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Measuring competition using the Profit Elasticity: American Suger Industry, 1890 - 1914

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Abstract
The Profit Elasticity (PE) is a new competition measure introduced in Boone (2008). So far, there was no direct proof that this measure can identify regimes of competition empirically. This paper focuses on this issue using data of Genesove and Mullin (1998) in which different regimes of competition are identified. We derive a version of PE suitable for this data set. This competition measure correctly classifies the monopoly / cartel regime as being less competitive than both the price was regime and break-up of cartel regime.

Keywords: competition, measures of competition, price cost margin, profit elasticity.

JEL classification: D43, L13.

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1. Introduction

The Profit Elasticity (PE) is a new competition measure introduced in Boone (2008). It has been estimated using Dutch data in Boone et al. (2007). The idea is to measure the percentage fall in a firm's profits in response to a 1% fall in this firm's efficiency. Even for a monopolist, a fall in efficiency leads to a decrease in profits. But the more competitive the environment, the bigger the fall in profits due to a given loss in efficiency.

A natural question with a (new) competition measure is the following. If the measure suggests that competition has become more intense over time in a certain sector, is this actually correct? To test this, one needs data on a well documented industry where one can distinguish periods with different competitive regimes. We use the sugar industry in the period 1890-1914 for this purpose which has been documented by Genesove and Mullin (GM) in GM (1998 and 2006).

As we argue below, during this period there were three regimes that can be distinguished in terms of competition intensity: (i) monopoly/cartel, (ii) price war and (iii) the break-up of the cartel through intervention by the Federal government. The main question is whether PE can rank regimes (ii) and (iii) as being more competitive than (i).

Boone et al. (2007) test PE indirectly as competition measure using Dutch firm level panel data. In particular, they show that PE and price cost margin (PCM) come up with conflicting predictions about the development of competition precisely when theory suggests that PCM points in the wrong direction. Compared to Boone et al. (2007), this paper has three advantages, besides the fact that GM document three different competition regimes. First, here we have a clear industry definition whereas Boone et al. (2007) rely on the standard industry classification. Second, the GM data allow us to instrument costs. Third, marginal costs are known in the Sugar industry (see below).

Since GM use their data to estimate a structural I.O. model with which they can identify conduct, a natural question is why would we be interested in PE? As mentioned, the goal of this paper is to verify that PE measures competition correctly; not to learn something new about the sugar industry. Second, many national statistical offices have firm level data available on many sectors; often this data is used to publish the country's national accounts. Typically, such data sets provide information on a firm's revenues, costs (divided into labor, energy, intermediate good costs etc.), number of employees, value added etc. Such data is usually not rich enough to estimate a structural I.O. model. Hence conduct cannot be identified in this way. With this data one can estimate standard measures (like concentration and PCM) and PE. As argued in Boone (2008), from a theoretical point of view, PE is a more robust competition measure than concentration and PCM. Boone et al. (2007) use this type of data to show that well known theoretical problems with PCM and concentration indeed occur in real data.

The rest of this paper is organized as follows. The next section introduces the sugar industry over the relevant period. This is a summary of the GM papers. Then we discuss the data and introduce the version of PE that we can use with this data. Section 5 shows that PE can rank the three regimes correctly.

2. Competition and costs in the sugar industry: 1890–1914

To verify whether PE can identify different regimes of competition, we use the well documented case of the US sugar industry from 1890–1914. Genesove and Mullin (1995, 1997, 1998 and 2006) provide a detailed description of the sugar industry in this period. Based on their work, we identify three different regimes of competition. We summarize Genesove and Mullin (1998)'s description of the sugar industry in the period 1887–1914. The description is summarized in Table 1.

From 1887 to the end of 1889, the sugar industry can be characterised as (almost) monopoly/cartel. The Sugar Trust controlled 80% of the market at that time. In December 1887, the Sugar Trust was formed as a consolidation of 18 firms controlling 80% of the industry's capacity. Refined (that is, output) prices increased by 16% after this consolidation.

The high prices attracted a new entrant to the market: Spreckels began production in early 1890.[1] This led to the first price war. In 1891, the Sugar Trust was reorganised as a corporation, the American Sugar Refining Company (ASRC) which acquired Spreckels' plant. By April 1892 this acquisition ended the price war. Due to the acquisition, ASRC's share of industry capacity was raised to 95%.

In the next period, from 1892 to 1897, the sugar industry was characterised by high levels of concentration and with 95% of the market, ASRC basically had a monopoly. In total, five firms entered the market, each with a single plant, with an average capacity of 1340 barrels of refined sugar per day. The ASRC (and associated firms) had a capacity of 49500 barrels of refined sugar a day. By 1896, contemporary publications indicate that American Sugar, leader of the cartel, had an agreement also with the new entrants.

In 1898, the next phase of competition began with the construction of a plant by the Arbuckle Brothers which began initial production in August 1898. The Doscher refinery, another entrant, began production in November 1898. These new plants had a capacity of 3000 barrels per day. This led to a price war, marked by pricing at (and sometimes even below) cost. As a result, the smaller independent refiners were shut down. This second price war ended in May 1900.

After this, the period can best be characterised as a mixed regime in which the intensity of competition is unclear. In the period 1900 Q3–end of 1909, competition increased compared to the oligopolistic period with the gradual decline of the market share of ASRC. However, at the same time, import tariffs changed. In 1903, a preference was granted towards raw Cuban sugar. Under the Cuban reciprocity Treaty, Cuban raw sugar was admitted to the US at a tariff rate of 80% of full duty. This lowered the price of raw sugar in New York relative to the price of German raw beet sugar and protected the American sugar industry from European competition on the refined sugar (final output) market. As we have no strong prior on the intensity of competition in this period we ignore it in our analysis.

Then antitrust regulation started to increase competition. Seeking the dissolution of ASRC in 1910, the Federal government filed suit with regard to the antitrust regulation, charging

[1] Genesove and Mullin (1997), p. 21 and Genesove and Mullin (2006).

monopolization and restraint of trade. Although this case was not formally resolved until a consent degree was signed in 1922, the government's victories in the American Tabacco and Standard Oil cases in 1911 led American Sugar to initiate partial, voluntary, dissolution. In the "Chronicle" of January 1910, the Board of ASRC recognizes that the Circuit Court of Appeals gave a much wider interpretation of the competition law in the American Tabacco case than previously. The break-up of the cartel took place between 1910-1914.

Given that we only have data from 1890 onwards, we cannot use the 1887-1889 period in our analysis. The two price wars will be taken together into one price war regime. The period of monopoly/cartel is defined as: 1892Q3 - 1898Q3, the period in between the two price wars. The break-up of the cartel was in the period: 1910Q1–1914Q2.

Period	**Regime**
1887–1889	(i) monopoly/cartel
1890–1892 Q2	(ii) price war due to Spreckels' entry
1892 Q3–1898 Q3	(i) monopoly/cartel
1898 Q4–1900 Q2	(ii) price war due to entry by Arbuckle Brothers and Doscher
1900 Q3–1909	mixed regime of competition
1910–1914	(iii) break-up of cartel due to Federal government antitrust suit

Table 1: Three competition regimes

Below we test whether PE indicates that the monopoly/cartel regime is less competitive than both the price war and the break-up cartel regime. Since cartel break-up can be a tumultuous affair with turf wars between former cartel members, we have no prior on whether the price war regime is more or less competitive than the break-up regime.

After describing the development of competition intensity, we move to the second important point for estimating PE: marginal costs. As documented by GM, the production technology of sugar is a straightforward process. In this period, raw sugar consisted of 96% pure sugar and 4% water and impurities. To transform raw sugar into refined sugar, all sugar refiners use the same constant returns to scale production process. Marginal costs are a linear function of the price of raw sugar, p_{raw}, with constant slope k. In order to calculate the marginal costs of producing refined sugar, variable costs like labour and other costs have also to be included. This leads to the following expression for marginal costs (independent of the output level) in period t:

$$c_t = c_0 + k * p_{raw,t} \qquad (1)$$

where c_0 denotes all variable costs other than the cost of raw sugar.

The fixed coefficient is equal to $k = 1.075$ according to Genesove and Mullin (1995, 1998), because the production of one pound of refined sugar requires 1.075 pounds of raw sugar. The value of c_0 is less straightforward. Genesove and Mullin (1998) put as best guess $c_0 = 26$ cents. This estimate is based on the testimony of a partner in Arbuckle Brothers. In this testimony, it is said that if raw sugar costs 4.5 cents a pound, it will cost 5 up to 5.1 cents to produce one pound of refined sugar. Subtracting 4.5*1.075 from a total cost of 5 or 5.1, we obtain a value of c_0 ranging between 16 and 26 cents (per hundred pound). In line with Genesove and Mullin (1998), we will use the estimate of 26 cent to calculate the marginal costs of ASRC and show as a robustness check the results for 16 cents as well.

Finally, as a commission merchant for one of the independents testified "it is possible that the [larger houses] can refine at smaller margin than the others. . . . [but] it can [not] amount to a great deal" (Genesove and Mullin (1995: pp. 13)). Hence we derive our results for the case where firms are perfectly symmetric. By continuity, the results go through for small asymmetries.

3. The data

With profits and marginal costs one can calculate PE. The relevant profit concept is variable profits: revenues minus variable costs (see Boone (2008) and below). Profits are not reported in the GM data. In this paper, variable profits of ASRC are calculated as

$$\pi_t = (p_t - c_t) Q_t ms_t \tag{2}$$

where the price p_t of refined sugar is the same for each firm (refined sugar is a homogeneous good), c_t is given by equation (1), Q_t denotes total market output and ms_t Sugar Trust/ASRC's market share in period (quarter) t. Of these variables, p_t, c_t and Q_t are reported on a quarterly basis. The market share ms_t is only available on a yearly basis. We assume that ASRC's market share is constant in the four quarters of a year. This is an approximation that may worsen the performance of PE as competition measure. However, as shown below this turns out not to be an issue.

Below, we use Cuban imports of raw sugar to instrument c_t (again following Genesove and Mullin (1998)). This is available on a quarterly basis for the period 1890Q1 -1914Q2.

Table 3 presents summary statistics.[2] In principle there are 98 observations (for the quarterly data). In line with Genesove and Mullin(1998), observation 1897-Q4 is dropped because reported Cuban raw sugar imports are zero in this quarter. Therefore, we have 97 observations divided in four regimes.

Quarterly profits change with the different regimes. They are at their lowest level during the price wars. During the period of monopoly/cartel, the profits reach their peak, nearly ten times as high as during the price war. After the break-up of the cartel, profits are low again (but not negative as in some quarters during the price war).[3] Marginal costs are relatively high in the monopoly/cartel and mixed regimes due to the high prices for raw sugar.

[2] All prices are reported in dollars per hundred pounds. All quantities are reported in 100,000 of long tons (one long ton is 2240 pound). Profits are in 100,000 dollars.

[3] As explained in Boone (2008), profit levels are not a robust measure of competition. Hence the fact that profits are lower in the price war regime than in the break-up regime does not prove that the former regime is more competitive. Such comparisons are particularly hazardous in this data because marginal costs are higher during the price war compared to the break-up regime.

Variable	observations	Mean	Std. Dev.	Min	Max
Total production (Q) in long tons	97	4.43	1.11	2.35	7.80
Cuban imports of raw sugar in long tons	97	2.18	1.73	8.62	7.07
Price of refined sugar (p) in dollars	97	4.03	0.62	2.75	5.51
Price of raw sugar (p_{raw}) in dollars	97	3.30	0.59	2.25	4.87
market share in %	24	63.0	12.0	43.0	91.0
marginal cost (mc) in dollars	97	3.81	0.64	2.68	5.50
$profit_{pricewar}$ in dollars	17	2.52	12.00	-11.95	36.56
$profit_{monopoly/cartel}$ in dollars	24	28.12	12.67	3.93	49.51
$profit_{breakup}$ in dollars	18	6.58	5.00	0.87	17.20
$c_{pricewar}$ in dollars	17	4.47	0.80	3.25	5.50
$c_{monopoly/cartel}$ in dollars	24	3.97	0.47	3.27	4.82
$c_{breakup}$ in dollars	18	3.34	0.47	2.68	4.37

Table 2: Summary statistics

4. Profit elasticity using Sugar data

In this section we explain how the PE can be identified for the sugar industry. We first present the standard way PE is used in papers like Boone et al (2007). Then we explain why we need to adapt this method for the data available here. In order to facilitate comparison with the GM (1998) set up, we adopt their model.

Following GM (1998: 364) we use the following demand function

$$Q(p) = \beta(\alpha - p)^{\gamma} \tag{3}$$

with $\alpha, \beta > 0$, which encompasses linear ($\gamma = 1$) and quadratic ($\gamma = 2$) demand. With $\alpha, \gamma \to +\infty$ while α/γ is constant, we get exponential demand. As described above, for refined sugar, marginal costs are constant. Hence firm $i \in \{1, 2, ..., n\}$ chooses q_i to solve

$$\max_{q}\{(p(Q) - c_i)q_i\} \tag{4}$$

where c_i is i's constant marginal cost level, q_i is i's output level and $Q = \sum_j q_j$ equals total output on the market. The first order condition for firm i can be written as

$$p'(Q)(1 + \lambda)q_i + p(Q) - c_i = 0 \tag{5}$$

where the conduct parameter (or conjectural variation) is defined as $\lambda = \frac{d\sum_{j\neq i} q_j}{dq_i}$.[4] Cournot competition implies $\lambda = 0$ and lower λ's are interpreted as leading to more competitive outcomes.

[4] Here we deviate slightly from GM who work with $\theta = (1 + \lambda)q_i/Q$ as conduct parameter. Working with λ allows us to identify q_i, which GM do not need as they focus on the price cost margin. For notational simplicity we focus on the case where each firm i has the same conduct parameter λ.

Summing equation (5) over all firms (taking firm 1 as the firm we are interested in) yields

$$p'(Q)Q(1+\lambda) + np(Q) = c_1 + C_{-1} \tag{6}$$

where $C_{-1} = \sum_{j \neq 1} c_j$. With the demand curve as specified in (3) we can solve this for Q as follows

$$Q = \beta \left(\frac{n\alpha - (c_1 + C_{-1})}{n + \frac{1+\lambda}{\gamma}} \right)^{\gamma} \tag{7}$$

A firm i can only be active in the market if $\alpha > c_i$ and hence $Q > 0$. Now we can use equation (5) to solve for q_1 as

$$q_1 = \frac{p(Q) - c_1}{-(1+\lambda)p'(Q)} \tag{8}$$

As mentioned, we consider the variable profits of firm 1 defined as $\pi_1 = (p(Q) - c_1)q_1$. It is routine to verify that with the demand function above this profit function can be written as

$$\pi_1(c_1, C_{-1}) = \frac{\beta\gamma}{1+\lambda} \left((\alpha - c_1) \left(\frac{n\alpha - (c_1 + C_{-1})}{n + \frac{1+\lambda}{\gamma}} \right)^{\gamma - 1} - \left(\frac{n\alpha - (c_1 + C_{-1})}{n + \frac{1+\lambda}{\gamma}} \right)^{\gamma} \right)^2 \tag{9}$$

The PE is defined as

$$PE = \frac{d \ln \pi_1}{d \ln c_1}$$

the percentage fall in profits due to a 1 percent increase in marginal costs.

The effect of the conduct parameter λ on PE is given by

$$\frac{dPE}{d\lambda} = c_1 \frac{2((n-1)\alpha - C_{-1}))}{(n\alpha - (c_1 + C_{-1}))(1 + n\gamma + \lambda)} \frac{\frac{n\alpha - (c_1 + C_{-1})}{n + \frac{1+\lambda}{\gamma}}}{\left(\alpha - \frac{n\alpha - (c_1 + C_{-1})}{n + \frac{1+\lambda}{\gamma}} - c_1 \right)^2} > 0$$

because $\alpha > c_i$ for each i. Hence $PE = d \ln \pi_1 / d \ln c_1 < 0$ becomes more negative as λ falls (more intense competition). Profits always fall as costs increase. But the percentage fall in profits is bigger in more competitive circumstances (lower λ).

There is the following problem in the current data set that prevents us from using this approach. We do not have data on changes in c_1 for given value of C_{-1}. Instead, we have data on the price of the input raw sugar, p_{raw}, which is the same for every producer. Hence, a change in p_{raw} affects both c_1 and C_{-1} which is not taken into account in the framework used by Boone (2008) and Boone et al. (2007).

Therefore, for this dataset we consider the following related approach. Following equation (1) we write

$$c_i = c_{0i} + k_i p_{raw} \tag{10}$$

As discussed above, c_{0i} and k_i are roughly the same across firms. To stress that differences between firm 1 and the other firms should be thought off as being small, we write

$$\frac{1}{n-1}C_{-1} - c_1 = \delta + \varepsilon p_{raw} \tag{11}$$

where $\delta, \varepsilon > 0$ are close to zero.

In order to derive a variant of PE, we first define firm 1's price cost margin as $pcm_1 = (p - c_1)/p$. Then it is routine to verify that

$$pcm(c_1, C_1) = 1 - c_1 \frac{1 + n\gamma + \lambda}{(1+\lambda)\alpha - \gamma(c_1 + C_{-1})} \tag{12}$$

Taking into account that p_{raw} affects both c_1 and C_{-1} we define (with a slight abuse of notation) $pcm(p_{raw}) = pcm(c_{01} + k_1 p_{raw}, (n-1) * (c_{01} + \delta + (k_1 + \varepsilon)p_{raw}))$. We can show the following.

Lemma 1 *Assume $\delta = \varepsilon = 0$, then*

$$\frac{d\left(\frac{d \ln pcm(p_{raw})}{d \ln p_{raw}}\right)}{d\lambda} = \frac{k_1 n \alpha \gamma p_{raw}}{(n\gamma(c_{01} + k_1 p_{raw}) + \alpha(1+\lambda))^2} > 0$$

Hence for the case where firms are symmetric (or by continuity, almost symmetric) a fall in λ (more intense competition) makes pcm more sensitive to a change in p_{raw}. An increase in p_{raw} reduces firm 1's pcm but this reduction in pcm is bigger in more competitive circumstances.

Although taking logs removes negative pcm from the dataset, this is not much of an issue here as we have quarterly pcm and enough observations remain (86 with $c_0 = 26$ cents and 97 with $c_0 = 16$ cents).[5]

Lemma 1 considers pcm while PE focuses on profits. It turns out that in this case, $d \ln pcm / d \ln p_{raw}$ and $d \ln \pi / d \ln p_{raw}$ react to λ in the same way. To see this, consider the effect of p_{raw} on the market share of firm 1: $ms = pq_1/(pQ) = q_1/Q$. It is routine to verify that

$$ms(c_1, C_{-1}) = \frac{\gamma}{1+\lambda}\left(-1 + (\alpha - c_1)\frac{1 + n\gamma + \lambda}{n\alpha - (c_1 + C_{-1})}\right) \tag{13}$$

Again defining (with slight abuse of notation) $ms(p_{raw}) = ms(c_{01} + k_1 p_{raw}, (n-1) * (c_{01} + \delta + (k_1 + \varepsilon)p_{raw})$, we find the following

Lemma 2 *Assume $\delta = \varepsilon = 0$ then*

$$\frac{d\left(\frac{d \ln ms(p_{raw})}{d \ln p_{raw}}\right)}{d\lambda} = 0$$

[5] It is also not clear what the effect of competition intensity λ should be in case $pcm < 0$. The model above does not deal with this type of predatory behaviour and hence such observations are ignored here. See GM (2006) for an analysis of predation in the sugar industry.

Hence, there is no effect of λ on $\frac{d \ln ms(p_{raw})}{d \ln p_{raw}}$ if firms are symmetric ($\delta = \varepsilon = 0$).[6]

Combining the two effects above, we can derive the following adjusted profit elasticity. Instead of looking at profits directly, we consider firm 1's profits relative to (normalized on) industry revenue:

$$\bar{\pi} = \pi/(pQ) \tag{14}$$

Then we can derive the following.

Corollary 1 *For $\delta, \varepsilon \geq 0$ close enough to zero, we have*

$$\frac{d\left(\frac{d \ln \bar{\pi}(p_{raw})}{d \ln p_{raw}}\right)}{d\lambda} > 0$$

Proof The proof follows from the observation that

$$\ln(\bar{\pi}) = \ln pcm + \ln ms$$

and the two lemma's above. *Q.E.D.*

Hence we have shown that the sensitivity of both $\bar{\pi}$ and pcm with respect to p_{raw} increases as competition becomes more intense (λ falls). The next section uses this idea to rank the intensity of competition of the regimes in Table 1.

5. Empirical model and results

Following corollary 1, we estimate the following equation:

$$\ln \bar{\pi}_t = \alpha + \alpha_1 + \alpha_2 + \alpha_3 + \Sigma_{r \in R} \beta_r \ln p_{raw,t} + \varepsilon_t \tag{15}$$

where the profits of Sugar Trust/ASRC relative to total revenue of the market ($\bar{\pi}_t$) is explained by the logarithm of $p_{raw,t}$ in four different regimes $R = \{monopoly/cartel, pricewar, breakup, mixed\}$. Furthermore, we correct for seasonal effects by incorporating quarterly dummies $\alpha_1, \alpha_2, \alpha_3$ (as in GM(1998)). Note that $\beta_r = d \ln \bar{\pi}/d \ln p_{raw}$ which is the version of PE that we are interested in here.

To avoid endogeneity issues, we estimate this equation with instrumental variables (IV).[7] We use the Cuban import of raw sugar to instrument p_{raw}. This removes the effect where an increase in demand for refined sugar would simultaneously raise profits and the price of raw sugar and thus marginal costs.

From Table 3, it follows that the parameters β_r for the price of raw sugar differ significantly from zero at the 5 % level during three out of four regimes for the two regressions with log

[6]In fact, we have also estimated equation (15) below with $\ln ms$ as dependent variable (not reported separately). The coefficients on $\ln p_{raw}$ do not differ significantly for the different regimes. This is consistent with this lemma.

[7]The results with OLS (not reported separately) turn out to be similar with smaller standard errors. The ranking of the three relevant regimes is the same with OLS and IV.

profits as dependent variable. With log pcm, the parameters are different from zero for the price war and break-up regimes (only price war regime) in the case where $c_0 = 26$ (16) cents. The standard errors are heteroskedasticity-robust and autocorrelation-robust by using Newey-West's kernel-based heteroskedastic and autocorrelation consistent variance estimations, where the bandwidth has been set on four periods, as has been done by Genesove and Mullin (1998).

To investigate whether PE is able to identify the different competition regimes, we test whether the values of the β_r are significantly different from each other using the Wald test. Our prior is that $0 > \beta_{monopoly/cartel} > \beta_{pricewar}$ and $0 > \beta_{monopoly/cartel} > \beta_{breakup}$. In words, we expect that competition is less fierce during the monopoly/cartel regimes than during either the price war or the break up of the cartel. A priori, we cannot rank the price war regime and the break up of the cartel regime since breaking up a cartel can be accompanied by fierce competition as well. As mentioned, we do not know how to rank the mixed regime because competition intensity is, well, mixed during this period

dep. var.	$\bar{\pi}$	$\bar{\pi}$	pcm	pcm
c_0	26 cents	16 cents	26 cents	16 cents
	Coefficient (Std. Err.)	Coefficient (Std. Err.)	Coefficient (Std. Err.)	Coefficient (Std. Err.)
$\beta_{mon./cart.}$	-1.217(1.030)	-1.621 (1.118)	-0.556 (0.959)	-0.985 (1.066)
$\beta_{pricewar}$	-2.546$*$ (1.082)	-2.789$**$ (1.017)	-1.873† (0.999)	-2.117$*$ (0.975)
$\beta_{breakup}$	-3.197$*$ (1.246)	-3.075$*$ (1.362)	-2.155† (1.153)	-2.0626 (1.292)
β_{mixed}	-2.049† (1.139)	-2.344† (1.234)	-1.193 (1.052)	-1.514 (1.170)
α_1	0.079 (0.190)	0.341$*$ (0.168)	0.117 (0.196)	0.372$*$ (0.171)
α_2	0.527$**$ (0.151)	0.589$**$ (0.162)	0.587$**$ (0.152)	0.637$**$ (0.163)
α_3	0.245 (0.198)	0.499$**$ (0.165)	0.285 (0.199)	0.533$**$ (0.166)
α	-5.188$**$ (1.259)	-4.615$**$ (1.384)	-0.157 (1.170)	0.093 (1.322)
N	86	97	86	97
R^2	0.566	0.782	0.520	0.593

Significance levels : † : 10% $*$: 5% $**$: 1%

Table 3: Estimation results of IV regressions with different dependent variables and c_0.

Turning to the hypotheses, we used a Chi-squared distributed Wald test with one degree of freedom to determine whether the β_r is significantly different between two regimes. We test the following hypothesis H_0 against the alternative H_1:

$H_{0_{pricewar}} : \beta_{monopoly/cartel} = \beta_{pricewar}$

$H_{1_{pricewar}} : \beta_{monopoly/cartel} > \beta_{pricewar}$

$H_{0_{breakup}} : \beta_{monopoly/cartel} = \beta_{breakup}$

$H_{1_{breakup}} : \beta_{monopoly/cartel} > \beta_{breakup}$

The results are presented in Table 4. From the first row of Table 4, it follows that β during price wars is significantly different from β during the monopoly/cartel regime for both values of mc_0. Similarly, β during the break-up of the cartel is significantly more negative than during monopoly/cartel. The null hypotheses are thus rejected at the 1% level. These results are confirmed by the estimations using *pcm* as dependent variable.[8]

dep. var.	$\bar{\pi}$	$\bar{\pi}$	*pcm*	*pcm*
c_0	26 cents	16 cents	26 cents	16 cents
	χ^2 (p-value)	χ^2 (p-value)	χ^2 (p-value)	χ^2 (p-value)
$H_{0_{pricewar}}$	13.89** (0.00)	24.43** (0.00)	15.27** (0.00)	24.10** (0.00)
$H_{0_{breakup}}$	38.03** (0.00)	24.64** (0.00)	29.90** (0.00)	16.43** (0.00)

Significance levels : † : 10% * : 5% ** : 1%

Table 4: One sided Wald tests of β_r estimated with different dependent variables and c_0.

6. Conclusion

This paper has used the well documented American sugar industry (for the period 1890–1914) to see whether PE can identify different competition regimes. The data allow us to instrument marginal costs to correct for endogeneity issues. Further, we know what marginal costs look like for this industry in this period. Unlike previous work, PE is now estimated for one (dominant) firm taking into account that cost shocks affect the whole industry, not just this firm.

PE indeed shows that both the price war and break-up of the cartel regimes are more competitive than the monopoly/cartel regime. In this sense, PE measures competition correctly.

[8]Recall that the Wald test is a one-sided test while the z-values in Table 3 refer to a two-sided test. This explains why the Wald test has a significant outcome in the last column of Table 4 even though both parameters for the regimes monopoly/cartel and breakup in the last column of Table 3 are (just) insignificantly different from zero.

References

Amir, R. (2000). 'Market structure, scale economies and industry performance', CIE Discussion Papers, University of Copenhagen. Department of Economics. Centre for Industrial Economics.

Boone, J., van der Wiel, H. and van Ours, J.C., (2007),'How (not) to measure competition', CEPR Discussion Papers 6275.

Boone, J., (2008), 'A new way to measure competition', Economic Journal, 118, 1245 -1261.

Bulow, J. and Klemperer, P. (1999). 'Prices and the winner's curse', RAND Journal of Economics, 33, 1-21.

Chronicle, January issues of 1909 -1915.

Corts, K. (1999), 'Conduct parameters and the measurement of market power', Journal of Econometrics, 88, 227-250.

Genesove D., and Mullin, W.P., (1995), 'Validating the conjectural variation method: the sugar industry, 1890-1914', NBER paper 5314.

Genesove D., and Mullin, W.P., (1997), 'Predation and its rate of return: the sugar industry, 1890-1914', NBER paper 6032.

Genesove D., and Mullin, W.P., (1998), 'Testing Static Oligopoly Models: Conduct and Cost in the sugar industry, 1890-1914', Rand Journal of Economics, 29, 355-377.

Genesove D., and Mullin, W.P., (2006), 'Predation and Its Rate of Return: The Sugar Industry, 1887-1914', Rand Journal of Economics, 37, 47-69.

NY Times, "Sugar Trust makes first open report", 25 March 1908.