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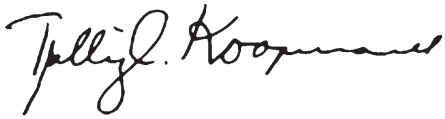

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# The Boone-indicator: Identifying different regimes of competition for the American Sugar Refining Company 1890-1914

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# The Boone-indicator: Identifying different regimes of competition for the American Sugar Refining Company 1890-1914

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**Abstract**
Boone (2008) introduces a new theory based measure of competition, the so-called Boone-indicator. The indicator is based on the relationship between performance, in terms of profits, and efficiency, measured as marginal costs. Whether the indicator is able to correctly measure competition in practice is an unanswered question yet. In this paper, I provide empirical evidence that the Boone-indicator appropriately is measuring levels of competition. To this purpose, I follow a seminal paper by Genesove and Mullin (1998) where they show that the elasticity-adjusted Lerner index is able to identify regimes of price wars from nonprice wars by comparing the outcomes of this index with independent reports on the regimes of competition for the American sugar industry for the period 1890-1914. Using their data, I construct a proxy for profits. I calculate both the elasticity-adjusted Lerner index as the Boone-indicator for a single firm, the American Sugar Refining Company. Using the same data, I am able to demonstrate empirically that the Boone-indicator is better able to identify the different regimes of competition than the elasticity-adjusted Lerner index. The Boone-indicator, therefore, adds value to the insights provided by the elasticity-adjusted Lerner index. Several robustness checks are performed that show that the results are insensitive for alterations in the profit proxy.

**Keywords**: competition, measures of competition, sugar industry.

**JEL classification**: D43, L13

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## 1. Introduction

Recently, a new approach to measuring competition has been introduced by Boone (2008). His new measure of competition is based on the notion that in a competitive market more efficient companies are likely to gain larger market shares than in a non-competitive market. The price-cost margin (PCM) or Lerner index is a widely used measure of competition. Compared to other measures of competition, it has a very good empirical underpinning that is provided by Genesove and Mullin (1998). The new approach gives a superior alternative to the price-cost margin (PCM),, because the theoretical foundations of the PCM as a competition measure are not robust. Amir (2000), Bulow and Klemperer (1999), Rosenthal (1980) and Stiglitz (1989), for example, present models where more intense competition leads to higher instead of lower PCM values. Furthermore, Corts (1999) shows that, the estimates of the PCM will typically underestimate the price-cost margin and the level of market conduct itself. Boone (2008) presents a competition measure that is both theoretically robust and does not pose more stringent data requirements than PCM.

The contribution of this paper is to demonstrate that this new measure is better able to measure competition empirically by using data from Genesove and Mullin (1998). They collect data of the US sugar industry for the period 1890-1914. It is a very well documented period in terms of competition due to testimonies before the US Industrial Commission in 1900 and the US Tariff Commission in 1920. Based on these testimonies, it is possible to identify periods with different degrees of competition. Genesove and Mullin (1998) show that the elasticity-adjusted Lerner index - the Lerner index adjusted for the price elasticity of demand- for the overall sugar industry can distinguish periods of price war from those without price wars.

There is only information available for one firm, the American Sugar Refining Company (ASRC). I am not able to estimate the competition level for the overall market as this implies that data should be available for all market participants. Thus, in this study, I will measure the competitiveness of one firm in different time periods, while Genesove and Mullin (1998) look at the competitiveness of the sugar industry. Furthermore, this is also in contrast to previous studies that use the Boone-indicator, like Bikker and Van Leuvensteijn (2008), where different levels of

competition in the market at the same time are measured by estimating the cross sectional relationship between marginal costs and profits of different firms at one given time. I am estimating the relationship between profits and marginal costs of one firm during different periods of time. The underlying hypothesis is that each period is internally homogenous with respect to the prevailing competition regime but that regimes differ across periods. The estimate can be used to compare the different levels of competitiveness across time. The firm is the American Sugar Refining Company (ASRC), the leading company in the sugar industry during the period 1890 -1914. Given that the elasticity-adjusted Lerner index is estimated for the market as totality by Genesove and Mullin (1998), I will estimate this indicator for the American Sugar Refining Company as such for the different periods mentioned above. These results will be compared to those of the Boone-indicator.

The structure of this paper is as follows. First, I introduce the Boone-indicator and explain its advantages in section 2. In section 3, I describe the period 1890-1914 and the different regimes of competition in the US sugar industry according to the public testimonies available. Special attention will be given to the technology of production which is relevant for the marginal costs. In section 4, I provide a description of the data as derived from Genesove and Mullin (1998). In section 5, a description is given of the empirical model. In section 6, I will estimate both the elasticity-adjusted Lerner index and the Boone-indicator for the different periods that represent different regimes of competition. Finally, some conclusions are drawn.

## 2. The Boone-indicator model

Boone's model is based on the notion, first, that more efficient firms (that is, firms with lower marginal costs) gain higher market shares or profits and, second, that this effect is stronger the heavier the competition in that market is. Boone develops a broad set of theoretical models (see Boone, 2000, 2001, 2004 and 2008, Boone *et al*., 2004, and CPB, 2000). I use from this broad set of theoretical models the most standard industrial organization model with a linear demand curve to explain the Boone-indicator and to examine its properties compared to common measures such

as the Herfindahl-Hirschman Index (HHI) and the price-cost margin (PCM). Following Boone *et al*. (2004), I consider an industry where each firm $i$ produces one product $q_i$. The firm faces a linear demand curve of the form:

$$p\ (q_i,\ q_{j\neq i}) = a - b\ q_i - d\ \sum_{j\neq i}\ q_j \qquad (1)$$

and has constant marginal costs $mc_i$. It maximizes profits $\pi_i = (p_i - mc_i)\ q_i$ by choosing the optimal output level $q_i$. I assume that $a > mc_i$ and $0 < d \leq b$. The first-order condition for a Cournot-Nash equilibrium can then be written as:

$$a - 2\ b\ q_i - d\ \sum_{i\neq j}\ q_j - mc_i = 0 \qquad (2)$$

When $N$ firms produce positive output levels, I can solve the $N$ first-order conditions (2), yielding:

$$q_i\ (mc_i) = [(2\ b/d - 1)\ a - (2\ b/d + N - 1)\ mc_i + \sum_{j}\ mc_j]/[(2\ b + d\ (N - 1))(2\ b/d - 1)] \qquad (3)$$

I define profits $\pi_i$ as variable profits excluding entry costs $\varepsilon$. Hence, a firm enters the industry if, and only if, $\pi_i \geq \varepsilon$ in equilibrium. Note that Equation (3) provides a relationship between output and marginal costs. It follows from $\pi_i = (p_i - mc_i)\ q_i$ that profits depend on marginal costs in a quadratic way:

$$\pi_i\ (mc_i) = [(2\ b/d - 1)\ a - (2\ b/d + N - 1)\ mc_i + \sum_{j}\ mc_j]/[(2\ b + d\ (N - 1))(2\ b/d - 1)]\ (p_i - mc_i) \qquad (4)$$

Therefore, in this market, competition can increase in three ways. First, competition increases when the products of the various firms become closer substitutes, that is, $d$ increases (keeping $d$ below $b$). For example in the sugar industry, refined sugar and beet sugar became closer substitutes due to the entry of sugar beet producers. Domestic beet sugar supplied less than 1% of U.S. consumption until 1894. This rose to 5% by 1901 and 15% by 1914. (Genesove and Mullin (1998), p. 358) Second, competition increases when entry costs $\varepsilon$ decline and

entry occurs, like for example the entry of new companies like Spreckels and Arbuckle in the sugar industry. Boone *et al*. (2004) prove that profits of more efficient firms (that is, with lower marginal costs m*c*) increase both under regimes of stronger substitution and amid lower entry costs. Third, changes in *b* are more related to adjustments in preferences of consumers, and thus their willingness to pay for refined sugar. An increase in *b* reflects a lower price sensitivity of the demand for sugar and increases the market power of firm *i* and all other firms.

The theoretical model above can also be used to explain why widely-applied measures such as the HHI and the PCM fail as reliable competition indicators. The standard intuition of the HHI is based on a Cournot model with symmetric firms, where a fall in entry barriers reduces the HHI. However, with firms that differ in efficiency an increase in competition through a rise in *d* reallocates output to the more efficient firms that already had higher output levels. Hence, the increase in competition raises the HHI.

Another often used measure of competition the price-cost margin (PCM), or the so called Lerner index, has similar disadvantages. Graddy (1995), Genesove and Mullin(1998) and Wolfram (1999) estimate the elasticity-adjusted Lerner index, Lerner-index times the price-elasticity of sugar demand. They show that the conjectural variation parameter can be interpreted as a measure of competition. Corts (1999) criticises this approach and shows that, in general, efficient collusion cannot be distinguished from Cournot competition using the elasticity adjusted Lerner index. Generally, heavier competition reduces the PCM of all firms. But since more efficient firms may have a higher PCM (skimming off part of the profits stemming from their efficiency lead), the increase of their market share may raise the industry's average PCM, contrary to common expectations. As such, the estimates of the PCM will typically underestimate the price-cost margin (PCM) and the level of competition itself.

Boone (2000, 2001 and 2004, Boone *et al*., 2004), and CPB (2000) consider firms in a market with homogenous goods at time t and estimate the cross sectional Boone-indicator. The Boone-indicator measures competition between firms in the market by measuring the strength of the relationship between profits and marginal costs for different firms at one moment in time. The original formulation of the

Boone-indicator considers three firms and shows that the competitiveness of one firm can be measured relative to another firm. It is not necessary that these three firms are compared at the same time. Therefore, I introduce a new element to the Boone-indicator as described in Boone (2008), and use the Boone-indicator to compare the relative competitiveness of one firm in different periods to its average competitiveness. Then, the Boone-indicator is no longer measuring the competitiveness of a market, but can only indicate whether a specific firm in one period is more or less competitive compared to another period. Of course, comparing one firm at different moments in time means that also the circumstances over time may differ under which this firm is operating.

The Boone-indicator looks at the relationship between profits and marginal costs. As said before, this relationship depends on the price elasticity of the demand curve (see equation (1)) and the quantity and price set by the firm to maximise profits (see equation (2)). However, a general shift of the demand curve, which increases production and increases prices for raw sugar and thus marginal costs, should be corrected for in the measurement of competition as it is not the direct outcome of competition forces. To circumvent this effect, we estimate the relationship between profits and marginal costs with instrumental variables. This indicator shows the relative competitiveness of one firm at different points in time (see section 5). So equation (3) can be rewritten as:

$$q_{1,p}\,(mc_{1,p}) = [(2\,b_p/d_p - 1)\,a_p - (2\,b_p/d_p + N_p - 1)\,mc_{1,p} + \textstyle\sum_j mc_{j,p}]/[(2\,b_p + d_p\,(N_p - 1))(2\,b_p/d_p - 1)] \qquad (5)$$

where the subscript p denotes different periods with distinct competition regimes. Again, competition over time can increase, because competition increases when the produced (portfolios of) services of the various firms become closer substitutes, that is, $d_p$ increases (again keeping $d_p$ below $b_p$), or due to a fall in entry costs ($\varepsilon_p$) fall and the number of firms increases $N_p$. Finally, an increase in $b_p$ reflects a lower price sensitivity of the demand for sugar in period p and leads to decreased competition. One firm will be compared at four different periods, p: a period of oligopoly, a

period of price war, a period in which the cartel is split-up and a period between the last price war and the break-up of the cartel.

Following equation (4), I can write the relationship between profits and marginal costs as:

$$\pi_{1,p}\,(mc_{1,p}) = [(2\,b_p/d_p - 1)\,a_p - (2\,b_p/d_p + N_p - 1)\,mc_{1,p} + \Sigma_j\, mc_{jp}]/[(2\,b_p + d_p\,(N_p - 1))(2\,b_p/d_p - 1)]\,(p_p - mc_{1,p}) \quad (6)$$

Where price, $p_p$, stands for the price in the sugar market in period p. The Boone-indicator, BI, is the profit elasticity of marginal costs derived from this equation (6):

$$BI = d\,\pi_{1,p}/dmc_{1,p}\,(mc_{1,p}/\pi_{1,p}) < 0$$

The expectation is that BI is negative, where $mc_{1,p}$ is the average value of marginal cost in period p and $\pi_{1,p}$ is the average profit in period p

## 3. The sugar industry

### 3.1 History: 1887 -1914

To verify whether the Boone-indicator properly tracks different regimes of competition, I use the case of the US sugar industry from 1887 -1914. Genesove and Mullin (1995, 1997, 1998 and 2006) provide a detailed description of the sugar industry in this period. Based on their work, I identify four different regimes of competition, following Genesove and Mullin (1995, 1998). According to Genesove and Mullin(1998), the sugar industry experienced the following structural changes in the period 1887 -1914.

In chronical order, from 1887 – and 1889, the sugar industry can be characterised as oligopolistic. 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 percent of the industry's capacity. The 20 plants owned by the original trust members were quickly reduced to 10 plants. Refined prices increased by 16 %.

The high prices attracted a new entrant to the market: Claus Spreckels began production in early 1890[2] (Q1). This led to the first price war. In 1891, the Sugar Trust was reorganised as a corporation, the American Sugar Refining Company (ASRC). The American Sugar Refining Company (ASRC) acquired Spreckel's plant. By April 1892 (Q2), the acquisition ended the price war. Due to the acquisition, ASRC's share of industry capacity was raised to 95 percent.

In the next period, from 1892 to 1897, the sugar industry was characterised by high levels of concentration and with a maximum of 95% of the market, ASRC was an oligopoly. 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 friendly 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 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 severe price war, marked by pricing at or below cost. As a result, the smaller independent refiners were shut down and one of the new entrants partially left the market. With the entry of Arbuckle, the second price war started in August 1898 and ended in May 1900.

After this price war, competition went into another phase in which the regime of competition and the level of competition was unclear. In the period 1900 Q2 – end of 1909, on the one hand, competition increased with the end of the Arbuckle war compared to the oligopolistic period with the gradual decline of the market share of ASRC. However on the other hand, competitive pressure from abroad was strongly reduced, because American sugar industry was able to produce refined sugar at low cost due to a tariff structure that reduced the price of raw sugar. The tariff structure contained two chief components, the duty on raw sugar, an input, and the duty on refined sugar, the final consumption product. The latter tariff protected the US refining industry from foreign, chiefly European, competition. In

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

1903, an important preference was granted toward (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.

Antitrust regulation increased competition at the same time. Seeking the dissolution of ASRC in 1910, the Federal government filed suit with regard to the antitrust regulation, charging monopolization and restrain of trade. Although this case was not formally resolved until a consent degree was signed in 1922, the government 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 to the competition law in the American Tabacco case than previously. The break-up of the cartel took place between 1910 and 1914.

Given that I have only data from 1890 onwards, five from these six episodes in the history of the American Sugar industry will be used in the analysis. The two price wars will be taken together, because of their small number of observations. Table 1 summarizes these episodes. I define two periods of price war: 1890Q1 - 1892Q2, with the entry of Claus Spreckels in early 1890 and the subsequent takeover of his plant by ASRC in 1892Q3, and 1898Q4 - 1900Q2, with the entry of the Arbuckle Brothers. The period of oligopoly is defined as: 1892Q3 - 1898Q3, the period in between two price wars, a time that ASRC had acquired 95% of the production. From 1900Q3 till 1909, competition for the cartel was increasing due to the rise in raw imports from Cuba, and due to the preferential treatment in tariffs in 1903. The slow break-up of the cartel was in the period: 1910Q1 - 1914Q2, beginning with the first successes in anti-trust regulation against American Tabacco and Standard Oil and the voluntary split-up of the cartel. (see also Genesove and Mullin (1995, 1998, 2006)).

**Table 1 Competition regimes**

| **Periods** | **Competition regimes** |
|---|---|

| | |
|---|---|
| 1887 -1889 | Sugar Trust possesses 80% of the market: oligopoly |
| 1890 – 1892Q1 | Spreckels entry, price war |
| 1892 Q2- 1898Q2 | Cartel operation, small scale entry, acquisition of Spreckels: oligopoly |
| 1898Q3 – 1900 Q2 | Entry by Arbuckle Brothers and Doscher, price war |
| 1900 Q3 -1909 | Mixed regime of competition |
| 1910 -1914 | Government antitrust suit, break-up of cartel:end of oligopoly |

### 3.2 Technology of sugar production

The production technology of sugar is a very 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 process, the same technology. Therefore, marginal costs are a linear function of the price of raw sugar, $P_{raw}$, with a fixed coefficient k. In order to calculate the marginal costs of producing refined sugar, variable costs like labour and other costs have also to be included, in addition to the fixed coefficient input costs. This leads to the following formula for marginal costs:

$$mc_t = mc_0 + k * p_{raw,t} \quad (7)$$

where $mc_t$, the marginal costs depend on all variable costs other than the cost of raw sugar, $mc_0$ and the price of raw sugar, $p_{raw,t}$ .

The fixed coefficient, k, is equal to 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 $mc_0$ is less straightforward. Genesove and Mullin (1998) put as best guess for $mc_0$: 26 cents. This estimate is based on the testimony of a partner in Arbuckle Brothers (an entrant in the second price war). The true net-of-raw-sugar-costs margin is equal to $p_t - p_{raw,t} * 1.075$, where $p_t$ is the price of refined sugar. In this testimony, it is said that if raw sugar costs 4.5 cents a pound, it will cost over 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 $mc_0$ ranging between 16 and 26 cents (per hundred pound). The upper limit of these non-raw sugar costs are still small compared to the mean raw price of 3.31 dollar, 7.5% of the costs. It could be that larger houses (refining units) can refine at smaller margin than others, but 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: I suppose 3 to 5 cents a hundred would represent the difference*."(Genesove and Mullin (1995), p. 13) So there could be slight differences in marginal costs between producers depending on the scale of their production capacity. In line with Genesove and Mullin (1998), I will use the estimate of 26 cent to calculate the marginal costs of ASRC.

In theory, differences in marginal cost of even 3 to 5 cents per hundred pound would have been enough to calculate a cross-sectional Boone-indicator measuring competition between market participants, at the same time. Different marginal costs lead to differences in profit margins, profits and market shares. Although the differences may seem small, compared to an average profit margin of 22 cents (see Table 2 the average difference between price and marginal cost, mc) 3 to 5 cents are 13.6% to 22.7% of the profit margin. Unfortunately, data for the competitors of the ASRC are unavailable, so the analysis is limited to a time series perspective.

## 4. The data

Profits and marginal costs are the key variables to calculate the Boone-indicator. Profits cannot be directly observed from the data of Genesove and Mullin (1998). Moreover, the data could not be directly derived from the profit & loss accounts of the ASRC, because in the period 1890 -1906, only the balance sheet of the ASRC was reported as required under law of the State of Massachusetts. Furthermore, the ASRC admitted that the figures presented in the balance sheet did not accurately describe the real profits of the company. This policy of secrecy was meant not to attract attention of potential competitors (NY times, March 30, 1908). Even shareholders were misled. Havemeijer, director of ASRC, declared that this was done only to serve their best interests.

In this paper, a proxy for the profits of ASRC is constructed by using information on market shares quoted *on a yearly basis*, the total production in the market, quoted on *a quarterly basis,* and the difference between price of refined sugar, $p_t$, and marginal costs, $mc_t$. The latter two are also available on *a quarterly basis*. The marginal costs are calculated following the formula of Genesove and Mullin (1998): $mc_t = 0.26 + 1.075 * p_{raw,t}$. The proxy for profits is calculated as the product of the profit margin and the quantities of refined sugar sold. The profit margin is equal to the difference in price *p* and marginal costs, mc. The quantities sold is equal to the total demand in the market times ASRC's market share, $Q_i$ where subscript I represents firm i In formula terms, the proxy for profits is (p -mc) $Q_i$. We use Cuban imports of raw sugar as instrumental variable. These data are also available on a quarterly basis for the period 1890Q1 -1914Q2.

In Table 2, I present a number of stylized data characteristics. Originally, we had 98 observations. In total we use 97 observations. In line with Genesove and Mullin(1998), the observation of 1897Q4 is left out of the estimation because reported Cuban raw sugar imports are zero in this quarter which is very unlikely. These observations are divided in four periods: price war with 17 observations, oligopoly with 24 observations, break-up of the cartel with 18 observations and a period with a mixed regime of competition with 38 observations. The total production of melted sugar on average was on a quarterly basis, 0.443 mln long

tons of sugar.[3] Average Cuban imported raw sugar was 0.218 mln long tons, on a quarterly basis. Total production reached its highest level after the break-up of the cartel with the entry of more producers. Production was kept low during the period of oligopoly. The sugar price was at its highest level during the price war, 4.51 dollars, due to high prices for raw sugar, and at its lowest level after the break-up of the cartel, 3.45 dollars. This may have been related to the high level of production of refined sugar at the time. The price of refined sugar and raw sugar are both expressed in dollars per hundred pounds. The average market share of ASRC is 63% and moves over time from 91 % during the time of oligopoly to 43% after the break-up of the cartel.

Quarterly profits differ strongly over the different periods. They are at their lowest level during the price wars and also strongly negative. During the period of oligopoly, the profits reach their highest level, nearly ten times as high as during the price war. After the break-up of the cartel, profits decrease strongly compared with the intermediate period between oligopoly and the break-up of the cartel. Marginal costs are relatively high during the period of oligopoly and price war due to the high prices for raw sugar. The preferences granted to imports of Cuban sugar decreased marginal costs substantially in the period after the price war and in the period after the break-up of the cartel.

[3] One long ton is 2240 pounds.

**Table 2 Descriptive statistics**

| Variable | Observations | Mean | Std. Dev. | Min | Max |
|---|---|---|---|---|---|
| | | | | | |
| Total production 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 % | 97 | 63.0 | 12.0 | 43.0 | 91.0 |
| marginal cost (mc) in dollars | 97 | 3.81 | 0.64 | 2.68 | 5.50 |
| *Calculating the Boone-indicator* | | | | | |
| profit_price_war in dollars | 17 | 2.52 | 12.00 | -11.95 | 36.56 |
| profit_oligopoly in dollars | 24 | 28.12 | 12.67 | 3.93 | 49.51 |
| profit_break-up_cartel in dollars | 18 | 6.58 | 5.00 | 0.87 | 17.20 |
| profit_mixed_regime war in dollars | 38 | 13.35 | 7.68 | -1.65 | 27.36 |
| mc_price_war in dollars | 17 | 4.47 | 0.80 | 3.25 | 5.50 |
| mc_oligopoly in dollars | 24 | 3.97 | 0.47 | 3.27 | 4.82 |
| mc_break-up_cartel in dollars | 18 | 3.34 | 0.47 | 2.68 | 4.37 |
| mc_mixed_regime in dollars | 38 | 3.63 | 0.42 | 3.06 | 4.74 |

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.

Our calculation of the Boone-indicator has two potential weaknesses. First, due to data limitations, I use a proxy for profits which is partially based on information contained in marginal costs. The analysis is therefore vulnerable for the critique that

this proxy may not accurately describe actual earnings from operations. In Figure 1, it is shown that the proxy for profits follows the same pattern as the earnings from operations. Here, I am able to compare the calculated profit-proxy with the actual earnings on operations as reported in the journal "Chronicle" and in the annual reports of ASRC for the period 1909 - 1913. From1890 - 1906, the ASRC only published balance sheet data and did not provide profit and loss account.
From 1907 - 1908, only total earnings are published, they are not split-up in earnings from operations and other earnings.

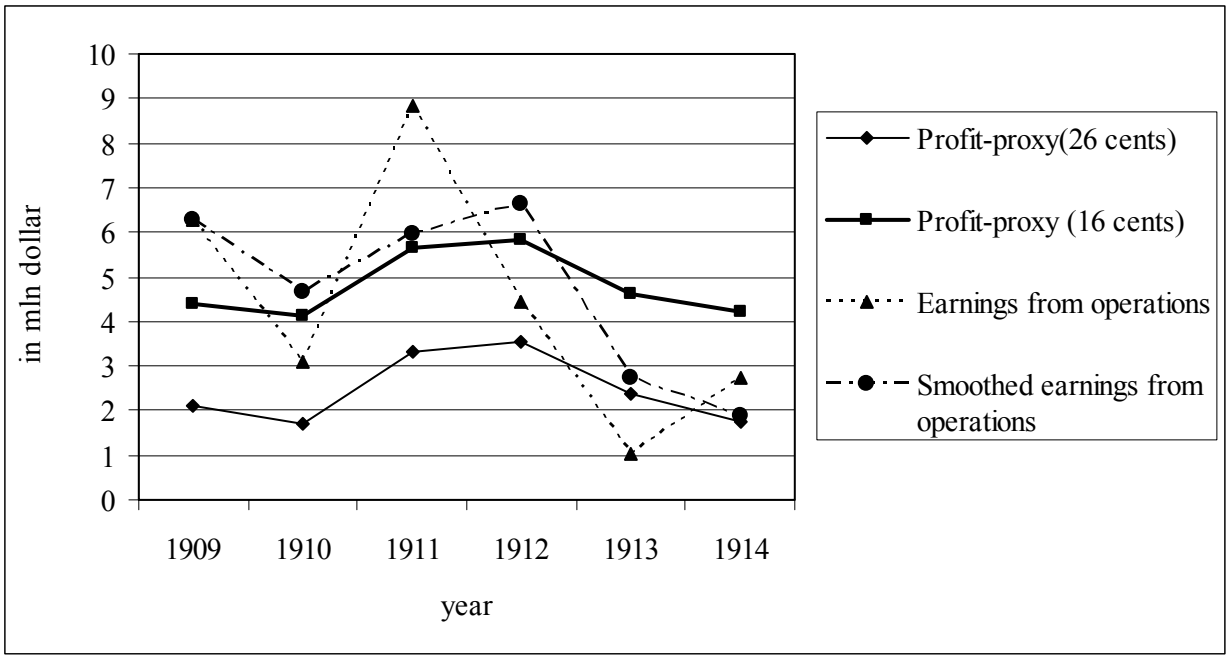
My proxy for profits accurately describes profits actually earned. Smoothing the earnings figures by calculating a two years moving average could provide a very accurate picture of the earned profits. It is reasonable to smooth the data, as some of the reported profits are actually earned in the previous year before, but accounted for in the current year. From Figure 1, it follows that my profits proxy is lower than the actual reported profits with 1913 as exception. The correlation between the proxy and the reported earnings on operations is 0.43 (Pearson correlation), and with the smoothed earnings 0.47 for the years 1909-1913. Taking into account the numbers of 1914, of which we have only the first half of 1914, would raise the correlation to respectively 0.50 and 0.61. So, both the proxy for profits and the actual (smoothed) figures for earnings from operations clearly move together and therefore the proxy for profits can be used as a representation of earnings of operations.

All in all, the comparison shows an overestimation of the marginal costs. Genesove and Mullin(1998) suggest that the additional marginal costs from personnel expenses ranges between 16 cents and 26 cents. As is shown in Figure 1, a profit proxy for which the additional marginal costs are set to 16 cents indicates a better fit to the earnings data. Also, the Pearson correlation increases respectively to 0.49 for 1909-1913 and 0.54 for 1909 - 1914. With the smoothed earnings from operations, these correlations are respectively 0.51 and 0.60. Therefore, as a robustness check I will provide an additional estimate of the Boone-indicator using 16 cents as additional marginal costs, $mc_0$.

The second critique could be that the proxy for profits is not independent from marginal costs to begin with as it is calculated using information on marginal

costs. As a robustness check, I will estimate the relationship between profits and instrumented marginal costs. The estimated value of marginal costs is derived from a regression of marginal costs as dependent variable and lagged values of marginal costs as independent variables. Recall that the proxy for profit used information on marginal costs and not on the instrumented marginal costs. If the profit proxy is determined significantly by the instrumented marginal costs, then this would indicate that the relationship between the proxy for profit and marginal costs is not significantly influenced by the fact that profits are partly calculated with information on marginal costs.

**Figure 1 Profit-proxy compared to earnings from operations**




*Since we only have the first half of the year, the calculated profit-proxy is doubled.

## 5 The empirical model

Ideally, I would like to estimate equation (6), which shows a nonlinear relationship between marginal costs and profits. However, the outcome of this model was that most parameters were insignificant at the 5%-level. The standard errors of the parameter were too large to determine significant effects. From this, the conclusion can be drawn that a nonlinear model was too demanding for the small number of observations available. Therefore we have estimated a linear model. In this model, profits of firm 1**,** $\pi_{1,t}$ , are related to marginal costs of firm 1, $mc_{1,t}$ , in linear form at different moments in time t. Equation (6) can be rewritten in an empirical model:

$$\pi_{1t} = \psi_s + \Sigma d_p \, \delta_p \, mc_{1t} \qquad (8)$$

where $d_p$ is a dummy equal to 1 if $t$ is an element in the subperiod p and zero otherwise. I have defined four subperiods so that p= 1,..,4. The profit of firm 1, $\pi_{1t}$, in period t depends on the marginal cost in different subperiods of period t. The

Boone-indicator, BI, is equal to $\delta\, mc_{1p} / \pi_{1p}$, the elasticity of profits, $\pi$, to mc for the subperiod p. Period 1890 -1914 is divided in subperiods, of price war, oligopoly, the break-up of the cartel and a period with a mixed competition regime. $\psi_s$ is a constant with quarterly dummies, s =0,1..3.

Genesove and Mullin (1998) explicitly test whether the elasticity-adjusted Lerner-index, PCM times the absolute value of the price elasticity of sugar demand, is able to distinguish between periods of price war and periods with no price war for the sugar industry. To investigate whether the Boone-indicator is able to identify the different subperiods, I test whether the values of the Boone-indicator in the different subperiods are significantly different from each other using the Wald test. Given there are four periods, we have in principle six hypotheses. Of these six hypotheses, I leave out the hypotheses that test whether competition after the period with a mixed regime was more or less intense than during the period of oligopoly or the period of the break-up of the cartel, because it is impossible to have priors on these hypotheses.

These four remaining hypotheses are all one-sided tests. For example I test whether the Boone-indicator, BI, in a period of oligopoly is larger than the Boone-indicator, BI, during the break-up of the cartel. Recall that the Boone-indicator is smaller than zero. Therefore, Hypothesis I is:

$H0: BI_{oligopoly} \leq BI_{break\text{-}iup}$
$H1: BI_{oligopoly} > BI_{break\text{-}iup}$

Furthermore, following Genesove and Mullin (1998), competition must be more fierce during a price war than in other periods, like the period during which the cartel was split-up. Competition during price war was very strong as is shown by the drastic reductions in price at the time. Prices were even temporary lower than marginal costs resulting in losses for the ASRC. Because, after the break-up of the cartel, ASRC was still making profits, (Genesove and Mullin, 2006), I conclude that

competition during the price war was heavier than after the break-up of the cartel. My prior is to reject the H0 of Hypothesis II:

$H0: BI_{break\text{-}up} \leq BI_{price\ war}$
$H1: BI_{break\text{-}up} > BI_{price\ war}$

Of course, the entry of firms like Spreckel's and Arbuckle and the following price war to fend off these entrants, must have increased the level of competition compared to the period of oligopoly in which the market share of ASRC reached 95%. Thus, hypothesis III is expected to be rejected:
$H0: BI_{oligopoly} \leq BI_{price\ war}$
$H1: BI_{oligopoly} > BI_{price\ war}$

It is difficult to classify the competition regime of the period 1900 -1909, the period after the Arbuckle war, a period with a mixed regime of competition. The price war was not an outright win over the Arbuckle group. After the price war the Arbuckle group was incorporated in the cartel. Based on the earlier mentioned testimonies, it is on clear whether competition had been improved or the degree of competition had returned to pre-price war days. Therefore, it is hard to set prior beliefs on whether competition during the period 1900-1909 should be higher or lower than during the period of a break-up of the cartel or oligopoly. Based on the testimonies, the Boone-indicator should, however, indicate more competition during the periods of price wars than during the period with a mixed regime of competition. Given these considerations we test only the following hypothesis IV:

H0: $BI_{mixed\ regime} \leq BI_{\text{price war}}$
H1: $BI_{mixed\ regime} > BI_{\text{price war}}$.

## 6. Results

In this section, I will compare the elasticity-adjusted Lerner index with the Boone-indicator. First, both measures of competition will be calculated from the data of the sugar industry. Then, the hypotheses I -IV previous defined above will be tested for

both these measures of competition. There are several reasons why I would like to make this comparison. The first is that Boone (2008) already explained that the Boone indicator is theoretically a better indicator for competition than the PCM. The elasticity-adjusted Lerner index is an improved version of PCM and thus the question remains whether the Boone-indicator is also empirically a better indicator. The other reasons are more of a practical nature. Genesove and Mullin (1998) calculate the elasticity-adjusted Lerner index for the overall sugar industry, instead of one firm, which makes a comparison of my results for the Boone-indicator with those of Genesove and Mullin (1998) complicated. The other reason is that Genesove and Mullin (1998) only look at price wars versus nonprice wars as our analysis of different regimes of competition is more demanding. Therefore in section 6.1 the results for the elasticity adjusted Lerner index will be presented and in section 6.2 those for the Boone-indicator. Finally, in section 6.3, the results are compared.

### 6.1 The elasticity-adjusted Lerner index revisited

There are two reasons for revisiting the elasticity-adjusted Lerner index as it is previously calculated by Genesove and Mullin (1998). First, Genesove and Mullin (1998) only test whether the elasticity-adjusted Lerner index is able to identify price wars from non price wars correctly. I test the more elaborate hypothesies of section 5, comparing different periods representing different regimes of competition. To be able to compare the Boone-indicator with the elasticity-adjusted Lerner Index, I test whether this latter indicator is able to distinguish between oligopolies, price wars and break-ups of cartels as well. So, I will test the same hypothesis for both the Boone-indicator and the elasticity-adjusted Lerner index. Second, Genesove and Mullin (1998), calculate the elasticity-adjusted Lerner index for the total sugar market as I am calculating the Boone-indicator merely for one company, the American Sugar Refining Company (ASRC). Therefore, I will estimate the elasticity-adjusted Lerner index for this firm only. The elasticity-adjusted Lerner index, $L_\eta$, is defined as:

$$L_\eta = \eta(p)\,(p-mc)/\,p \qquad (10)$$

where (p-mc)/p is the price-cost margin (PCM) and η(p) is the absolute value of the price elasticity of demand for sugar. For a monopolist or a functioning cartel, we would expect $L_\eta = 1$. In a perfectly competitive or Bertrand market, $L_\eta = 0$. We estimate the price elasticity of demand in the following model:

$$D = \gamma_0 + \gamma_1 Q3 + \Sigma d_p \tau_p p_{1t} \qquad (11)$$

Where D, total demand in the market, depends on the price set in the market, p, and a dummy for the high season, Q3. Equation (11) is again estimated with instrumental variable, Cuban imports, to distinguish between supply and demand.[4] The standard errors are again heteroskedasticity-robust and autocorrelation-robust by using Newey-West's kernel-based heteroskedastic and autocorrelation consistent (HAC) variance estimations, where the bandwidth has been set as before on four periods This model provides the following results which are presented in Table 3. Here, it follows that the parameters of price do not vary significantly among the different regimes of competition. Furthermore, as expected the demand for sugar during the high season is higher than during the rest of the season.

[4] Genesove and Mullin(1998) differentiate between low and high season by estimating different price elasticities for demand. Introducing three quarterly dummies yields positive price elasticities for demand during the price war due to the limited number of data.

**Table 3 Results for the demand for refined sugar**

| **Variable** | **IV** | |
|---|---|---|
| Demand (production) | **Parameter** | **z-value** |
| p_oligopoly | -39.68 | **-3.32 |
| p_price_war | -39.57 | **-3.60 |
| p_break-up_cartel | -35.73 | *-2.35 |
| p__mixed_regime | -39.17 | **-2.93 |
| Q3 | 26.64 | **5.67 |
| Constant | 248.98 | **4.99 |
| $R^2$-adj. | 0.139 | |
| Anderson correlation test (p-value) | 12.83 ( 0.00) | |
| Hansen J-statistic | Exactly identified | |
| number of observations | 97 | |

* means significance at the 5% level , ** means significance at the 1% level.

*Elasticity-adjusted Lerner index*

The elasticity-adjusted Lerner index, $L_\eta$ has an average value of 0.093, a minimum of 0.027 and a maximum 0f 0.203. It is calculated by the following formula:

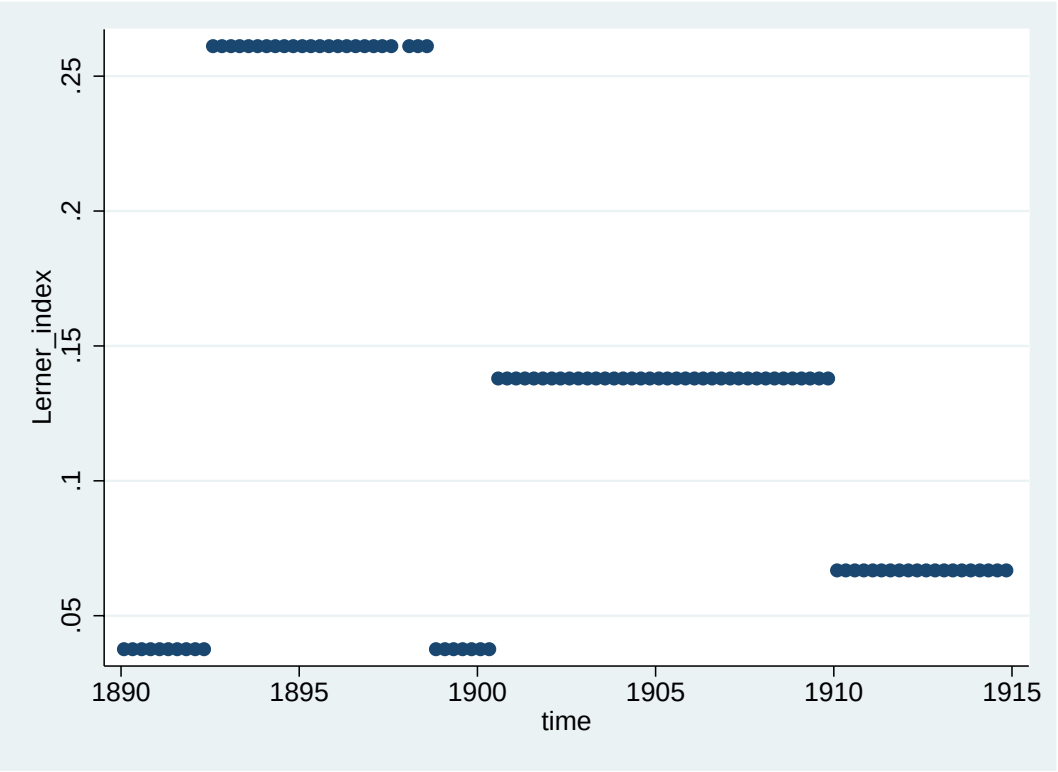
$$L_{\eta,p} = \tau_p * (p_p/D_{ip})*(p_p-mc_{ip})/p_p$$

where $p_p$ is the average price, $D_{ip}$ is the average production of ASRC, $(p_p-mc_{ip})/p_p$ is the average price-cost margin of ASRC (see Table A, in Appendix) and $\tau_p$ is the price elasticity of demand, i.e. the parameter of price in equation (11), in period p (see Table 3). As said, before, this calculation of the elasticity-adjusted Lerner index differs slightly from the version of Genesove and Mullin (1998). They use $D_p$, the average total production in the market, to calculate the elasticity-adjusted Lerner index for the total market. I only look at the competitiveness of one firm, the ASRC. Therefore, I use the production of this company to evaluate the elasticity-adjusted Lerner index. I assume that all sugar firms face the same demand curve. This

assumption is reasonable given the small quality differences between the firm's products as sugar is a bulk good. [5]

[5] Would we have used total production of the market, The Wald test of Hypothesis II would be equal to 0.471 with a p-value of 0.77 and would have been rejected at the 10 % level.

**Figure 2 The elasticity-adjusted Lerner index of ASRC**




In Figure 2, the different values of the elasticity-adjusted Lerner index are shown. Here, it is shown that competition is at its highest level during the price war of 1890 -1891 and 1899-1900. The price-cost margin (PCM) is in these periods at its lowest level and so is the elasticity-adjusted Lerner index. Competition is at its lowest level during the period of oligopoly, 1892 -1898. The level of competition increases after the second price war and after the abolishment of the cartel in 1910. The hypotheses tested in Table 4 confirm that the differences in the elasticity-adjusted Lerner index are significant between all regimes of competition at the 1%, with one exception: the elasticity-adjusted Lerner index can only identify differences in competition between price war and the break-up of the cartel at the 10% level.

**Table 4 Wald tests of the elasticity-adjusted Lerner index[6]**

| **Hypotheses** | **IV** | |
|---|---|---|
| | **$\chi^2(1)$** | **p-values** |
| Test H0: Lerner _oligopoly <= Lerner_pricewar H1: Lerner _oligopoly > Lerner_pricewar | 10.65 | 0.00 |
| Test H0: Lerner_price war >= Lerner _break_up_cartel H1: Lerner_price war < Lerner _break_up_cartel | 2.50 | 0.06 |
| Test H0: Lerner _oligopoly <= Lerner_break_up cartel H1: Lerner _oligopoly > Lerner_break_up cartel | 14.79 | 0.00 |
| Test H0: Lerner_price war >= Lerner_mixed_regime Test H1: Lerner_price war < Lerner_mixed_regime | 7.35 | 0.00 |

### 6.2 The results for the Boone-indicator

In table 5, the second column, the estimations of the linear model are shown using instrumental variables (IV). The standard errors are heteroskedasticity-robust and autocorrelation-robust by using Newey-West's kernel-based heteroskedastic and autocorrelation consistent (HAC) variance estimations, where the bandwidth has been set on four periods, as has been done by Genesove and Mullin (1998). The estimations are corrected for seasonal effects by introducing quarterly dummies, Q1 -Q3. The estimations show that the high season of spring and summer, respectively Q2 and Q3 are more profitable than the low season of winter, Q1, and the benchmark season of autumn.

Marginal costs are determined by the price of raw sugar. This price could increase when the demand curve for sugar shift to the right and thus indicates

[6] The Lerner_Arbuckle war indicator was significantly different from the other periods at the 1 % level. The Wald tests are available on request.

increased demand for sugar and thus an increase in profits. This shift in the demand curve is not related to changes in the competitive environment, and could therefore pollute our estimates for the Boone-indicator. To correct for this endogenous effect, we estimate the same equation with instrumental variables (IV). The instrumental variable used is the Cuban import of raw sugar, which most probably diminishes the price for raw sugar, but not the demand for sugar and profits of the firm. Genesove and Mullin (1998) point out that the potential endogeneity of Cuban imports depends upon the sources of variation in Cuban production: the seasonality of the yearly production, yearly climate variation, the Cuban Revolution, the subsequent Spanish-American War and a secular increase in planting of sugar cane. Only the last factor could be related to demand shocks. This is only possible when a shock in US demand for sugar would induce speculative raw sugar storage in Cuba. The only storage of raw sugar happened at the shipping docks. Storage meant delaying the cane harvest. However, this meant that the sugar looses some sucrose. Postponing the harvest in hopes of receiving higher prices ran the significant risk that the rainy season would begin before all the can could be harvest (page 363, 364, Genesove and Mullin(1998)). Diminished Cuban imports could increase the price of raw sugar. We find in table 6, second column, that the parameter for marginal costs differs significant from zero at the 1 % level during all periods, with the exception of that of oligopoly. The difference between the parameters of marginal cost is only significant between the period of oligopoly and all the other periods. In all other cases, these differences are not significant.[7]

The parameters of marginal costs, mc, for the subperiod of price war and break-up of the cartel are both significantly different from zero, at the 1% level. The parameter of marginal costs in the period with a mixed regime of competition is also at the 1%-level significantly different from zero. Marginal costs do not seem to have any relationship with profits in the period of oligopoly. The parameter of marginal costs, mc, is at its lowest level during a price war and at its highest during an oligopoly. The parameters of marginal costs during oligopoly and the other periods differ significantly from each other at the 1% -level. There are no significant differences in these parameters in the periods of price war, break-up of the cartel

[7] The Wald tests are available on request.

and with a mixed regime of competition. The conclusion is that estimating different parameters for these different regimes of competition only matters for periods of oligopoly.[8]

I have performed two robustness checks. In section 4, I already discussed that the proxy for profits is calculated using information on marginal costs and is therefore not independent from marginal costs. As a robustness check I estimate the same equation in GMM with additional instrumental variables, the marginal costs four quarters lagged, to analyse whether the instrumented marginal cost are related to profits in the same way as marginal costs. If this is the case, it would indicate that using a profit proxy based on marginal costs does not distort the results significantly. The instrumented marginal costs are the residual of the equation in which marginal costs are regressed on the four quarters lagged marginal costs. To test for overidentification of the instruments, we apply the Hansen J-test for GMM (Hayashi, 2000). The joint null hypothesis is that the instruments are valid instruments, i.e. uncorrelated with the error term. Under the null hypothesis, the test statistic is chi-squared with the number of degrees of freedom equal to the number of overidentification restrictions. A rejection would cast doubt on the validity of the instruments. Only instruments with four periods lagged rejected the Hansen J-statistic with more than 5%-significance. The results, in the fourth column of Table 5, show the same picture as the first column. The parameters are of the same order of size as in the first column, and are even more significant. Therefore, I conclude that the use of a profit proxy based on marginal costs does not alter the results significantly.

As a second robustness check, I estimate the same relationship in IV but this time with an estimate for $mc_0$ of 16 cents, instead of 26 cents resulting in lower marginal cost and profits. I use 16 cents as this mimicked the figures for earnings from operations acquired from the Chronicles and annual reports of ASRC best. Again, in the sixth column of Table 5, I find that the original estimate does not differ substantially from that with additional marginal costs of 16 cents. Also, there is little difference between the different parameters for marginal costs in the various

[8] The estimations presented below use also yearly data for market shares. As a robustness check, I have also used a moving average over four quarters from 1891 onwards for market shares. Using this smoothed version of market share did not change the results significantly.

regimes of competition across the different specifications. This means that the results are insensitive to the choice of additional marginal costs, $mc_0$.

**Table 5 Results**

| **$mc_0$** | **26 cents** | | **26 cents** | | **16 cents** | |
|---|---|---|---|---|---|---|
| **Variable** | **IV** | | **GMM** | | **IV** | |
| Profit | **Parameter** | **z-value** | **Parameter** | **z-value** | **Parameter** | **z-value** |
| mc_oligopoly | -6.56 | -1.83 | -8.40 | **-3.18 | -6.82 | -1.83 |
| mc_price_war | -11.43 | **-3.49 | -14.06 | **-5.60 | -11.99 | **-3.59 |
| mc_break-up_cartel | -14.89 | **-3.42 | -15.97 | **-4.84 | -15.65 | **-3.45 |
| mc__mixed_regime | -11.76 | **-3.00 | -13.59 | **-4.69 | -12.39 | **-3.05 |
| Q1 | 0.04 | 0.02 | 0.17 | 0.09 | -0.07 | -0.04 |
| Q2 | 7.25 | **3.38 | 7.41 | **3.48 | 8.52 | **3.86 |
| Q3 | 9.22 | **4.43 | 8.74 | **4.28 | 10.93 | **5.00 |
| Constant | 51.09 | **3.67 | 57.65 | **5.55 | 57.38 | **4.07 |
| $R^2$-adj. | 0.546 | | 0.516 | | 0.562 | |
| Anderson correlation test (p-value) | 32.88 ( 0.00) | | 51.71 (0.00) | | 32.79 (0.00) | |
| Hansen J-statistic (p-value) | Exactly identified | | 6.712 (0.15) | | Exactly identified | |
| number of observations | 97 | | 92 | | 97 | |

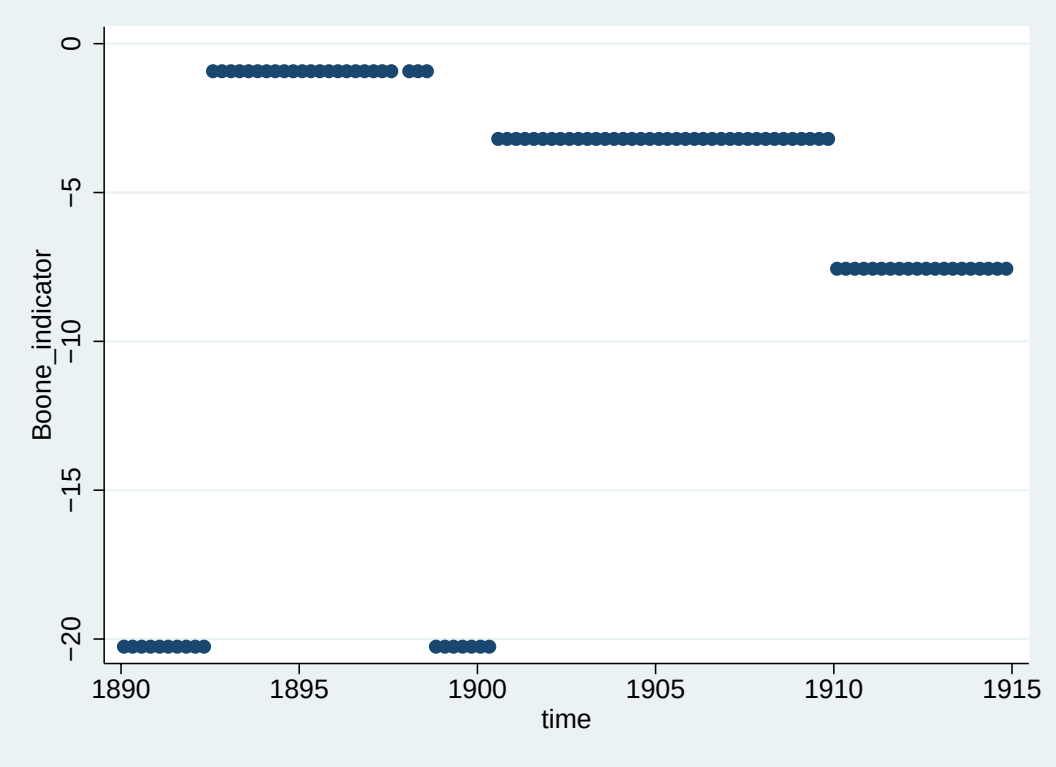
* means significance at the 5% level , ** means significance at the 1% level.

*The Boone-indicator*

The Boone-indicator, BI, is the elasticity of profits to marginal costs, ie $\delta\ mc_p / \pi_p$. The Boone-indicator for the different subperiods is calculated by multiplying the IV-estimates of the parameter δ of mc in subperiod p from the second column of Table

5 with the ratio of average marginal costs, $mc_{p,}$ and average profits, $\pi_p$, in the same subperiod p (as presented in Table 2).

**Figure 3 The Boone-indicator of ASRC[9]**




In Figure 3, the values of the Boone-indicator are presented for the different regimes of competition. It is shown that competition during the price wars of 1890-1891 and 1899-1900 has been very strong compared to other periods, with very negative values of the Boone-indicator. The Boone-indicator has been at its highest point (least negative) during the period of oligopoly, 1892-1898. After the break-up of the cartel in 1910, the Boone-indicator becomes again more negative, indicating that ASRC has become more competitive compared to the previous period of oligopoly. The period 1900 -1909 shows that competition in the sugar market was moderate during the mixed regime, higher than during the previous period of

[9] In line with Genesove and Mullin observation 1897Q4 is left out of the estimation because the instrumental variable Cuban imports of raw sugar was zero.

oligopoly, but lower than during the period after the break-up of the cartel. [10]Now, I will examine the significance of these differences by testing the hypotheses of section 5.

*Hypotheses*

Turning to the hypotheses, I used a Chi-squared distributed Wald test with one degree of freedom to determine whether the Boone-indicator is significantly different between two periods. The results are presented in Table 6, second column. They show that the Boone-indicator during the break-up of the cartel is significantly more negative than the Boone-indicator in times of a oligopoly. $H_0$ '$Boone_{oligopoly} > Boone_{break\_up\_cartel}$', null hypothesis I, is thus not rejected at the 1% level. Furthermore, for all the other hypotheses, all the null hypothesis are not rejected, which indicates that the Boone-indicator is very well able to distinguish between the different regimes of competition. Therefore, the Boone-indicator could very well be used to measure the different regimes of competition. In the Table 6 fourth and sixth columns, it is also shown that with instrumented marginal cost or with additional marginal costs of 16 cents, the Boone-indicator is well able to identify the different regimes of competition from each other. Again, the conclusion is that the degree in which the Boone-indicator, BI, is able to identify different regimes of competition is not affected by the fact that the proxy for profits is based on marginal costs.

[10] The figures of the Boone-indicator with the estimates of the fourth and sixth column of Table 5 are not shown because they are almost identical with figure 2. They are available upon request.

**Table 6 Wald tests of the Boone-indicator[11]**

| Hypotheses | 26 cents | | 26 cents | | 16 cents | |
|---|---|---|---|---|---|---|
| | IV | | GMM | | IV | |
| | $\chi^2(1)$ | p-values | $\chi^2(1)$ | p-values | $\chi^2(1)$ | p-values |
| Test H0: Boone _oligopoly <= Boone_pricewar H1: Boone _oligopoly > Boone_pricewar | 13.30 | 0.00 | 33.71 | 0.00 | 16.95 | 0.00 |
| Test H0: Boone_price war >= Boone _break_up_cartel H1: Boone_price war < Boone _break_up_cartel | 11.67 | 0.00 | 34.07 | 0.00 | 10.21 | 0.00 |
| Test H0: Boone _oligopoly <= Boone_break_up cartel H1: Boone _oligopoly > Boone_break_up cartel | 14.87 | 0.00 | 27.56 | 0.00 | 17.77 | 0.00 |
| Test H0: Boone_price war >= Boone_mixed_regime Test H1: Boone_price war < Boone_mixed_regime | 12.83 | 0.00 | 33.00 | 0.00 | 15.09 | 0.00 |

### 6.3 Comparison

Above we have discussed two measures of competition: the elasticity-adjusted Lerner index and the Boone-indicator. Both measures provide a similar picture with regard to levels of competition. In times of oligopoly competition is low and both the elasticity-adjusted Lerner index and the Boone-indicator are high. Competition is most fierce when there are price wars according to both measures of competition: The elasticity-adjusted Lerner index is close to zero and the Boone-indicator has a very negative value.

The Boone-indicator adds additional information to the elasticity-adjusted Lerner index. It identifies the different regimes better than the elasticity-adjusted Lerner index. This latter index is not able to differentiate significantly between competition

[11] The $\text{Boone}_{\text{mixed\_regime}}$ indicator was significantly different from the other periods at the 1 % level. The Wald tests are available on request.

levels of price wars and the break-up of the cartel. However, a limitation of the Boone-indicator is that there is no benchmark, no absolute value, which indicates the regime of competition. The elasticity-adjusted Lerner index has such benchmark. For instance, it is possible to test whether during a price war the level of competition reaches perfect competition. For that purpose, I use a Wald-test with the H0-hypothesis that the elasticity-adjusted Lerner index was equal to zero. This H0-hypothesis was rejected at the 1 % level ($\chi^2(1) = 12.94$**)**, meaning that during these price wars there was no perfect competition. This means that the elasticity-adjusted Lerner index is significantly different from zero.

## 7. Conclusion

This paper tests whether a new concept to measure competition introduced by Boone (2008) is able to identify empirically significant differences in the level of competition between periods of oligopoly, price war and split-up of cartels. A limitation of the Boone-indicator, compared to the elasticity-adjusted Lerner index, is that it cannot measure the absolute level of competitiveness of the firm. It can only tell us whether the firm in one period is on average more or less competitive than in another period. For this purpose, a linear model is estimated between a proxy for profits and marginal costs by using data of the dominant firm in the sugar industry, ASRC, in the period 1890-1914. These data are derived from Genesove and Mullin (1998). The profit proxy is based on information on marginal costs. From these estimates, it follows that the Boone-indicator indeed is able to identify the different regimes of competition empirically. The results of the Boone-indicator show that during a price war competition is significantly more intense than in a period of an oligopoly. The Boone-indicator further indicates that competition during the break-up of the cartel is also significantly higher than during an oligopoly, just in line with expectation. Finally, the Boone-indicator during a price war is lower than in the period after the break-up of the cartel indicating that competition is more fierce in the first period compared to the latter period. Robustness checks with regard to the accurate measurement of profits by the proxy of profits show that these results are insensitive for variation in the specification of the profit proxy. Estimations with instrumented marginal costs reveal that the results of the Boone indicator is not

substantially influenced by the fact that the proxy is based on marginal costs. From a comparison of these results with those of the elasticity-adjusted Lerner index, I learn that the Boone-indicator adds additional insights to the adjusted Lerner index as this indicator is not able to distinguish between price wars and break-up of cartels, and the Boone-indicator is able to identify both periods.

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**Appendix**

**Table A Descriptive statistics for calculating the elasticity-adjusted Lerner index**

| | **observations** | **Mean** | **Std. Dev.** | **Min** | **Max** |
|---|---|---|---|---|---|
| PCM_price_war ( in terms of price) | 17 | 0.01 | 0.05 | -0.04 | 0.14 |
| PCM_oligopoly ( in terms of price) | 24 | 0.10 | 0.04 | 0.02 | 0.15 |
| PCM_break-up_cartel ( in terms of price) | 18 | 0.03 | 0.02 | 0.01 | 0.07 |
| PCM__mixed_regime ( in terms of price) | 38 | 0.06 | 0.03 | -0.01 | 0.10 |
| production_price_war in long tons | 17 | 82.37 | 15.47 | 55.54 | 118.94 |
| production_oligopoly in long tons | 24 | 83.39 | 16.64 | 52.66 | 122.08 |
| production_break-up_cartel in long tons | 18 | 124.90 | 28.65 | 81.09 | 165.54 |
| production_mixed_regime in long tons | 38 | 104.46 | 17.67 | 74.26 | 145.18 |
| marketshare_price_war (in %) | 17 | 71 | 8 | 65 | 91 |
| marketshare_oligopoly (in %) | 24 | 78 | 6 | 70 | 91 |
| marketshare_break-up_cartel (in %) | 18 | 47 | 3 | 43 | 50 |
| marketshare_mixed_regime (in %) | 38 | 59 | 5 | 50 | 70 |
| price_price_war (in dollars) | 17 | 4.51 | 0.68 | 3.55 | 5.50 |
| price_oligopoly (in dollars) | 24 | 4.40 | 0.412 | 3.72 | 5.07 |

| | | | | | |
|---|---|---|---|---|---|
| price_break-up_cartel (in dollars) | 18 | 3.45 | 0.47 | 2.75 | 4.44 |
| price_mixed_regime (in dollars) | 38 | 3.85 | 0.44 | 3.38 | 5.02 |

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.

From Table A, it follows that the price-cost margin as percentage of price was at its lowest level during the price wars, 1% of the price, and at its highest level during the period of oligopoly, 10% of the price. Furthermore, production increased over time, from around 0.83 million long tons to 0.124 million long tons after the break-up of the cartel as the entry of firms increased. Market shares declined gradually from 78% on average during the oligopoly period to 47% after the break-up of the cartel. Prices were indeed high during the times of oligopoly but this is partly due to high prices for raw sugar. Prices reached their lowest levels after the break-up of the cartel.