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Cartel Detection – Is Market Share Volatility a Significant Indicator?

In this short paper, cartel behaviour is analysed with respect to the market shares of cartel members. There is some evidence in previous theoretical and empirical research that market shares under collusion are more stable than in phases of competition. It is shown that this can be an artifact and that market share volatility may not be used by antitrust authorities as an exclusive indicator of tacit collusion. Using the Kolmogorov-Smirnov test, the distribution of market share changes during both the competitive and the collusive phases of ten recently discovered conspiracies is compared. Only in 3 of the 10 cartels were the distributions of market share changes significantly different.

In any market, firms have an incentive to coordinate their decisions and increase their collective profits by restricting output and raising market prices, which leads to a welfare loss. Antitrust authorities therefore require effective methods of detecting such collusion. Previous studies have revealed many different characteristics of collusive behaviour. For example, Porter and Zona[1], and Bajari and Ye[2] concentrate on some selected bidding markets and demonstrate the difference between collusive and competitive bidding behaviour. For studies that analyse price dispersion in order to detect collusive behaviour, see Abrantes-Metz et al.[3] and Bolotova et al.[4] Blanckenburg and Geist[5] present a system of cartel markers (SCM), which includes a number of cartel markers based on expected behavioural patterns such as a low level of capacity utilisation, slackness of price adjustments to exogenous shocks, excess rates of return, near constant capacities, minimal price changes, a low variance of capacity growth rate and cost inefficiency.

In this paper, we extend the discussion to the stability of market shares as a further marker, as proposed by Harrington[6], for example. The hypothesis is that market shares are more stable under collusion. If so, antitrust authorities may be able to detect cartels by identifying changes in market share volatility. However, no empirical verification of this marker has so far been undertaken. In order to do so, we analyse ten recently discovered instances of collusion and compare the distributions of market share changes during the competitive phase and under collusion. If the cartel members are able to agree on market shares (collusion), we expect a leptokurtic distribution of market share changes around zero because of more "near-zero changes" compared to a competitive situation. We employ the Kolmogorov-Smirnov test, which is a non-parametric (distribution-free) test comparing two distributions. All the cartels we analyse are German and the relevant organisations were recently prosecuted by the European Commission. The data was provided by the German Federal Statistical Office. The paper is structured as follows. Firstly, we discuss the theoretical background and hypothesis. We then present the data used for our analysis. Finally, the empirical results and some conclusions are presented.

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Figure 1
Expected Distribution of Market Share Changes

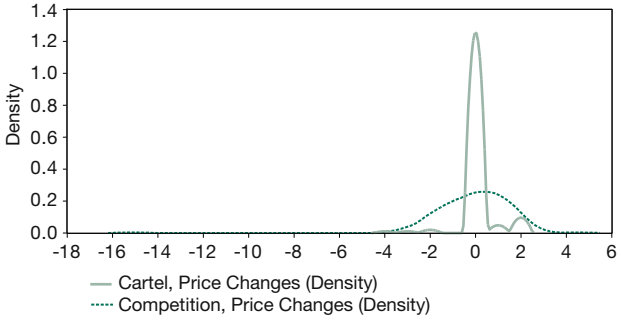

Table 1
Example for the Calculation of the Market Share Indicator $\Delta\Omega$

	t = 0		t = 1		
	Gross output (Φ_0) (€ m.)	Market share (Ω_0)	Gross output (Φ_1) (€ m.)	Market share (Ω_1)	$\Delta\Omega=\Omega_0-\Omega_1$
Firm 1	3.5	0.35	3.0	0.30	0.05
Firm 2	2.5	0.25	1.5	0.15	0.10
Firm 3	4.0	0.40	5.5	0.55	0.15
Σ	10.0	1.00	10.0	1.00	
Mean of absolute market share changes (in t = 1)					0.10

Theoretical Background and Hypothesis

The stability of market shares has been the focus of both enforcement and academic efforts to analyse collusive behaviour. In a dynamic Bertrand game, Athey et al.[7] show that under collusion market shares are more stable than in competitive equilibria, which holds for independent cost shocks across firms and over time and also when firms' costs are consistent over time. Caves and Porter[8] analyse the influence of market structure on oligopolistic behaviour and conclude that stable market shares provide an indicator of oligopolistic bargaining. When firms agree on a cost-minimising distribution of production, they effectively allocate market shares. If this constancy is interrupted, we expect that this instability will lead to less complete collusion. Shepherd[9] states that the greater the stability, the higher the probability of overt or covert cooperation. Lorenz[10] provides some empirical evidence of more stable market shares for the German cement cartel. Ogur[11] finds that market shares in the turbine generator industry were more stable during its period of formal collusion.

However, no empirical verification of this marker by the analysis of numerous cartel cases has been undertaken so far. If firms are able to freeze their market shares, we expect to observe zero changes in market shares. Harrington[12] warns that market share stability may only be observed when one uses the right measure. If the cartel is not all-inclusive, a particular cartel member's market share may fluctuate if the non-cartel supply changes (the latter would generally be expected to increase due to the high prices created by cartel members) while at the same time its share of the cartel supply is stable. Therefore, we do not expect exact zero changes, but more changes near zero, compared to the competitive benchmark. Hence,

> *H_0: the distribution of changes in market shares under collusion has a higher peak around zero.*

The expected distributions of market share changes under collusion and competition are illustrated in Figure 1.

The introduced marker can only be used for antitrust screening and regulatory purposes if a *change* in the distribution of market shares changes is observable. There is some evidence supporting the hypothesis that stable market shares are not the consequence of a collusion but a precondition. Staiger and Wolak's[13] theoretical model states that under capacity constraints instable market shares across oligopolistic firms are an indicator of an inability to collude effectively. Grout and Sonderegger[14] provide an empirical approach, analysing economic factors that are critical to the identification of cartels. They find that cartels are less likely in markets with

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11 J.D. Ogur: Competition and Market Share Instability, Bureau of Economics, Staff Report to Federal Trade Commission, R-6-I 5-3I.1976.
12 J.E. Harrington Jr., op. cit.
13 R.W. Staiger, F.A. Wolak: Collusive Pricing With Capacity Constraints. In The Presence Of Demand Uncertainty, Papers e-90-14a, Stanford - Hoover Institution 1990.
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Table 2
Descriptive Statistics of Cartel Cases by Data Periods

Product	NACE	Data Period	N_{all}	Cartel Period	N_{cartel}
Coffee	108311	02/1995-04/2009	59	01/2000-02/2008	30
Copper tubes, Copper fittings	244426	02/1995-04/2009	59	02/1988-01/2001	24
Gas insulated switchgear	271210	02/1995-04/2009	59	01/1988-04/2004	39
Hydrogen peroxide and perborate	201363	02/1995-04/2009	59	01/1994-04/2000	23
Marine hose	221930	02/1995-04/2009	59	01/1986-04/2007	53
Monochloroacetic acid	20143220	02/1995-04/2009	59	01/1984-02/1999	17
Plasterboard	236210	02/1995-04/2009	59	01/1992-04/1998	15
Plastic industrial bags	222211	02/1995-04/2009	59	01/1982-02/2002	29
Synthetic rubbers	201710	02/1995-04/2009	59	02/1996-04/2002	26
Vitamins	21105	02/1995-04/2009	59	04/1989-01/1999	16

significant changes in market share, or in markets with regular exits and entries.

Data Description

The present study uses quarterly data of market share changes provided on request by the German Federal Statistical Office (GFSO) for selected industries from 1995 to 2009. Because of data protection, the values of the market shares of the individual firms are not publicly available. In order to anonymise the data, we used the mean of the absolute market share changes $\Delta\Omega$ of individual firms $i,j = \{1,...,n\}$ at time t, which is sufficient to indicate the volatility of market shares. The market shares for the firms are calculated as a quotient Ω_t of gross output Φ_t and the output sum of the industry. In the following analysis, $\Delta\Omega$ is used as a "market share indicator":

$$\Delta\Omega = \frac{1}{n}\sum_{i=1}^{n}\left(\frac{\Phi_{i,t}}{\Sigma_{j=1}^{n}\Phi_{j,t}} - \frac{\Phi_{i,t-1}}{\Sigma_{j=1}^{n}\Phi_{j,t-1}}\right) = \Omega_t - \Omega_{t-1}$$

An example for the calculation of $\Delta\Omega$ is given in Table 1. If there are no changes in market shares the mean is zero. All cartel industries in the study are grouped according to the statistical classification of economic activities in the European Community (NACE). The classification

Table 3
Descriptive Statistics of Cartel Cases by Companies and Fines

Product	Companies	Fines[1] (€ million)
Coffee	Tchibo, Melitta, Dallmayr	no decision
Copper tubes, Copper fittings	Mueller Industries, Austria Buntmetall, Boliden AB, Boliden Cuivre Zinc, Buntmetall Amstetten, Deno Acquisition, Deno Holding Company, Europa Metalli SpA, HME Nederland BV, Halcor SA, IMI Plc, KM Europa Metal AG, Mueller Europe Ltd, Outokumpu Oyj, Tréfimétaux SA, WTC Holding Company, Wieland Werke AG, Yorkshire Copper	222
Gas insulated switchgear	Schneider Electric, ABB Ltd, AREVA T&D AG, AREVA T&D Holding SA, AREVA T&D SA, Alstom, Areva SA, Fuji Electric, Fuji Electric Systems, Hitachi Europe Ltd, Hitachi Ltd, Japan AE, Mitsubishi Electric, Nuova Magrini G, Siemens AG, Siemens AG Österreich, Siemens Transmis Ltd, Siemens Transmis SA, Toshiba Corporation, VA TECH Transmission	751
Hydrogen peroxide and perborate	Degussa AG, Akzo Nobel Chemicals, Akzo Nobel NV, Arkema SA, Caffaro, Chemoxal, Edison SpA, Eka Chemicals, Elf Aquitaine, FMC Corporation, FMC Foret, KEMIRA OYJ, L'AirLiquide, SNIA, Solvay NV, Solvay Solexis, Total SA	388
Marine hose	Yokohama Rubber Co, Bridgestone, Bridgestone Industri, ContiTech AG, Continental AG, Dunlop Oil & Marine, Manuli Rubber Indust, Parker Hannifin Corp, Parker ITR Srl, Trelleborg AB, Trelleborg Industrie	132
Monochloroacetic acid	Hoechst AG, Akzo Nobel AB, Akzo Nobel Base Chem, Akzo Nobel Chemicals, Akzo Nobel Funct, Akzo Nobel NV, Akzo Nobel Nederland, Arkema SA, Clariant AG, Clariant GmbH, Eka Chemicals, Elf Aquitaine	217
Plasterboard	BPB, Gyproc Benelux, Knauf W.G. KG, Lafarge SA	478
Plastic industrial bags	UPM-Kymmene Oyj, Armando Álvarez SA, BPI, Bernay Film Plastiqu, Bischof + Klein FR, Bischof + Klein GmbH, Bonar Technical Fabr, Cofira-Sac SA, Combipac BV, FL Smidth& Co A/S, FLS Plast A/S, Fardem Packaging BV, Groupe Gascogne, JM Gesellschaft, KV Stempher CV, Kendrion NV, Low & Bonar plc, Nordenia IAG, Nordfolien GmbH, Plásticos Españoles, RKW, Sachsa Verpackung, Stempher BV, Trioplast Industrier, Trioplast Wittenheim	290
Synthetic rubbers	Bayer AG, DOW Deutschland Inc, Dow Chemical Company, Dow Deutschland, Dow Europe GmbH, Eni SpA, Kaucuk as, Polimeri Europa SpA, Shell NL Chemie BV, Shell Nederland BV, Shell Petroleum NV, Trade-Stomil Ltd, Unipetrol as	519
Vitamins	BASF AG, Aventis SA, Daiichi, Eisai Co Ltd, F. Hoffmann-La Roche, Kongo Chemical Co, Lonza AG, Merck KGaA, Solvay Pharmaceutic, Sumika Fine Chemical, Sumitomo Chemical Co, Takeda Chemical Ind, Tanabe Seiyaku Co	855

[1] http://ec.europa.eu/competition/cartels/statistics/statistics.pdf.

Figure 2
Density of Market Share Changes in Cartels and Competitive Markets

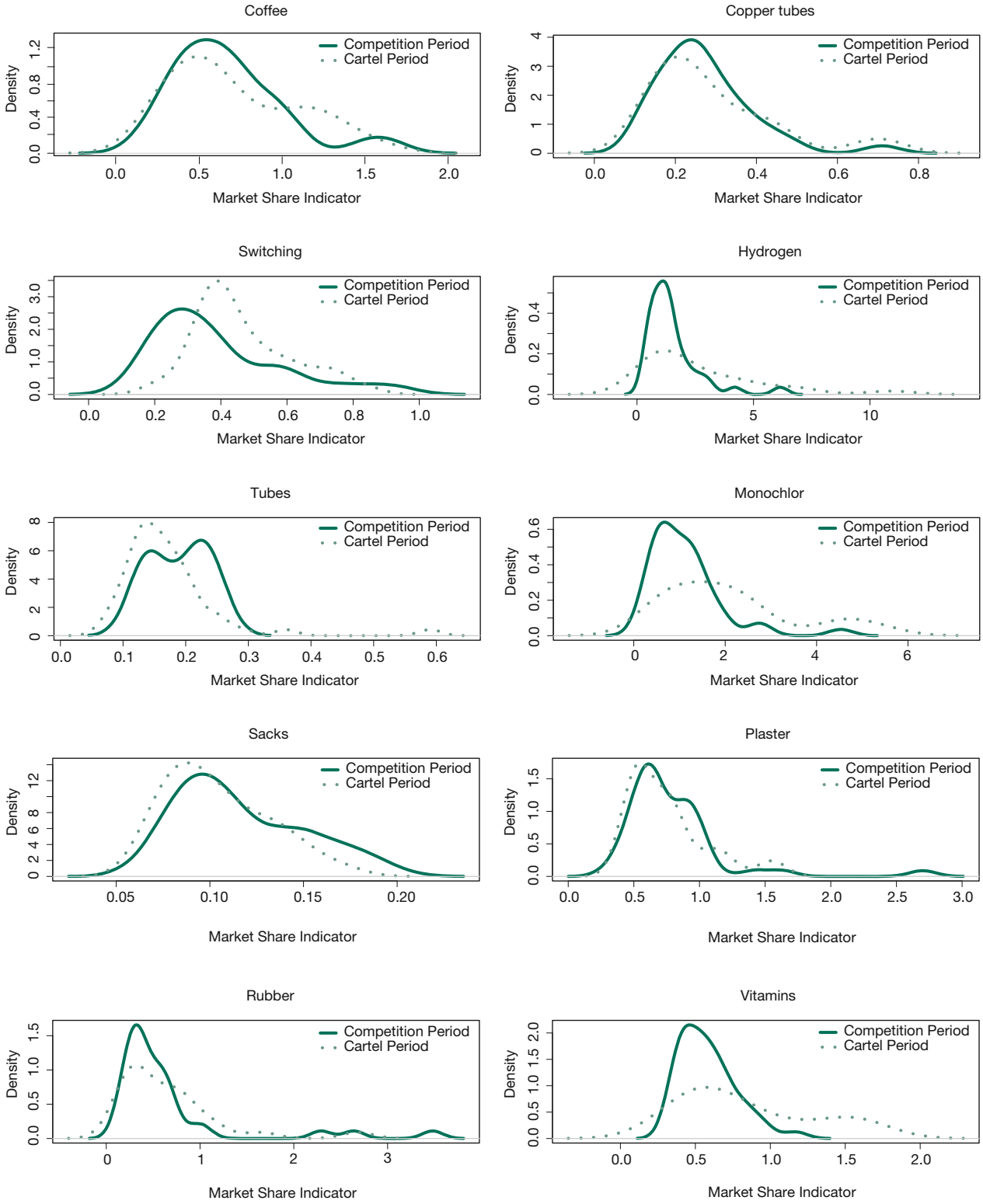

Table 4
Comparing Cartel and Competition Market Share Volatility

	Kolmogorov-Smirnov test	
	D-statistic	p-value
Coffee	0.198	0.457
Copper tubes	0.126	0.873
Switching	0.422***	0.005
Hydrogen	0.296*	0.098
Tubes	0.304	0.315
Monochlor	0.480***	0.004
Sacks	0.195	0.309
Plaster	0.239	0.361
Rubber	0.241	0.296
Vitamins	0.314	0.132

Notes: significance level: *** 0.01, ** 0.05, *0.1.

is designed to categorise data.[15] The cases presented were of firms prosecuted by the European antitrust authority. The case descriptions also contain the cartel periods, which we use to differentiate between the periods of competition and the periods of collusion.[16] Table 2 lists the product markets analysed. We were able to analyse cartel markets at the lowest possible of level aggregation. Finally, in Table 3 we list the companies involved and the total fines imposed by the European Commission.

Empirical Results

In order to detect whether cartel market share volatility is different from that in situations of competition, let us first observe the distribution of market share changes under competition (continuous line) compared to the distribution of market share changes in a cartel (dotted line) in Figure 2. To illustrate the changes in market shares, we use our "market share indicator" $\Delta\Omega$, as introduced above. In particular, we show the kernel density of the distribution of $\Delta\Omega$.[17]

In Figure 2 mixed results can be observed. For only two industries (hydrogen, monochlor) is it immediately evident that in a cartel the market share changes are much less volatile. For all other industries, no large differences can be found.

Furthermore, we employed the Kolmogorov-Smirnov test, which is a non-parametric (distribution-free) test which measures the distance between the empirical distribution functions of two samples. The null hypothesis of the test is that both samples are drawn from the same distribution. Formally, the test statistic is defined as follows:

$$D = \sup_x | F_0(x) - F_1(x) |$$

where $F_0(x)$ and $F_1(x)$ are the empirical cumulative distribution functions for each of the two samples being compared. In other words, the empirical cumulative distribution functions are compared (as absolute differences in function values) at each point of distribution support, after which the largest absolute difference is taken as the Kolmogorov-Smirnov test statistic. If this supreme absolute difference exceeds a certain critical value, the null hypothesis of the two samples being drawn from the same distribution is rejected.

The results of the traditional Kolmogorov-Smirnov test data are reported in Table 4. In this case, the null hypothesis is rejected for three industries (switching, monochlor and hydrogen peroxide) and almost rejected for Vitamins. We can conclude that the distributions of market share changes under competition and cartels differ only in three of ten cases. These differences can be detected graphically and with the Kolmogorov-Smirnov test.

Conclusions

There is some evidence in previous theoretical and empirical research that market shares under collusion are more stable than in competition. If so, changes in market share volatility could be used by antitrust authorities as a possible marker of tacit collusion. In this paper,we test this hypothesis using data from ten recently discovered conspiracies. We use the Kolmogorov-Smirnov test to examine the differences in the distributions of market share changes during collusive and non-collusive periods. Only in 3 out of 10 cartels were the distributions of market share changes significantly different. In two out of these three cases (monochlor and hydrogen), however, the market share changes under competition are even less volatile than under a cartel. Hence, we find no support for the hypothesis that market shares in a cartel are more stable than under collusion. A possible explanation could be that market share stability is a condition for, rather than a consequence of, successful collusion. However, further empirical research would be necessary to verify this hypothesis.

15 The NACE Classification is based on the International Standard Industrial Classification of all Economic Activities (ISIC Rev.2). Parts of ISIC Rev.2 were insufficiently aggregated to represent and monitor European national economies, and the necessary adjustments were therefore made accordingly.
16 http://ec.europa.eu/competition/cartels/cases/cases.html.
17 Our kernel density estimation is based on an Epanechnikov kernel.