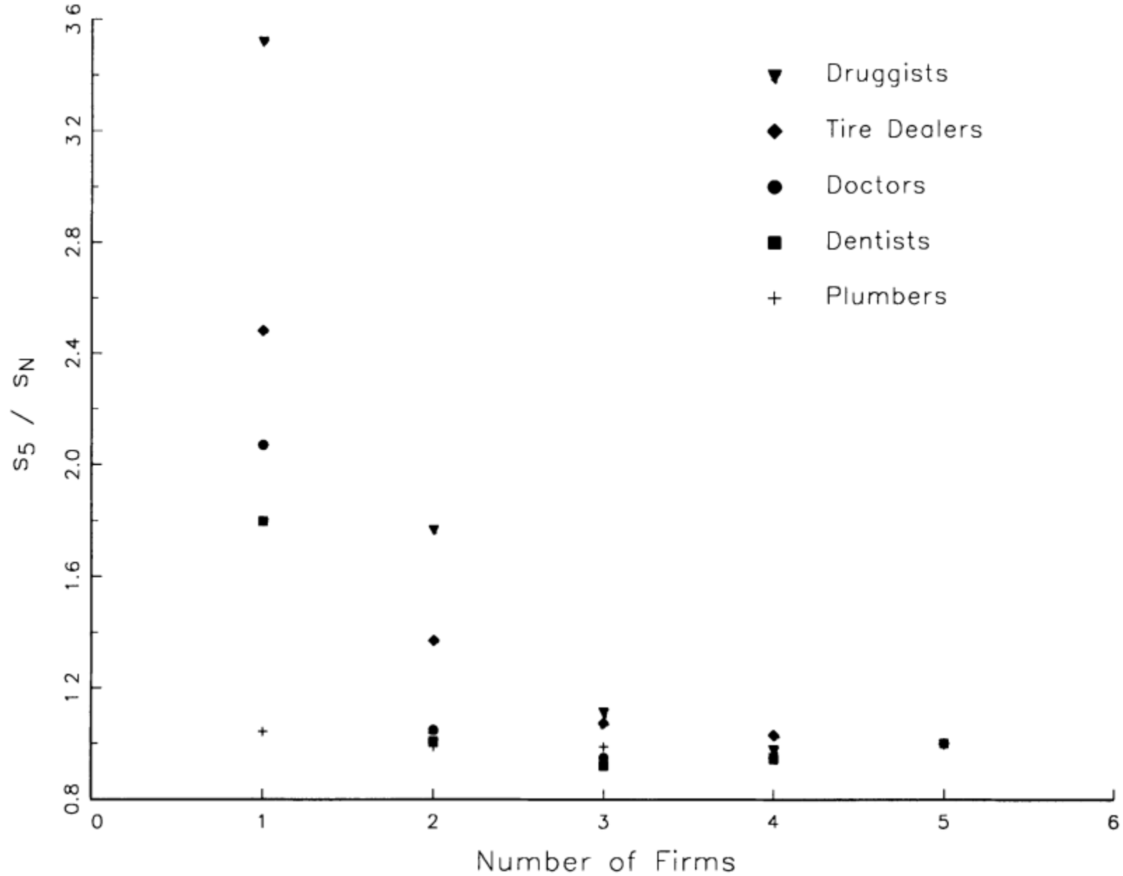
This difference is not a technicality. It has crucial implications for market structure and welfare. In the first case moving to a higher N in a market is positive for consumers: prices go down, the surplus previously captured by the monopolist now goes to consumers. In the second case prices don't change and consumers are just as badly off as under a monopoly, but now the firms are also wastefully investing more in fixed costs.

Abraham et al. (2007) use data about quantity Q_N to isolate the effects of fixed costs from those of variable profits. Their model thus consists of two equations:

$$\pi_N = V_N d_N \frac{S}{N} - F_N \tag{6}$$

$$Q_N = S d_N \tag{7}$$

Figure 1: Entry Threshold Ratios by N (Bresnahan and Reiss, 1991)



The first line is similar to equation (1) from BR. Like BR, they assume that profits, demand, and costs are log-linear functions of exogenous shifters $\boldsymbol{Z}$ and $\boldsymbol{W}$ and market size of $\boldsymbol{Y}$:

Substituting equation (7) into the entry threshold ratio equation (3) we get

$$\frac{s_{N+1}}{s_N} = \frac{F_{N+1}}{F_N} \frac{V_N}{V_{N+1}} \frac{Q_N}{Q_{N+1}} \tag{8}$$

Because Q_N increases when competition increases – since competition decreases prices and demand is assumed to be somewhat elastic – a change in Q_N accompanying a change in $\frac{s_{N+1}}{s_N}$ signals an increase in competition rather than an increase in costs. This procedure is a strong step towards refining the BR model, but it still ignores two issues. First, it only provides suggestive evidence as to whether changes in thresholds are due to competition or costs. It does not exactly identify changes in p, AVC and F. In the next section I will explain how my research using Canadian radio station data will solve this issue. Second, it assumes that firms are perfectly homogeneous. If firms are all identical, then the entry of an (N+1)$^{\text{th}}$ does not increase demand keeping price constant. So $Q_{N+1} > Q_N$ can only be caused by extra competitive pressure. But if firms are heterogeneous, then the entry of an (N+1)$^{\text{th}}$ firm with differentiated products can increase demand without affecting competition by reaching a previously under-served segment of demand. As explained, at the end of section 2, my research project will not model heterogeneity, but will provide suggestive evidence towards understanding the effects of firm heterogeneity

2 Industry, Data and Outline of Model

The datasets I used, as well as the sources for those datasets and the Julia notebook I used to describe the data can be found at `https://github.com/julesboud/econ-567-proposal/`.

I use data from the Canadian radio industry to improve further on BR's model. I combine radio listening data from Numeris consumer surveys with market-level financial data from the Canadian Radio-television and Telecommunications Commission (CRTC). Numeris has market-level measures for the listening universe (population reached by local radio signals) and number of listeners.[1] The listening universe is a high quality measure for market-size. Other entry model studies use arbitrary cutoff for size of geographic markets (city, county, etc.), but the Numeris data gives an exact measure of how many people are reached by the radio signals. The CRTC compiles the aggregate financial results of radio stations (revenue, costs, etc.) and the number of firms in a market. Such financial data is available because

[1] It also has listening data on all the individual stations. I don't use that information, but will later touch upon the possibilities it opens.

radio stations are compelled by law to submit their annual financials to the CRTC.

Like Abraham et al. (2007), we have a measure of Q_N (number of listeners). But by combining the two datasets we also have a measure of price p_N (local ad revenue divided by quantity of listeners) and fixed costs per station F_N (total expenses divided by number of firms in market). This will allow us to relax even further the functional assumptions of BR. Figure 2 shows some summary statistics for the most relevant variables in the combined dataset for the 2016 cross-section.

Figure 2: Description of variables in the combined dataset (Numeris+CRTC, 2016 Cross-Section)

	variable	mean	min	median	max
	Symbol	Union...	Any	Union...	Any
1	Market		Calgary Total		Winnipeg Total
2	Stations (N)	10.4138	4.0	7.0	32.0
3	Local Time Sales	2.41276e7	1.88147e6	1.22887e7	1.37708e8
4	Total Expenses	3.02774e7	2.48791e6	1.43613e7	1.81793e8
5	Universe (S)	7.66959e5	92090	355540.0	5321000
6	Number of Weekly Listeners (Q_N)	868.323	113.8	356.0	5468.5
7	Costs Per Station Per Week (F_N)	43257.7	11961.1	33613.7	1.09251e5
8	Ad Selling Price Per Listener (p_N)	794.103	340.457	663.047	1860.34

In addition to my data containing more observables than previous market entry studies, the radio industry has idiosyncrasies that simplify the model. The marginal cost of adding an extra listener is 0, so $AVC_N = 0$ for all N. Deciding which costs are fixed and which are variable is an important issue in empirical IO. Hence, I can sidestep this issue by treating all costs in the data as fixed costs.

As outlined above, Abraham et al. (2007) claim that the assumption that fixed costs do not change with the number of stations in market is unrealistic and that changes in entry thresholds can reflect changes in fixed costs rather than in prices. Figure 3 suggests that this is likely true, although those higher fixed costs could be explained by the fact that markets with more stations probably cover a larger geographic area.

Figure 3:

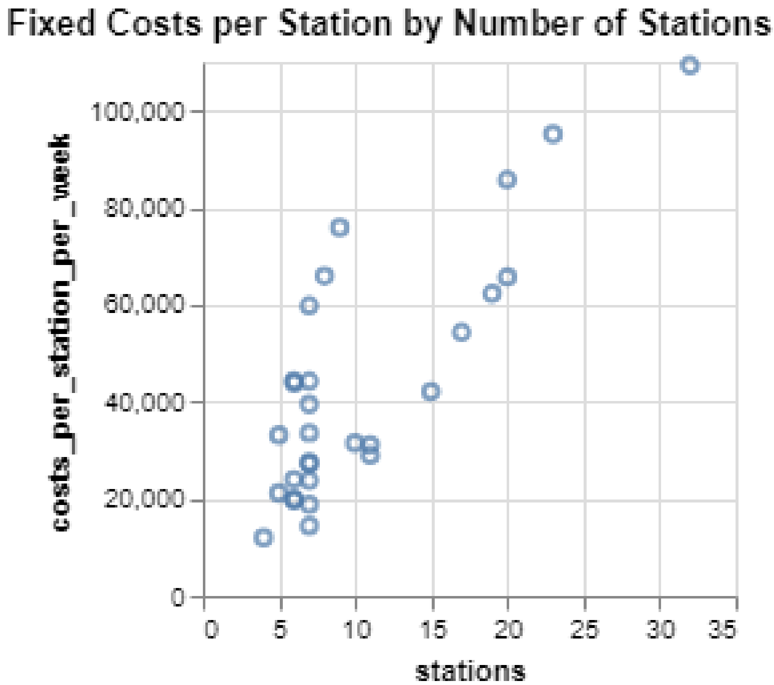


Figure 4 shows the tight correlation between the number of stations in a market and the size of the market, the motivating relationship behind entry models. Figure 5 shows the relationship between unit price and the number of stations in a market. The price of a listener to advertisers declines as the number of stations in market increases. This is BR's hypothesis – more stations mean more competition and so lower prices – but they don't have the price data to directly show it. Figure 5 shows that this hypothesis is right, although the relationship is not incredibly strong. Even before formally applying the entry model to this data, looking at Figure 3 and Figure 5 suggests that we should find that the drop in entry thresholds as $N \to \infty$ is caused in part by a decrease in p_N and in part by an increase in F_N.

Here is an outline of the entry model. We observe N, p_N, Q_N, F_N, and S. Only S can plausibly be treated as exogenous. So we will need instruments for our measures of p_N,

Figure 4:

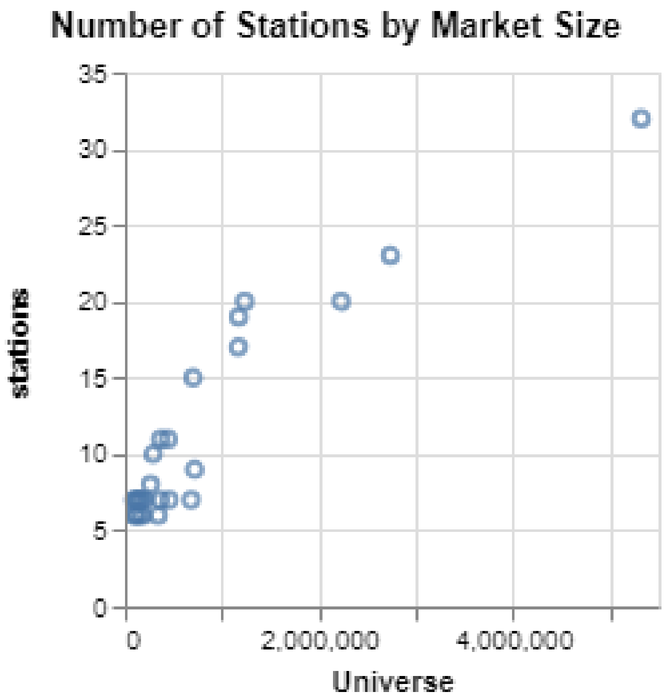
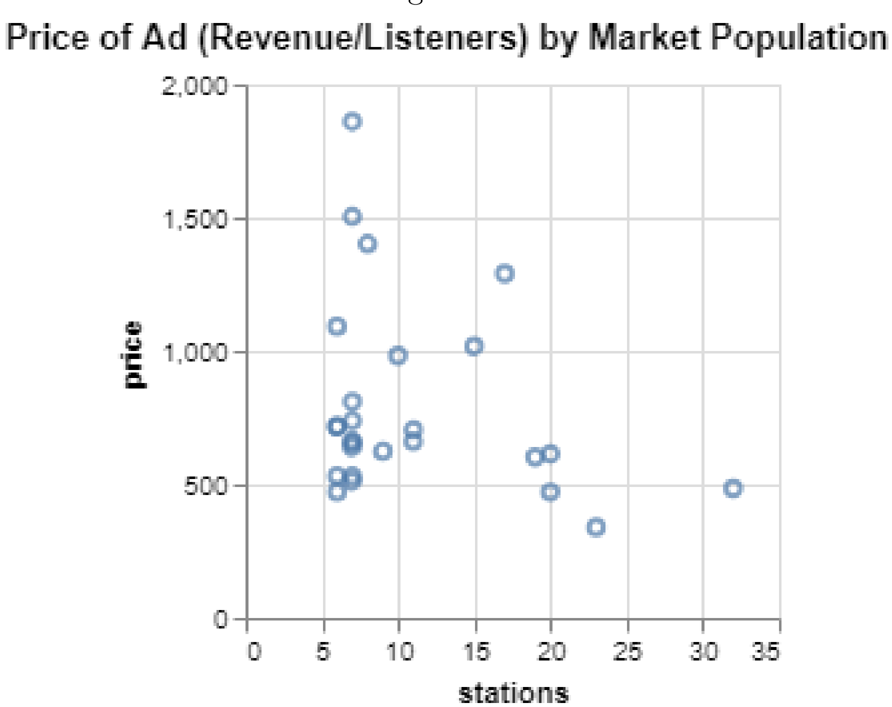


Figure 5:



Q_N and F_N. Following BR (1991) and Abraham et al. (2007), and with the $AVC_N = 0$ assumption the profit equation is

$$\pi(N) = V_N - F_N = p_N d_N \frac{S}{N} - F_N \tag{9}$$

Substituting the quantity equation $Q_N = d_N S$ in as in Abraham et al. (2007) we get

$$\pi(N) = p_N \frac{Q_N}{N} - F_N + \epsilon \tag{10}$$

The first-stage equations for our endogenous variables are

$$\begin{aligned} Q_N &= \exp(\delta_N + S + X\delta_X + \epsilon_Q) \\ p_N &= \exp(\alpha_N + Z\alpha_Z + \epsilon_p) \\ F_N &= \exp(\gamma_N + W\gamma_W + \epsilon_F) \end{aligned} \tag{11}$$

We can then simultaneously solve the ordered probit as in BR (see section 1) and the first-stages by maximum likelihood (Rivers and Vuong, 1988).

The obvious problem here is to find appropriate instruments X, Z and W. W is not an issue. Land area and construction costs increase fixed costs, but don't affect demand for radio or price of ads. X and Z are more complicated. Consumer-side variable such as income and education are promising, but it is difficult to find controls that affect quantity demanded but not price. Fortunately, even if we cannot find distinct variables for X and Z we can still estimate our model. Price and quantity effects will be jointly identified, but we can still isolate the effects of competition (p and d_N) from those of costs.

The data I compiled and analyzed in my GitHub repository only contains the 2016 cross-section. Using panel observations on the Canadian markets in multiple years would increase variation in the variables and give better identification. To use this information, I would have to take into account that the ϵ's of the same market in different time periods are correlated.

On one hand, it is probably unrealistic to assume homogeneity of firms, as radio stations specialize in different genres of music. On the other hand, Rogers and Woodbury (1996) find that substitution between stations is high and show a weak correlation between diversity of programming and total listenership. Regardless, it would be interesting to take heterogeneity into account in our model, but the data doesn't allow it. Heterogeneity in product/demand cannot be modeled because I don't have a variable for the genre of stations. Heterogeneity in fixed cost cannot be modeled either because the data only contains a market-level measure of fixed cost, so the assumption that all firms in a market have the same fixed costs is binding. To test the effect of homogeneity on entry thresholds without having access to data about costs/genres of individual firms, I will use the 1999 Canadian Content policy change as an exogenous increase in homogeneity. This policy required that 40% of music broadcasted by Canadian radio stations be performed by Canadian artists. Considering the relatively small pool of Canadian artists, this policy likely decreased the variety of radio programming and thus the product differentiation. Comparing entry thresholds before and after the policy would provide evidence as to whether heterogeneity of firms has an impact on competitive behaviour.

References

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