CARTELS AND TACIT COLLUSION
Advanced Industrial Organization 1

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ENSAE 3A / Master APE (2009-2010)
Outline

1. Introduction
2. Basic Theoretical Model
3. Factors Facilitating Collusion
4. Informational issues
5. Cartels and Competition Policy
Fighting cartels is at the core of competition policy.

### Biggest European Cartel Cases

<table>
<thead>
<tr>
<th>Year</th>
<th>Industry</th>
<th>Fine (m€)</th>
<th>Fines (m€)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2008</td>
<td>Car Glass</td>
<td>1384</td>
<td>Saint-Gobain (896), Pilkington (370)</td>
</tr>
<tr>
<td>2009</td>
<td>Gaz</td>
<td>1106</td>
<td>E.O.N (553), GDF-Suez (553)</td>
</tr>
<tr>
<td>2007</td>
<td>Elevators</td>
<td>992</td>
<td>ThyssenKrupp (480)</td>
</tr>
<tr>
<td>2001</td>
<td>Vitamins</td>
<td>790</td>
<td>Hoffmann-LaRoche (462)</td>
</tr>
<tr>
<td>2007</td>
<td>Switchgear</td>
<td>750</td>
<td>Siemens (396)</td>
</tr>
</tbody>
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### In France

<table>
<thead>
<tr>
<th>Year</th>
<th>Industry</th>
<th>Fine (m€)</th>
<th>Fines (m€)</th>
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<tbody>
<tr>
<td>2009</td>
<td>Temporary Work</td>
<td>94</td>
<td>Manpower (42), Adecco (32)</td>
</tr>
<tr>
<td>2008</td>
<td>Steel</td>
<td>575</td>
<td>ArcelorMittal (309), KDI (169)</td>
</tr>
<tr>
<td>2005</td>
<td>Mobiles</td>
<td>534</td>
<td>Orange (256), SFR (220)</td>
</tr>
</tbody>
</table>
What is Collusion?

Explicit or Tacit Collusion

- **Collusion** $\equiv$ collusive agreement that should be outlawed
- **Collusion** $\approx$ high prices, prices above the “competitive” level
- **Explicit Collusion**: firms act through an organized cartel
- **Tacit Collusion**: firms maintain high prices in a non-cooperative way
**Reading List**


Prisoners’ Dilemma

<table>
<thead>
<tr>
<th></th>
<th>$P_1$</th>
<th>$P_2$</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>C</strong></td>
<td>(2,2)</td>
<td>((-1,3))</td>
</tr>
<tr>
<td><strong>NC</strong></td>
<td>(3,-1)</td>
<td>((0,0))</td>
</tr>
</tbody>
</table>

- Unique Nash Equilibrium: No cooperation (strictly dominant strategies), zero payoffs.
- Cooperation is Pareto dominant
- *When is cooperation possible?*
The Main Ingredients of Collusion

- Suppose the game is **repeated** over time

- Players could agree to cooperate (and obtain higher payoffs)

- However, at any stage, a player would have a strong incentive to **deviate**

- In order for cooperation to be sustainable, the rival player needs to be able to **detect the deviation** . . .

- . . . and to enforce the “agreed” **(credible) punishment**
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(Tacit) Collusion in a General Framework

The important variables

1. $\pi^C$ the per-firm collusive profit
2. $\pi^D$ the profit of the deviating firm
3. $\pi^{NC}$ the per-firm non-cooperative profit (i.e. the equilibrium payoff in the Nash-equilibrium of the static game)
4. $\delta$ the discount factor

Idea: Collusion is a SPNE if

The short term gain of deviation is lower than the long term loss (punishment).
Unique Subgame Perfect Nash Equilibrium

Backward Induction: Start with the last period

- Last stage $\iff$ Static Game
- Unique Nash Equilibrium, without cooperation.

Penultimate Period

- Last period profits are not affected by the history
- Penultimate stage $\iff$ Static Game
- Unique Nash Equilibrium, without cooperation.

Unique SPNE

NE of the static game repeated over time. No cooperation.
Multiple Subgame Perfect Nash-Equilibria

**General Result**

- The NE of the static game is always a SPNE of the infinitely repeated game.
- No cooperation is always a SPNE.

**Formally**

- In an infinitely repeated game, strategies are complex.
- History: \( h_t = (s_1,0, s_2,0; \ldots; s_1,t-1, s_2,t-1) \)
- Choice at \( t \) depends on \( h_t \).
Cooperation (collusion) as a SPNE?

Question
- Can collusion be an equilibrium?
- Are there other equilibria?

Focus on particular equilibria with **trigger strategies**
- If nobody has deviated in the past, each player chooses to cooperate at date \( t \)
- If somebody deviates from the collusive path at date \( t - 1 \), then from \( t \) onwards players revert to the non-cooperation solution

*Trigger strategies or reversal to Nash*
Existence condition for a collusive equilibrium

**Short-term gain (at \( t = 0 \))**

- Deviation: \( \pi^D \)
- Collusion: \( \pi^C \)
- **Gain:** \( \pi^D - \pi^C \)

**Long Term Loss**

- Deviation: \( \sum_{t=1}^{+\infty} \delta^t \pi^{NC} = \frac{\delta}{1-\delta} \pi^{NC} \)
- Collusion: \( \sum_{t=1}^{+\infty} \delta^t \pi^C = \frac{\delta}{1-\delta} \pi^C \)
- **Loss:** \( \frac{\delta}{1-\delta} (\pi^C - \pi^{NC}) \)
Basic Theoretical Model  
Infinitely Repeated Game

Tradeoff Today / Future: Summary

### Collusion as an equilibrium iff loss > gain

- **Loss:** \( \frac{\delta}{1-\delta} (\pi^C - \pi^{NC}) \)
- **Gain:** \( \pi^D - \pi^C \)

\[
\frac{\delta}{1-\delta} (\pi^C - \pi^{NC}) > \pi^D - \pi^C \iff \delta > \tilde{\delta} \equiv \frac{\pi^D - \pi^C}{\pi^D - \pi^{NC}}
\]

### Conclusion

If firms are patient enough \( (\delta > \tilde{\delta}) \) there exists a subgame perfect Nash equilibrium (with trigger strategies) with collusion.
Price Competition with Perfect Substitutes

Bertrand Competition between $n$ firms

- $\pi^{NC} = 0$
- $\pi^C = \frac{\Pi^M}{n}$
- $\pi^D = \Pi^M (-\varepsilon)$

Discount Factor Threshold

$$\tilde{\delta} = \frac{\Pi^M - \frac{\Pi^M}{n}}{\Pi^M - 0} = \frac{n - 1}{n} = 1 - \frac{1}{n}$$
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Factors Facilitating Collusion

1. Concentration
2. Entry
3. Cross-ownership
4. Regularity and frequency of orders
5. Evolution of demand
6. Symmetry
7. Multi-market contacts
8. Excess Capacities
9. **Price transparency / Exchange of information**
10. Antitrust enforcement
11. Leniency programs
Concentration and Entry

Concentration

- Many identical firms under price competition
- The gains from collusion are smaller the larger the number of firms
- However, non-cooperation and deviation profits do not depend on the number of firms
- **Collusion is easier to sustain when the number of players is smaller**

Entry

- The easier the entry into an industry, the more difficult to sustain collusive prices
- If the entrant behaves aggressively, the incumbent firms (cartel members) will have to react by lowering prices
- If the entrant is willing to join the cartel, then collusion is more difficult as the number of firms increases
Factors Facilitating Collusion

Structural Factors

Cross-ownership

Symmetric case with 2 firms

- Two identical firms competing in prices, each owning a share $\alpha$ of the rival firm
- $\pi^{NC} = 0$
- $\pi^C = \frac{(1+\alpha)\Pi^M}{2}$
- $\pi^D = \Pi^M + 0$
- Therefore: $\tilde{\delta} = \frac{\Pi^M - (1+\alpha)\Pi^M}{\Pi^M - 0} = \frac{1-\alpha}{2}$

Conclusion

Collusion is easier when firms own shares of their rivals
Evolution of Demand

Stochastic Demand
- At each period, demand can be either high \( d_H \) or low \( d_L \)
- Demand shocks are i.i.d.
- Equal probabilities
- We denote by:
  - \( \Pi^M_H \) and \( \Pi^M_L \) the corresponding monopoly (collusive) profits
  - \( \Pi^M = \frac{\Pi^M_L + \Pi^M_H}{2} \) the expected monopoly profit

Collusion and deviation expected profits (state \( s = H, L \) at \( t \))
- **Collusion:** \( \frac{\Pi^M_s}{2} + (\delta + \ldots + \delta^t + \ldots) \frac{\Pi^M}{2} = \frac{\Pi^M_s}{2} + \frac{\delta \Pi^M}{2(1-\delta)} \)
- **Deviation:** \( \Pi^M_s + (\delta + \ldots + \delta^t + \ldots)0 = \Pi^M_s \)
Collusion is sustainable whenever:

\[
\frac{\Pi^M_s}{2} + \frac{\delta \Pi^M}{2(1 - \delta)} > \Pi^M_s \iff \frac{\delta \Pi^M}{1 - \delta} > \Pi^M_s \iff \delta > \tilde{\delta}_s \equiv \frac{\Pi^M_s}{\Pi^M + \Pi^M_s}
\]

**Conclusion**

- Note that \(\Pi^M_H > \Pi^M_L \iff \tilde{\delta}_H > \tilde{\delta}_L\)
- Collusion is more difficult to sustain when demand is high
- Short term gains are higher when demand is high
- Long term (expected) losses are the same in the two states
Growing and Declining Industries

Evolving industries

- Demand is certain but changes over time
- Monopoly profit in period $t$ is given by $\theta^t \Pi^M$

Conclusion

- We then have: $\tilde{\delta}(\theta) = \frac{1}{2\theta}$
- Collusion is easier to sustain in growing industries ($\theta > 1$) than in declining industries ($\theta < 1$)
- At $t = 0$, short term gains are identical but long term losses are higher when future demand is expected to be higher
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**Identifying Deviations to Sustain Collusion**


- **Stigler** (*JPE*, 1964): Collusion would break down because of secret price cuts

- **Green and Porter**: If actual prices are not observable, collusion is more difficult to sustain, but could still arise in equilibrium.

- With secret price cuts, a firm does not know if a low demand is due to a price cut (deviation from the collusive path) or a negative demand shock (on the collusive path)

- **Idea**: trigger a price war (reversal to Nash) but for a limited number of periods

- **A period of low prices (price war) does not necessarily mean that there is no collusion**

A simplified version

- $n$ identical firms selling a homogenous product.
- Price competition.
- Uncertain demand shocks (i.i.d over time): demand can be either low ($D(p) = 0$ for any price $p$) with probability $\alpha$ or high ($D(p) > 0$).
- Firms **never** observe the actual state of demand.
- Firms **do not** observe prices set by rival firms.

→ A firm facing a zero demand does not know whether it is:
  1. Because the demand was low.
  2. Because some rival(s) undercut its price.
Temporary Price Wars

Temporary Price Wars in Equilibrium

- Each firm sets the collusive price $p^m$ at the outset of the game.
- It continues to do so as long as all firms have positive demands.
- When at least one firm observes zero demand (which is assumed to be common knowledge), the industry enters the “punishment phase”: each firm sets price equal to marginal costs for the next $T$ periods.
- Collusive phases restarts at the end of the “price war”.

Some notations

- $V^+$ represents the present discounted value of a firm in each period which belongs to the collusive phase.
- $V^-$ represents the present discounted value of a firm at the start of the punishment phase.
Temporary Price Wars

Relationships between $V^+$ and $V^-$

- The following two equations hold:

$$V^+ = (1 - \alpha) \left( \frac{\pi(p^m)}{n} + \delta V^+ \right) + \alpha \delta V^- \quad \text{and} \quad V^- = \delta^T V^+$$

- This yields:

$$V^+ = \frac{(1 - \alpha) \frac{\pi(p^m)}{n}}{1 - (1 - \alpha) \delta - \alpha \delta^T+1} \quad \text{and} \quad V^- = \delta^T V^+$$

Collusion is possible as long as

$$V^+ \geq (1 - \alpha) \left( \pi(p^m) + \delta V^- \right) + \alpha \delta V^-$$

i.e. (after some computation . . .)

$$[\delta n(1 - \alpha) - (n - 1)] + \delta^{T+1} (\alpha n - 1) \geq 0 \quad (1)$$
When is collusion feasible?

Three possible cases

1. If $\alpha < \alpha_1 \equiv 1 - \frac{n-1}{n\delta}$ (which may be impossible if $\delta$ is too small or $n$ is too large), then the left term is positive while the right term is negative. There may therefore exist a values of $T$ that satisfy (1).

2. If $\alpha_1 \geq \alpha < \alpha_2 \equiv \frac{1}{n}$, both terms are negative and equation (1) never holds.

3. If $\alpha \leq \alpha_2$, the left term is negative while the right term is positive. But:

   $$n - 1 - \delta n(1 - \alpha) = (n - 1)(1 - \delta) + \delta(\alpha n - 1) > \delta(\alpha n - 1) > \delta^{T+1}(\alpha n - 1),$$

   and thus equation (1) cannot hold.

Collusion is feasible whenever:

$$\alpha < \alpha_1 \quad \text{and} \quad T \leq T^{\text{min}} \equiv (\ln \delta)^{-1} \ln \left( \frac{\delta n(1 - \alpha) - (n - 1)}{\delta(1 - \alpha n)} \right)$$

(2)
Some Conclusions

- Temporary price wars may help sustaining collusion when deviations are not easily observable.

- Collusion is not feasible if the probability to be in the bad state is too high.

- The “punishment period” needs to be longer when the probability of the being in the bad state increases (i.e. $\partial T^{\text{min}} / \partial \alpha > 0$).
Information Exchange

Past (or Present) Prices and Quantities

Exchanging information about past (or present)

- (Individual) prices and/or quantities
- Aggregate demand

helps collusion.

- French mobile phone cartel (€(534m) fines for Orange, SFR and Bouygues Telecom)

Future Prices

Private (“cheap talk”) or public (credible) announcements about future prices help to sustain collusion

- Airline Tariff Publishers (ATP) in the US
- British Airways (fuel surcharges)
- Collusion in multi-unit auctions
Other Practices that Facilitate Collusion

**Most-Favored Nation Clauses**

- Also called *price matching clauses*
- Way of exchanging information through consumers
- Note that price comparison engines (*Kelkoo, ...*) or online agencies co-owned by rivals (*Expedia, Opodo, Orbitz, ...*) can also serve the same purpose.

**Resale Price Maintenance**

- Jullien and Rey (*RAND Journal of Economics, 2007*)
- Resale price maintenance prevents retailers from reacting to local demand shocks.
- Helps to sustain collusion among producers since deviations are more easily detected.
2 differentiated producers, selling through different retailers.
Price competition between retailers.

**Uncertain local demand shocks** (i.i.d over time and across products):

\[ D_i (p_i, p_j) = d + \varepsilon_i - p_i + \sigma p_j, \text{ with } \varepsilon_i \sim U ([-\Delta, \Delta]). \]

The exact terms of the contracts between a manufacturer and its retailer is never observed by the rival manufacturer.
Retail prices are observed at the end of each period.
Contracts consists of two-part tariffs (of the form \( T_i(q) = w_i q + A_i \)) and (only allowed) an imposed retail price.
A new retailer at each period (⇔ myopic retailers + no long term contracts). This implies that retailers are in essence passive.
Equilibrium of the Static Game

Timing of the stage game

1. Producers make take-it-or-leave-it offers.
2. Retailer $R_i$ observes $\varepsilon_i$ and chooses its retail price $p_i$ (unless RPM is used).
3. Demands and profits are realized.

Retailer $R_i$’s pricing decision

$$p_i = \arg \max_p (p_i - w_i) \left( d + \varepsilon_i - p_i + \sigma p_j^e \right)$$

$$= \frac{d + \varepsilon_i + w_i + p_j^e}{2} = \frac{d + w_i + p_j^e}{2} + \frac{\varepsilon_i}{2} = p_i^e + \frac{\varepsilon_i}{2}$$
Equilibrium of the Static Game

Retailer $R_i$’s expected profit

\[
ER_i(w_i) = E \left( \left( p_i^e + \frac{\varepsilon_i}{2} - w_i \right) \left( d + \varepsilon_i - \left( p_i^e + \frac{\varepsilon_i}{2} \right) + \sigma p_j^e \right) \right) \quad (3)
\]

Manufacturer $M_i$’s expected profit

\[
EM_i = E \left( w_i \left( d + \varepsilon_i - \left( p_i^e + \frac{\varepsilon_i}{2} \right) + \sigma p_j^e \right) \right) + ER_i
\]
\[
= E \left( \left( p_i^e + \frac{\varepsilon_i}{2} \right) \left( d + \varepsilon_i - \left( p_i^e + \frac{\varepsilon_i}{2} \right) + \sigma p_j^e \right) \right)
\]
\[
= p_i^e \left( d - p_i^e + \sigma p_j^e \right) + \frac{1}{4} E \left( \varepsilon_i^2 \right) = \pi \left( p_i^e, p_j^e \right) + v(\Delta).
\]

\[\equiv \pi(p_i^e, p_j^e)\]

\[\equiv v(\Delta) = \frac{\Delta^2}{12}\]
Equilibrium of the Static Game

Expected equilibrium prices:

\[ p_i^e = \arg \max_p \pi(p, p_j^e) = \frac{d + \sigma p_j^e}{2} \implies w_1^N = w_2^N = 0. \]

“Competitive” retail prices:

\[ p_1^N = p_2^N = p^N \equiv \frac{d}{2 - \sigma}. \]

Manufacturer’s expected profits:

\[ EM_1^N = EM_2^N = \Pi(p^N) + \nu(\Delta). \]

RPM in the Static Game

If \( M_i \) imposes a retail price \( p_i \), its expected profit is only \( \pi(p_i, p_j^e) \).

It thus loses the benefit of retail prices that adjust to local demand shocks (i.e., loses \( \nu(\Delta) \)).

RPM is never used in the static game.
Scope for Collusion

**Definition**

- Collusive prices:
  \[
  \left( p_1^M, p_2^M \right) = \arg\max_{(p_1, p_2)} \left( \pi(p_1, p_2) + \pi(p_2, p_1) + 2\nu(\Delta) \right).
  \]
- Recall: \( \Pi(p) = \pi(p, p) \).

**Assumptions**

\[
k \leq \Pi(p^N) + \nu(\Delta) \leq \Pi(p^M)
\]

- **First part:** \( k \) is a per-period fixed cost paid by the manufacturers. The assumption ensures that selling is indeed profitable.
- **Second inequality:** There is scope for collusion (under RPM).
Collusion without RPM

- Denote by \( \Pi^F \) (resp. \( \Pi_F \)) the maximal (resp. minimal) average per-period profit that can be obtained in a fully symmetric equilibrium, and by \( s^F \) (resp. \( s_F \)) the corresponding strategy.

- **Most profitable strategy:** the strategy \( s^F \) is of the form “charge an expected price equal to \( p^F \) as long as past retail prices belong to \([p^F - \frac{\Delta}{2}, p^F + \frac{\Delta}{2}]\), and \( s_F \) otherwise.

---

**Necessary Condition 1: Perfect Detection**

\[
\max_p \pi(p, p^F) - \Pi(p^F) \leq \frac{\delta}{1 - \delta} \left( \Pi(p^F) + v(\Delta) - \Pi_F \right)
\]  
(PD)
Collusion without RPM

Necessary Condition 2: Small Deviations

- Small deviations are less easily detected.
- Indeed, if \( p \in [p^F - \Delta, p^F + \Delta] \), the deviation may be undetected.
- Therefore, the following condition must also hold for any \( p \in [p^F - \Delta, p^F + \Delta] \):

\[
\pi(p, p^F) - \Pi(p^F) \leq \frac{\delta}{1 - \delta} \frac{|p - p^F|}{\Delta} \left( \Pi(p^F) + v(\Delta) - \Pi_F \right) \quad \text{(SD)}
\]

Collusion without RPM

Most profitable collusive equilibrium is such that \( p^F \) maximizes \( \Pi(p^F) + v(\Delta) \) subject to (PD) and (SD).
When RPM is used on the collusive path, all deviations are automatically detected.

**Necessary and sufficient condition**

$$\max_p \pi (p, p^{RPM}) + v(\Delta) - \Pi (p^{RPM}) \leq \frac{\delta}{1 - \delta} \left( \Pi (p^{RPM}) - \Pi_{RPM} \right)$$

**Collusion with RPM**

Most profitable collusive equilibrium is such that $p^{RPM}$ maximizes $\Pi (p^{RPM})$ subject to (RPM).
Comparing without / with RPM

**Constraints (PD) and (RPM)**

\[
\max_p \pi(p, p^F) + \nu(\Delta) + \frac{\delta}{1 - \delta} \Pi_F \leq \frac{1}{1 - \delta} \left( \Pi(p^F) + \nu(\Delta) \right) \quad \text{(PD)}
\]

\[
\max_p \pi(p, p^{RPM}) + \nu(\Delta) + \frac{\delta}{1 - \delta} \Pi_{RPM} \leq \frac{1}{1 - \delta} \Pi(p^{RPM}) \quad \text{(RPM)}
\]

**RPM**

- Facilitates collusion:
  - \( \Pi_{RPM} < \Pi_F \), i.e., harsher punishments.
  - Perfect detection for all deviations (no equivalent to (SD)).

- But yields lower expected profits for identical average prices:
  - additional term \( \nu(\Delta) \) in (PD).
Welfare Effect and Conclusions

- **There exist values of the parameters** (especially for intermediate values of the discount factor), **for which RPM would be used** by firms to facilitate collusion.

- Retail prices are then higher on average.

- But they no longer react to local shocks.
  - With retail cost shocks, rigid prices are bad for consumers and total welfare.
  - But for **local demand shocks**, consumers prefer rigid prices.

- Overall, ambiguous effect with local demand shocks. But, in the linear demand example, **RPM can only be bad for welfare if** $\sigma \leq \frac{2}{3}$. 
Detecting Collusion

- Need for hard evidence (minutes, memo, ...)
- What is a collusive price?
  - Uncertainty about price or demand
- Problems using historical price data (i.e. price evolution)
  - “Price parallelism” can be explained by common shocks
  - Unless “extreme parallelism” (e.g. Dyestuffs)
- Facilitating practices can only be stopped but not used to find firms guilty
- Tacit (*rk: requires coordination*) or explicit collusion?
Deterring Collusion (Ex ante policies)

- **Heavy punishment when detected**
  - Expected fines (fine x probability of audit), damages to “injured” parties, prison sentences

- **Black list of facilitating practices**
  - Exchange of information about individual prices and/or quantities
  - Best price clauses
  - Minority shareholdings
  - ...

- **Auction design**
Leniency programs

- As used against organized crime in order to obtain hard evidence

- **Leniency** ≡ immunity from fines and/or prison
  - Breaking trust within the cartel (preventing cartel formation but also detecting cartel more easily)
  - Saving resources for antitrust authorities

- **Ambiguous theoretical effects on deterrence**
  - Reduces the gains from collusion
  - Reinforces the possibility of punishment

- Optimal leniency programs
  - See Spagnolo (mimeo, 2000), Motta and Polo (IJIO, 2003), . . .
  - Automatic full immunity (from fines but also damages, possibly even rewards) even after an investigation has started
Leniency programs in the U.S.

- First introduced in 1978 but redesigned in 1993
- Automatic immunity from fines and prison sentences
  - Provide hard evidence before an investigation has begun
  - First arrived only and conditional on leaving the cartel
- Discretionary leniency for evidence provided once the investigation has been launched
- Number of applicants rose from 1 a year to 2 a month
Leniency program in the EU

- First introduced in 1996 (inefficient) but redesigned in 2002

- Complete immunity from fines
  - Provide hard evidence even after investigation has begun
  - First arrived only but discretionary partial immunity for second and third arrived if it helps convict firms
  - Not for the ring-leader

- Recent case (November 2006): Producers and traders of synthetic rubber fined a total of €519m
  - *Bayer* applied for leniency in December 2002 (was granted full immunity from a €204m fine)
  - Once the investigation had started, *Dow* applied for leniency (was granted partial immunity - 40% - from a €107m fine)
  - *Eni* (€272m), *Shell* (€160m), *Unipetrol* (€17.6m) and *Trade-Stomil* (€3.8m) were also involved