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A multi criteria study of collusion risk factors

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Abstract. Market features can be considered as forerunners of the European Commission's actions aimed at recognizing collusive behaviours. To identify information that might support the Commission in the exercise of its role of antitrust authority we propose a multi criteria approach. Its focus is on the manufacturing sector and the aim is also to prevent undesired behaviours. Market sector features, such as price-cost margin or market entrance rate, are linked to the likelihood of a collusive behaviour in the sector in terms of "implications rules" by means of Dominance-based Rough Set Approach. Data come from institutional sources concerning different manufacturing sectors from five countries (France, Germany, Italy, Spain and United Kingdom) from 2000 to 2010.

Keywords: collusion prevention, manufacturing sector, dominance based rough set approach, multi-criteria.

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A multi criteria study of collusion risk factors

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Abstract Market features can be considered as forerunners of the actions undertaken by the European Commission with the aim to recognize collusive behaviours. To identify information that might support the Commission in the exercise of its role of antitrust authority we propose a multi criteria approach. Its focus is on the manufacturing sector and the aim is also to prevent undesired behaviours. Market sector features, such as price-cost margin or market entrance rate, are linked to the likelihood of a collusive behaviour in the sector in terms of “implications rules” by means of Dominance-based Rough Set Approach. Data come from institutional sources concerning different manufacturing sectors from five countries (France, Germany, Italy, Spain and United Kingdom) from 2000 to 2010.

1. Introduction

The presence of certain characteristics of the market and the choices taken by companies may lead to an increase in the chances of success of collusive agreements. The European Commission produces merger-control and anti-cartel enforcement decisions aimed at recognizing collusive behaviours. Antonielli and Mariniello [1] study the risk of collusive behaviour in the manufacturing sector in Europe and identify the manufacturing sectors in which the European Commission has been more active as an Antitrust Authority. On one hand, for each manufacturing sector, they calculate some indicators with a positive impact on the probability of collusion (the so-called collusion risk indicators); on the other hand, they investigate some interventions of the Antitrust Authority on cartels and concentrations. Finally, they compare the Commission's actions as Antitrust Authority and the risk of collusion indicators, taken individually, for each industrial sector. Inspired by their work we analyse the issue from another point of view: is there a specific link between the manufacturing sector and the set of risk of collusion indicators? And if so, how can it be analysed? Data reported in [1] refer to various institutional sources concerning different manufacturing sectors from 5 countries in the period 2000-2010: France, Germany, Italy, Spain and United Kingdom that constitute the 71% of the European GDP in 2011. Moreover, the manufacturing sectors produce an average 12% of GDP in those countries. The time period of 10 years is long enough in order to make visible the effects of anti-competitive behaviour, in particular given the average length of an international cartel. We use Rough Sets Theory (RST) [2] and its recent generalisation, the Dominance-based

Rough Set Approach (DRSA) [3,4,5], to study, in terms of decision rules, the link between risk indicators and collusive behaviour detection. RST and DRSA are particularly useful for Multi-criteria Decision Analysis, in fact decision rules represent a method to express properties of data and constitute quite good tools to communicate the results to practitioners.

2. Dataset

As mentioned, Antonielli and Mariniello [1] considered the European countries France, Germany, Italy, Spain and UK, where in the time interval 2000-2011, the manufacturing sector covered about 12% of those countries' GDP. The market features variables considered are Total production, Value Added, Gross Operating Surplus, Market Size, Imports, Exports, Production and Number of firms by employment size, Production value and Production shares of up to five top companies; the categories in which the manufacturing sector has been partitioned (following the 2-digit Statistical classification of economic activities in the European Community, i.e. NACE 2-digit) are 22: *Food products, Beverages, Tobacco, Textiles, Wearing apparel, Leather products, Wood and wood products, Paper and paper products, Reproduction of recorded media, Chemicals, Pharmaceuticals, Rubber and Plastics, Other non-metallic mineral products, Basic metals, Fabricated metal products, Computers and electronics, Electrical equipment, Machinery and equipment, Motor vehicles, Other transport equipment, Furniture, Other manufacturing*. Note that *Coke and Refined Petroleum Products*, and *Repair and Installation of Machinery and Equipment* have not been considered in the analysis. According to the economic literature [6], features and indicators that have a positive impact on the probability of collusion were identified. More precisely, the considered antitrust risk indicators are Market Concentration, Entry, Market Stability, Market Symmetry, all computed at European level.

1. *Market Concentration*

Usually it is assumed that a higher degree of market concentration is related to higher likelihood of collusion and that cartels are more stable when markets are more concentrated. The average level of market concentration was measured by the average price-cost margin (time interval 2000–2011), the Four-Firm industry concentration ratio (*C4*) and the Herfindahl-Hirschman Index (*HHI*), both in 2010. Analogously to *C4*, *HHI* has been computed as the sum of the squares of the market shares of the four largest companies in each sector in 2010.

2. *Entry*

Entry may influence companies already in the market, e.g., in the choice of prices: it seems that in case of entry, collusion may happen with lower probability. In order to take into account information on entry, firm's size and import penetration are considered as indicators: the first gives the average size of companies for each sector, the

second is measured by the ratio between the yearly average of sector imports and the sector production. They are considered in the interval 2000-2011.

3. *Market Stability*

Stability in the market is measured by variance in market size and by variance in import penetration: the variance in market size is the yearly growth rate of nominal production values; the variance in import penetration is valued as the variance of the yearly growth rate of the ratio between imports and total production. It is supposed that High variance levels are related to low market predictability and consequently, to low probability of collusion.

4. *Market Symmetry*

In symmetric markets, collusion between players with similar market shares results to be more probable and Antonielli and Mariniello [1] propose an asymmetry index with range 0-100: higher values correspond to situations in which a significant gap separates market shares held by the biggest and the smallest companies.

For each manufacturing sector, the interventions of the European Commission between 2000 and 2013 were measured in order to contrast the anti-competitive conduct relatively to mergers and cartels (see [1]). With reference to merger investigations, sectors are analysed through the indicator

$$PPM = (M_{IC} + M_2) / M_T$$

representing the Percentage of Problematic Merger (i.e. mergers that were deemed in first phase either requiring adherence to some conditions, M_{IC} , or necessity of further control in second phase, M_2) with respect to the total number M_T of mergers. The second attribute considers the number SC of sanctioned anti-cartel actions weighted by the size of the market.

3. Data Mining via Rough Sets Theory

With the aim of detecting patterns in a data set, Dominance-based Rough Set Approach points out “decision rules” as a method to detect and to describe properties: the dependence between condition criteria and decision criteria, which easily represents patterns in the data in the form

$$\text{“if value of conditions then value of decisions”}$$

results to be particularly meaningful to communicate the results to practitioners. The main role in DRSA is now played [3,4] by dominance relation which substitutes indiscernibility relation on which the classical RST has been established [2]. Data are collected in a decision table, that is a 4-tuple $S=(U,Q,V,f)$ where U is the learning data set, i.e. the finite set of manufacturing sectors, which is related to the finite set Q of criteria that are divided into condition criteria C (Market Concentration, Entry, Market Stability, Market Symmetry) and decision criteria D (Percentage of Problematic Merger and Number of Sanctioned Anti-cartel Actions); V represents the sets of all the values of each criterion and f is the information function, that is the function through which it is possible to associate to each manufacturing sector the value assumed in correspondence with each attribute, both in the case of condition criteria and in the case of decision criteria. In RST the strength σ of the rule $C \rightarrow D$ is computed by the ratio between the support of the decision rule and the cardinality of U , the certainty factor cer and the coverage factor cov of the rule are defined by the ratios between the support of the decision rule and the cardinality of C and D , respectively:

$$\sigma(C, D) = \frac{|C \cap D|}{|U|} \quad cer(C, D) = \frac{|C \cap D|}{|C|} \quad cov(C, D) = \frac{|C \cap D|}{|D|}.$$

In particular, cer and cov factors admit a very interesting probabilistic meaning: in fact, the certainty factor represents the conditional probability of the value of the decision attribute, given the assumption of the value of the condition attribute, while the coverage factor represents the conditional probability of the value of the condition attribute, given the assumption of the value of the decision attribute. Originally, objects characterized by the same information are considered indiscernible: the corresponding equivalence relation enables the splitting of the finite nonempty universe into a family of equivalence classes (called elementary sets). Unfortunately this appealing idea is failing when objects are described by attribute with domains that are preference-ordered: in fact, violations of the dominance principle could generate inconsistencies. The main assumption in DRSA is that each domain is completely preordered by an outranking relation. This is related to the definition of upward and downward union of classes. P -dominating and P -dominated sets represent the basis of knowledge, that is, knowledge is approximated by upward and downward unions of decision classes. In this way, lower approximations contain the elements that certainly belong to upward and downward union of classes, while upper approximations contain the elements which could belong to upward and downward union of classes. The decision table generates in this way decision rules that can be certain, possible and approximate. Certain rules follow from lower approximations; possible rules are related to upper approximations while approximate rules refer to boundary regions, that is regions defined as set difference between P -lower ($\underline{P}$) and P -higher ($\bar{P}$) approximations with respect to upward union of classes $Cl_t^{\geq}$ where $P \subseteq C$:

$$\underline{P}(Cl_t^{\geq}) = \{x \in U: D_P^+(x) \subseteq Cl_t^{\geq}\} \quad \bar{P}(Cl_t^{\geq}) = \{x \in U: D_P^-(x) \cap Cl_t^{\geq} \neq \emptyset\}.$$

Likewise, P -lower and P -upper approximations of $Cl_t^{\leq}$ with respect to $P \subseteq C$ can be defined. The resulting rules are then ordered with respect to classification measures (see [7] for more details).

4. Main outcomes of the research

The numerical values of the set of indices we consider were collected in [1]. We created a "Hybrid" information system, considering the original numerical values for what concerns the conditional attributes, while the decision attributes were grouped into categories that allow a clearer interpretation of the results and less “granular” results [8]. In the following we discuss on the attributes that lead to detecting problematic merger and to the sanctioning of cartels. The below reported decision rules are obtained using software jMAF for Dominance-Based Rough Set Data Analysis [5].

Study of the Probability of Problematic Merger (PPM)

In Table 1 we report the rules which posses higher support with at least a Coverage of 0.40 (the only exception is rule 7, with a rather low Coverage of 0.13, which is reported since it allows some discussion on asymmetry). Observing the results, the following considerations can be made.

CONCENTRATION - Conditional attributes that describe market concentration are the most frequent in the detected rules. In particular the price to cost margin and index C4 seem to contain important information. Index HHI appears to be quite less informative; this is probably due to the fact that it takes into account only the top four largest companies in terms of market share [9]. Rules 2, 4, 5, and 6, suggest that high concentration implies high PPM. Among the sectors that support rules 2, 5 and 6, we can identify tobacco and pharmaceuticals, which have large sunk costs at market entrance.

Table 1. Main rules obtained concerning the probability of problematic merger (PPM).

Rule	IF	THEN	Support	Certainty	Coverage
1	Company size ≤ 13.69	PPM $\leq$ medium	13	0.93	0.87
2	C4 ≤ 19.61	PPM $\leq$ medium	10	1	0.67
3	Import penetration ≤ 19.6	PPM $\geq$ medium	6	1	0.40
4	HHI ≥ 210 & Import penetration ≤ 37.76	PPM $\geq$ medium	6	1	0.40
5	Price-cost margin ≥ 8.39 & Company size ≥ 14.58	PPM $\geq$ high	5	1	0.71
6	Price-cost margin ≥ 11.51 & C4 ≥ 31.44	PPM $\geq$ high	3	0.75	0.43
7	Asymmetry ≤ 17.75	PPM $\geq$ medium	2	1	0.13

ENTRY - Rule 1, which has the largest support (13 manufacturing sectors out of 22), suggests that a low company size (which is related to an easy entry) implies a not high PPM. Rule 3 suggests instead, that a low import penetration, which corresponds to high import barriers, is related to a high PPM.

STABILITY – The information power of the conditional attributes that characterize the stability of the market appears to be rather low. The variance on the import penetration does not appear at all in the extracted rules, while the variance of the market size appears only once (for the non-metallurgical industry). This confirms the intuition that, although the literature identifies stability of the market as critical to collusion [6], prior knowledge of this feature does not affect very much the propensity of a sector toward potentially problematic mergers.

SYMMETRY - The asymmetry index appears only once among the extracted rules (rule 7) and the sectors that support this rule are textiles and rubber where a new threshold-value for the middle class appears. We can conclude that the information about the asymmetry between companies of a manufacturing sector does not have a strong causal link with the outcome of the merger issue.

MANUFACTURING SECTORS - The sectors with a propensity to high problematic merger are those of tobacco and pharmaceutical industries, and the chemical industry. The size of concentration appears as an important signal (rules 5 and 6) like the presence or not of entry barriers (rules 1 and 3).

Study of Sanctioned Cartels (SC)

The rules extracted in this case are all certain (i.e., certainty=1). In Table 2 we report the 6 most supported rules; again, we can deduce the following considerations.

CONCENTRATION - The measures of concentration (linked to high HHI, C4 and price-cost margin) appears to provide useful information since it appears frequently in the extracted rules (rules 1, 2, 3, 5). Often the information on concentration is linked to symmetry and stability (rules 2, 3, 5). We can conclude that high concentration implies high SC.

ENTRY – In rules 1 and 4 the link of entry in the market with cartel creation is supported by firm size and not by the penetration of imports. Size and penetration of imports appear only in rules 2, 3, 4. The negative effects of barriers to the entry, i.e., the increase in market share and therefore concentration, appear to be better explained by the indicators that consider concentration itself.

STABILITY – The variability in the import penetration appears to be more relevant than the variability of the market size in this context. In fact, low variability in import penetration is linked to high SC (rules 2, 3, 6).

Table 2. Main rules obtained concerning the sanctioned cartels (SC).

Rule	IF	THEN	Support	Certainty	Coverage
1	Company size ≥ 3.0 & price-cost margin ≥ 9.28	SC $\geq$ medium	8	1	0.53
2	HHI ≥ 397 & Import penetration variance ≤ 260.91	SC $\geq$ medium	8	1	0.53
3	C4 ≤ 26.92 & Import penetration variance ≥ 77.84	SC $\leq$ medium	7	1	0.46
4	Market size variance ≥ 44.54 & Company size ≤ 1.41	SC $\leq$ low	4	1	0.57
5	C4 ≥ 38.36 & Asymmetry ≤ 25.28	SC $\geq$ high	4	1	0.57
6	Import penetration variance ≤ 44.39	SC $\geq$ high	3	1	0.43

SYMMETRY – Even if in Table 2, the asymmetry index attribute appears only in rule 5, it appears often in the whole set of rules of extracted rules, always indicating, as in rule 5, that a low asymmetry is related to high SC. A knowledge of this feature of the market thus, can be useful in determining cartels.

MANUFACTURING SECTORS - The analysis supports the claim that the manufacturing sectors most prone to the formation of cartels are involved with rubber and the manufacture of electrical equipment. For both, information is mainly provided by high concentration, symmetry and the variance of import. Low propensity to collusion is displayed by leather and wood industries and signaled by low concentration and low entry barriers.

5. Conclusion

The action of the European Commission is sometimes regarded as case-driven [10] and Antitrust intervention is often too delayed (the duration of undiscovered cartels fluctuates from 6 to 14 years [11]). Therefore, investing resources to monitor markets in which violations are more likely [12] would be helpful. The approach we suggest, provides a new way to evaluate the features of a manufacturing sector that can be considered as a premise of future infractions.

Concerning mergers, the most relevant feature appears to be the concentration of the market. Another aspect that the Authorities should take into account is related to the entry in the market: in fact, the size of the firm is a rel-

evant information with regard to mergers. Moreover, and it was unexpected, the results show that market stability and asymmetry appear to be less relevant for detecting collusion. The sizes of symmetry and concentration become significant, instead, when we consider cartel formation. Finally, as regards the stability of the market, it can be said that this kind of information appears to be of modest relevance in order to detect collusion [13].

It would be interesting to undertake a similar research, including specific information on the operating companies, in addition to the characteristics of the sector, allowing to take into account the effect on anti-trust violations in a competitive market.

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