Macroeconomic Effects of Market Structure Distortions

Flavien Moreau and Ludovic Panon*

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Abstract

This paper develops a quantitative framework with heterogenous firms and endogenous markups to assess the macroeconomic implications of sectoral distortions to market structure, namely the existence of cartels. The direct negative welfare impact of cartels is compounded by increases in non-colluders' prices (umbrella pricing). We then build a dataset on firm- and sector-level collusive cases constructed from the textual analysis of two decades of antitrust decisions taken by the French Competition Authority that we combine with exhaustive administrative firm microdata to test the predictions of our model.

1 Introduction

What are the effects of competition distortions on resource allocation and aggregate welfare? How do competitors respond to cartels? How much scope is there for competition policy to improve on macroeconomic outcomes? The answers to these questions are important but have been elusive. In an influential article, Harberger (1954) suggested that the inefficiency costs generated by monopolies in the U.S. are about a tenth of a percent. His method used a simple calibration and aggregate data to estimate the sizes of the 'Harberger triangles'. In contrast, we analyze two

*Flavien Moreau: Department of Economics, UCLA. Ludovic Panon: Department of Economics, Sciences Po

decades of antitrust decisions taken by the French Competition Authority and examine their impacts at the firm and sectoral level, as well as on the aggregate French economy. Our methodology uses textual analysis tools to build a database on collusive cases from the French Competition Authority decisions. We then combine these data with administrative firm-level data. To understand the aggregate impact of collusive behaviors on the whole economy, we develop a new framework of collusive practices based on the heterogenous firm model of Atkeson and Burstein (2008).

We infer the distortion to competition from the information contained in the sentencing decision. Merging our firm-level database on collusive cases with the universe of French firms allows us to measure the impact of anti-competitive practices on firms targeted by the investigation and their competitors. We develop a macroeconomic model where firms set their markups endogenously and we analyze the impact of colluding on the distribution of markups in the overall economy.

Our model builds on Atkeson and Burstein (2008) in that a finite number of firms compete with each other à la Cournot and where demand is CES.[1] This model generates variable markups as a firm's demand elasticity is a function of its market share: firms with a relatively high market share face less elastic demand which allows them to charge higher markups. We extend this framework by introducing the possibility for firms to form a cartel. To do so, we embed a cross-ownership model of firms à la Azar et al. (2018a) into the Atkeson and Burstein (2008) framework. In our model, a colluder maximizes its profits by internalizing the effect of its decision (quantity or prices) on other cartel members: the key advantage of our framework is that our results on the effects of collusion on firm-level outcomes and welfare can be easily simulated. In addition to its simplicity, this model delivers empirical predictions that we plan to take to the data using our newly created firm-level database on anti-competitive conduct.

On the theoretical side, we find that both colluding and non-colluding firms increase their markups and prices and that the output of the sector in which cartels operate decreases. We are yet to derive some welfare results. On the empirical side, the use of micro data permits identifying the effect of collusive behaviors on market shares and employment, controlling for a firm's revenue productivity. We find that firms operating in sectors where at least one firm is behaving anti-competitively lose market shares but that the effect is in fact positive for the firms that collude.

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[1]We consider a variant of the model with price competition à la Bertrand.

However, larger firms are more likely to join a cartel so that our estimates might suffer from sample selection bias. We therefore plan to use propensity score matching methods to correct for this source of endogeneity and identify a causal effect of collusion on firm-level outcomes.

The paper proceeds as follows. In Section 2, we review the literature and summarize important contributions. In Section 3, we introduce our model. Section 4 describes our data while our empirical framework is detailed in Section 5. Our empirical results are presented in Section 6. Finally, Section 7 concludes.

2   Related Literature

In this section, we review the key contributions on which our paper builds.

Market Structure in Macroeconomics.   Market structure is the object of a renewed interest in macroeconomics.[2] Recent work connects increasing concentration in markets with the fall of the labor share (Autor et al., 2017) or the increase in markups (De Loecker and Eeckhout, 2017). A burgeoning literature also examines the monposony effects of mergers (Azar et al., 2017, 2018b). In our setting, the labor market is perfectly competitive and we abstract from these welfare effects. Finally, Edmond et al. (2018) assess the role of markups in generating potentially large distortions in the economy. Our paper, on the other hand, focuses on a specific type of distortion arising from anti-competitive practices encompassing collusions and abuse of dominant positions. We can therefore precisely gauge the source of welfare loss arising from increases in concentration and/or markups.

Theory of Cartels.   The theoretical literature on cartels is extremely rich and we do not claim to provide an exhaustive list of works. Some of these studies are summarized in Tirole (1988). The seminal contribution of Stigler (1964) disseminated the idea that cartels are by their very nature unstable. Indeed, cheating incentives are strong and undermine the existence and stability of collusive cases. Much more recent is the work by Bos and Harrington (2010) who show that larger firms might have a strong incentive to form a cartel with smaller firms being able to increase

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[2]This renewed interest of market structure for macroeconomic policy is exemplified by the title of the 2018 Jackson Hole's conference: "Changing Market Structure and Implications for Monetary Policy".

their prices as the larger firms' prices serve as an umbrella.[3] Compared to these studies, our theoretical model is more tractable as we can easily estimate and simulate it, and derive empirical predictions to take to the data.

Empirical Analysis of Cartels. The empirical study of cartels and their impact on welfare is limited by the fact that secret agreements are by definition hard to observe. However, it is possible to focus on specific cartels operating in particular industries. Levenstein and Suslow (2006) summarize findings in the literature: the picture that emerges is not that predicted by Stigler (1964). Indeed, on average, cartels are not short-lived and antitrust activity is a likely cause for cartel death (Levenstein and Suslow, 2011). In an interesting study, Symeonidis (2008) finds that *manufacturing industries* that were cartelized experienced slower labor productivity growth than those that were not. Our data is more disaggregated as we match information on anti-competitive firms to firm-level balance-sheet data. This allows us to assess the causal effect of collusive practices on firm-level outcomes.

3   Model

We develop a model in which heterogeneous firms choose their markups endogenously along the lines of Atkeson and Burstein (2008). The model allows for Cournot and Bertrand competition. The economy is made of a continuum of sectors, but in each sector, only a *finite* number of firms compete. The firms are therefore "large in their own sectors, but small in the economy as a whole" (Neary, 2003). In equilibrium, firms' markups are proportional to their market share. We extend this framework to allow groups of firms to form cartels. Collusion affects how firms take into account the impact of their production and pricing decisions on the sectoral output and price level. Colluding in our model is akin to cross-ownership, and produces similar competition distortions (Azar et al. (2018a)). Collusion unambiguously raises prices and is harmful to consumers.[4]

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[3]Another important paper is Selten (1973)'s work on the optimal number of cartel members.

[4]In the text, we solve the model under Cournot competition. See the Appendix for the version with Bertrand Competition.

3.1 Setup

We keep the demand side of the economy voluntarily stark in order to focus on the supply implications of the competition shocks. All the important economic decisions are made by the firms. An infinite-lived representative household maximizes a time-separable utility

$$\mathbb{E} \sum_{i=0}^{\infty} \beta^t \log \left[c_t^{\delta} (1 - l_t)^{1-\delta} \right]$$

The first order conditions for the household are standard and yield the familiar intra-temporal tradeoff between consumption and leisure:

$$\frac{1-\delta}{\delta} \frac{c_t}{1 - l_t} = \frac{W_t}{P_t} \tag{1}$$

For simplicity we drop the time subscript and focus on the stationary case. The production side of the economy consists in a continuum of sectors indexed by $i \in [0,1]$. Final consumption c is produced by a competitive firm that combines the outputs from all the sectors y_i with a CES technology with demand elasticity η:

$$c = \left[\int_0^1 y_i^{\frac{\eta-1}{\eta}} di \right]^{\frac{\eta}{\eta-1}} \tag{2}$$

The inverse demand function for each intermediate output from sector i is given by:

$$\frac{P_i}{P} = \left(\frac{y_i}{c} \right)^{-\frac{1}{\eta}} \tag{3}$$

where P, the price index for final consumption representing the "true cost of living", is an harmonic mean of the sectoral prices:

$$P = \left[\int_0^1 P_i^{1-\eta} di \right]^{\frac{1}{1-\eta}} \tag{4}$$

Each sector is populated by a finite number of firms K_i. Because each firm has a non-zero measure, its decisions have an impact on its competitors' decisions. Firms are "large in the small but small in the large" (Neary (2003)) *i.e.* they are "small" with respect to the economy but "big" in their sector. The output in sector i is a composite of the firms' outputs, combined with a CES technology with elasticity

parameter ρ:

$$y_i = \left[\sum_{k=1}^{K_i} (q_{ik})^{\frac{\rho-1}{\rho}} \right]^{\frac{\rho}{\rho-1}} \tag{5}$$

The price index in sector i is given by

$$P_i = \left[\sum_{k=1}^{K_i} (P_{ik})^{1-\rho} \right]^{\frac{1}{1-\rho}} \tag{6}$$

We make the following assumptions:

Assumption 1. *Goods are imperfect substitutes $\rho < \infty$*

Assumption 2. *Goods within sectors are more substituable than between sectors $1 < \eta < \rho$*

Assumption 3. *Firms play a static game of quantity competition (Cournot)*

Assumption 4. *The Productivity distribution is lognormal $\log z_{ik} \sim \mathcal{N}(0, \theta)$*

Several remarks are in order. While Assumption 1 is standard, Assumption 2 is crucial and guarantees that firms' markups are increasing in market shares (see equation (10)) . Assumption 3 can be replaced by Bertrand competition which does not alter our qualitative results. Assumption 4 is made in order to keep the quantitative exercise simple but is unimportant for the proof. We now solve the model. The *vectors* of prices $\mathbf{P}$ and quantities $\mathbf{q}$ maximize profits

$$\max_{P,q} \mathbf{P}.\,\mathbf{q} - \mathbf{q}.\,W.\left[\frac{1}{z_{ik}}\right]_{(i,k)} \tag{7}$$

subject to the inverse demand functions

$$\left(\frac{\mathbf{P}}{P}\right) = \left(\frac{\mathbf{q}}{y_i}\right)^{-\frac{1}{\rho}} \left(\frac{y_i}{c}\right)^{-\frac{1}{\eta}} \tag{8}$$

When the firms compete *à la Cournot*, the first order conditions imply that the equilibrium price is a markup over the marginal production cost

$$P_{ik} = \frac{\epsilon(s_{ik})}{\epsilon(s_{ik}) - 1} \frac{W}{z_{ik}} \tag{9}$$

where the firm-specific inverse elasticity is a linear combination of the within- and between- sector elasticities

$$\epsilon\left(s_{ik}\right) = \left[\frac{1}{\rho}\left(1 - s_{ik}\right) + \frac{1}{\eta}s_{ik}\right]^{-1} \tag{10}$$

where

$$s_{ik} = \frac{P_{ik}q_{ik}}{\sum_{j=1}^{K} P_{ij}q_{ij}} \tag{11}$$

is the market share of firm k in its sector i. Hence firm-level markups are heterogenous and endogenous, reflecting their comparative advantage within their sector. The attractive feature of equation (10) is that while the underlying productivity is not observed, the market shares are. Moreover, we can further eliminate the quantities q_{ik} and obtain a system only in terms of prices P_{ik}. To see this, from the CES assumption, the market shares can be expressed solely in terms of prices:

$$s_{ik} = \frac{\left(P_{ik}\right)^{1-\rho}}{\sum_{j=1}^{K}\left(P_{ij}\right)^{1-\rho}} \tag{12}$$

as quantities produced are related to prices from the inverse demand functions (3) and (8)

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\begin{aligned}
\frac{P_{ik}}{P} &= \left(\frac{q_{ik}}{y_i}\right)^{-\frac{1}{\rho}}\left(\frac{y_i}{c}\right)^{-\frac{1}{\eta}} \\
&= \left(\frac{q_{ik}}{y_i}\right)^{-\frac{1}{\rho}}\left(\frac{P_i}{P}\right)
\end{aligned} \tag{13}
$$

Another way of characterizing the equilibrium markups is to express them in terms of the prices selected by the firms. Firm k's markup is a harmonic mean of the two markups associated with the CES demand, $\mu_\rho \equiv \frac{\rho}{\rho-1}$ and $\mu_\eta \equiv \frac{\eta}{\eta-1}$, where the weights are given by the market share, or, equivalently, by the firm's price relative to the sectoral price index

$$\frac{1}{\mu\left(P_{ik}\right)} = \left[\frac{1}{\mu_\rho} + \left(\frac{1}{\mu_\eta} - \frac{1}{\mu_\rho}\right)\left(\frac{P_{ik}}{P_i}\right)^{1-\rho}\right] \tag{14}$$

Small firms care mostly about the substitution from firms in the same sector while larger firms internalize more the substitution effect between sectors. As the market share converges to 1, the relative price $\frac{P_{ik}}{P_i}$ converges to 1 from above and the markup tends to μ_η, the markup associated with the between-sector CES demand.

For quantitative explorations of the models, we follow the baseline calibration in Atkeson and Burstein (2008) and choose a within sector elasticity of 10. That is, most of the market power is coming from the lack of substitution between sectors. We test the robustness of our results to different values for the elasticity. See the appendix for numerical explorations with other values for these elasticities.

General equilibrium. The model's equilibrium is found by solving a fixed point problem in the aggregate variables $\{\mathbf{P}, W, c, l\}$. The solution procedure takes three steps: i) given $\mathbf{P}, c, W$ we solve for the prices and quantities in every sector; then ii) using, in each sector, the system of N_i nonlinear equations (9) by substituting the expression for the market share (12) ; finally iii) we check that the household's FOC (1) holds.

Aggregate Productivity and Markups. The quantity of final output can be represented by an aggregate production function $Y = A \cdot L$. As shown in Edmond et al. (2015), the first-order condition for the optimal use of labor and the labor market clearing condition yield:

$$A = \left[\int_0^1 \left(\sum_{k=1}^{K_i} \frac{1}{z_{ik}} \frac{y_{ik}}{Y} \right) di \right]^{-1}$$

where aggregate productivity A is a quantity-weighted harmonic mean of firm productivities.

The aggregate markup in the economy, defined as the ratio of the aggregate price over marginal cost $\mu_{agg} = \frac{P}{W/A}$, can similarly be expressed as a revenue-weighted harmonic mean of firm productivities

$$\mu_{agg} = \left[\int_0^1 \left(\sum_{k=1}^{K_i} \frac{1}{\mu_{ik}} \frac{p_{ik}y_{ik}}{PY} \right) di \right]^{-1}$$

Alternatively, the aggregate productivity can be written in terms of the firm productivities and their relative markups

$$A = \left[\int_0^1 \left(\frac{\mu_k}{\mu_{agg}} \right)^{-\eta} z_k^{\eta-1} di \right]^{\frac{1}{\eta-1}}$$

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where z_k is the sector-level productivity given by

$$z_k = \left[\sum_{k=1}^{K_i} \left(\frac{\mu_{ik}}{\mu_k} \right)^{-\rho} z_{ik}^{\rho-1} \right]^{\frac{1}{\rho-1}}$$

and $\mu_k = \frac{P_k}{W/z_k}$ is the sectoral markup. An increase in markup dispersion therefore reduces the allocative efficiency of the economy (Edmond et al., 2015).

3.2   Collusion as Cross-ownership

We now analyze the effects of collusion in this economy. In each industry, firms can form a cartel $\mathcal{C}$ of any size. When firms collude, their productivities are unchanged but they partially internalize the effects of their production and pricing decisions on the other members of the cartel. As a consequence the markups of the colluding firms rise and so does the price index of their sector. Collusion therefore harms consumers.

Formally, we model a cartel as a joint venture, or a nexus of cross-ownership patterns between its members. The effects of cartelization operate just as the distortions created by common ownership (O'brien and Salop, 1999; Azar et al., 2018a).

Consider an industry with K firms, with profit functions Π_k. We distinguish between financial ownership - a claim to a share of profits - and corporate control - the right to participate in the firm's production decisions -. Let β_{lj} denote the share of firm j owned by investor l and γ_{lj} the controlling share of firm j by investor l. The profits of investor l correspond to the portfolio $\pi^l = \sum_k \beta_{lk} \Pi_k$. The managers of firm k maximize a weighted average of the firm's shareholders portfolios, where the weights depend on the controlling shares

$$\tilde{\Pi}_k = \sum_l \gamma_{lk} \sum_j \beta_{lj} \Pi_j \tag{15}$$

After rearranging, and dividing by $\sum_l \gamma_{lk} \beta_{lk}$ we have[5]

$$\tilde{\Pi}_k = \Pi_k + \sum_{j \neq k} \frac{\sum_l \gamma_{lk} \beta_{lj}}{\sum_l \gamma_{lk} \beta_{lk}} \Pi_j \tag{16}$$

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[5]The rescaling is innocuous regarding the incentives once in the cartel but would matter for the decision to become a member of the cartel or not.

Suppose that there are $M_\mathcal{C}$ firms involved in the cartel. One can view the cartel as a joint-venture between these firms, whereby each retains full control of its production ($\gamma_{kk} = 1$) but cedes a share of its profits to the other members of the cartel.[6] If each firm keeps a share $\beta_{kk} = \frac{1}{1+(M_\mathcal{C}-1)}$ and gives a share $\beta_{jk} = \frac{\kappa}{1+(M_\mathcal{C}-1)}$ to each other members of the cartel, then the objective function of firm k is now

$$\tilde{\Pi}(q_k) = \Pi_k(q_k) + \kappa \cdot \sum_{j \in \mathcal{C} \setminus \{k\}} \Pi_j(q_k) \tag{17}$$

where the parameter κ controls the intensity of the collusion. The demand side of the market is unchanged and firms face the same inverse demand functions as in the baseline case $\frac{\tilde{P}_k}{P} = \left(\frac{q_k}{y}\right)^{-\frac{1}{\rho}} \cdot \left(\frac{y}{c}\right)^{-\frac{1}{\eta}}$.

Proposition 1 (Markups under Collusion). *The equilibrium price $\tilde{P}_k$ of a firm k that is part of a cartel is characterized by*

$$\tilde{P}_k = \tilde{\mu}_k \cdot \frac{W}{z_k}$$

where the own-elasticity depends on the combined market shares

$$\frac{1}{\tilde{\epsilon}_k} = \frac{1}{\rho} + \left(\frac{1}{\eta} - \frac{1}{\rho}\right) \left[s_k + \kappa \cdot \sum_{j \in \mathcal{C} \setminus \{k\}} s_j\right]$$

The result follows directly from the maximization problem. Colluding firms in the same sector internalize part of the effect of their decisions on the other cartel members' profits. Figure 2 illustrate the effect of collusion on the prices, markups, and market shares in the special case where $\kappa = 1$. In that case, firms in the cartel set uniform weights on all the cartel members' profits. As a result, they all choose the same markup. However, since they still have different productivities, their prices are different. The effect of collusion on the prices is clarified by the following proposition.

Proposition 2 (Sectoral Effects of Collusion). *Under collusion, i) The prices and markups of the colluding firms increase, ii) Some of the competitors who are not in the cartel increase their markups as well (Umbrella Pricing), and iii) Total output of the colluding sector decreases.*

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[6]Another view is to interpret price-fixing as a mutual agreement whereby cartel members share part of the *control* of their firms with other.

The first result follows from the fact that the colluding firms increase their markup, which raises their price. The first order effects of collusion on price is

$$d \ln P_k = \mu_k \left(\frac{1}{\eta} - \frac{1}{\rho} \right) \cdot \sum_{j \in \mathcal{C} \backslash \{k\}} s_j \cdot \kappa$$

ii). Competitors raise their price as well but less than the colluding firm. iii). Because the overall price index is higher, equation (3) implies that consumers will substitute away from this sector. The magnitude of substitution is controlled by the between sector elasticity η , which is close to 1 in the baseline case. See Appendix C for the detailed proof.

Cartels also dampen the pass-through of productivity gains to prices. This is because firms that experience an increase in productivity gain market shares and are able to charge higher markups in return thereby reducing the pass-through of productivity shocks to prices. This is even more pronounced for cartel members.

Proposition 3 (Imperfect Pass-through). *The pass-through of productivity gains to prices is smaller in the presence of a cartel. In particular, we have*

$$0 < \left\| \tilde{T} \right\|_\infty < \left\| T \right\|_\infty < 1$$

where $\tilde{T} \equiv - \left[I - \tilde{\Omega} \right]^{-1}$.

3.3 Aggregate Welfare

Because there is a continuum of sectors, in the current model, any increase of the price index in one single sector washes out in the aggregate. To build up an aggregate effect we consider deviations in a non-trivial measure of sectors, ϕ. We estimate ϕ by computing the weighted average of the sectors for which cases where found. We then simulate 1000 times the model where colluding firms are randomly drawn.

4 Data Description and Institutional Background

We assemble a new firm-level dataset on anti-competitive practices of French firms over the period 1994-2015. The information we collect relies on antitrust decisions taken by the French Competition Authority over the last 20 years. Cases span-

ning multiple countries are handled at the supra-national level by the Directorate-General for Competition of the European Commission. In this section, we describe important institutional details and the datasets we use.

4.1 Antitrust Decisions

Institutional Background. Antitrust regulation in France can be broken down into four periods, during which the competition regulator changed its name, structure, and mission. Born in 1953,[7] the French Technical Commission for Collusions and Dominant Positions' main goal was to fight against cartels and price fixing given their prevalence in post-war France. In 1963, its objectives were extended as the Commission also started investigating cases of dominant positions.[8] In practice, this Commission was directly notifying the Ministry for the Economy which would then decide whether to impose fines or not.

Following the 1973 oil crisis, Raymond Barre, an Economics Professor, was then Prime Minister in 1976 and advocated restricting even further price fixing arising from anti-competitive behaviors. In 1977, the Commission became the Competition Commission ("Commission de la Concurrence"). In addition to having to detect cartels and cases of dominant positions, the Commission was able to directly advise the French government on any competition-related matters but also on vertical and horizontal mergers and acquisitions.

The period 1986 to 2009 is important as it spans the beginning of our empirical analysis. Over this period, the Commission undergoes important transformations: its name is changed to the Competition Council ("Conseil de la Concurrence") and the 1986 Ordinance introduces several changes. Companies can directly refer cases to the Council. Moreover, the antitrust body becomes more independent, better protects concerned parties' rights and is now able to directly fine the firms found guilty of anti-competitive practices, though this does not apply to merger projects. The 2001 New Economic Regulation Law further introduces leniency and transaction programs to better detect and fight cartels.[9]

Finally, as of 2008, the Competition Council turns into the Competition Author-

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[7]"Décret n°53-704 du 9 août 1953".

[8]"Loi n°63-628 du 2 juillet 1963".

[9]A firm part of a cartel can go to the authority and report it. Under specific circumstances the firm will receive a more lenient fine that the other members of the cartels or not be fined at all. There are eleven cases involving the leniency program over the period 1994-2015.

ity ("Autorité de la Concurrence" or ADLC, henceforth). The 2008 Law on the Modernization of Economy not only gives the right to the Authority to review merger and acquisitions independently from the Minister of Economy, but also to investigate potential anti-competitive cases on its own.

Anticompetitive Practices.   As mentioned above, after investigating, the Competition Authority fines companies that are found guilty of engaging in any form of anti-competitive practice (abuse of dominant position, collusion or predatory pricing). Collusive behaviors might involve firms trading information on their prices and markups, imposing standard form contracts, enforcing barriers to entry, imposing exclusive or selective distribution agreements, market sharing, purposely stepping down from call for bids.

The ADLC makes use of two tools in order to deter firm from taking part in illegal activities. The first one consists of fining these companies. The fines are set "according to the seriousness of the facts, the extent of the harm done to the economy, the individual situation of the company that has committed the infringement and of the group to which it belongs to, and whether it is an infringement that has been repeated or not".[10] The fines are capped as they cannot be higher than "10% of the global turnover of the group to which the company that is being fined belongs to". If the infringement is not committed by a company, the maximum amount of the fine is 3 million euros.[11] The second tool relies on issuing an injunction whereby the ADLC notifies the companies to change their behavior.

In practice, the information we extract to create our database comes from PDF files containing the description of the decisions made by the French Competition Authority. These files are freely available on the ADLC website. We make use of an automatic textual analysis to retrieve information on the identity of the firms fined by the antitrust body.[12] Crucially, our database contains the name of the firms that are fined which signals that these companies behaved illegally and are anti-competitive. We also have information on the amount of the fine in thousands of euros, the year the verdict is returned and the starting year of the investigation. We then use the companies' names to back out their national identification code ("SIREN" code) given by the French National Institute of Statistics and Economic

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[10]French Commercial Code, L.420-1 or L.420-2.

[11]French Commercial Code, L.464-2.

[12]We do not use information on firms notified by an injunction. Often, these firms are fined later on by the ADLC and thus appear in our database.

Studies (INSEE). This allows us to match our database with other firm-level production datasets. We describe in the Data Appendix how we assemble our database, the variables it contains and the features we will add in future versions of our paper.

Timing Assumptions. The information we do not have access to in the current version of the paper is the duration of cartels and how long did each firm engage in anti-competitive behavior. Getting data on the exact starting date of the cartel is complicated and the reported date is likely to be inaccurate as companies have an incentive to misreport the birth date of the cartel to pay a lower fine. We thus make one assumption on the duration of cartels in order to estimate the impact of anti-competitive behaviors on firm-level outcomes. We assume that firms fined by the ADLC were anti-competitive for a period of five years before being fined by the ADLC. The duration of five years corresponds to the average duration of discovered French cartels observed over the period 2003-2015 by Monnier-Schlumberger and Hutin (2016). This also matches the average duration of cartels summarized in Levenstein and Suslow (2006) for a wide range of studies.[13]

One can argue that firms stop colluding before the ADLC verdict is returned. As a robustness check, we change the timing of collusion and assume that firms collude for a period of five years before the ADLC is notified of the illegal behaviors. These assumptions might seem extreme to the extent that they entail that firms stop colluding right when they are being fined or investigated. This might not be the case if the benefit of joining and staying in a cartel is higher than the cost of getting caught and sanctioned. Moreover, Stigler (1964) argues that a firm in a cartel has an incentive to deviate and price below its competitors to increase its market share. This leads him to conclude that cartels are by nature unstable. Empirically, this does not seem to be the case (Monnier-Schlumberger and Hutin, 2016; Levenstein and Suslow, 2006) and our assumptions are not ill-advised: as Monnier-Schlumberger and Hutin (2016) show, around 63% of French cartels die after the ADLC starts investigating or when a company or client files an official complaint and seizes the Competition Authority.

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[13]It is possible to argue that these dates are not a correct approximation of the true duration of cartels as these studies are based on discovered cartels that might not be representative of all cartels. Harrington Jr and Wei (2017) study in a theoretical framework the magnitude of the bias associated to this issue. They find the bias to be modest which lead them to conclude that using the duration of discovered cartels as a proxy for the duration of all cartels, discovered and undiscovered, is not a bad approximation.

One caveat is that we are making the implicit assumption that the date at which the ADLC was notified corresponds to the start of the investigation and that the companies are fully aware of it. In practice, it takes more time for the ADLC to launch an investigation and notify the potential colluders. The duration of cartels will be wrongly assigned if the year when the ADLC was notified of the case is different from that when the companies were notified of the start of the investigation. Finally, to the extent that there is a lot of variation in cartels duration, with some lasting for a few days and some lasting for several years, we further assume in a robustness check that firms engage in anti-competitive practices for two years, corresponding to the first-quartile of cartels duration according to Monnier-Schlumberger and Hutin (2016). Our results are quantitatively and qualitatively unaltered. In a future version of our paper, we will add more precise information on the duration of cartels from the decision files.

4.2 Firm-level datasets

We match our database on anti-competitive firms with firm-level data for France. Matching the firms is made possible by the fact that French firms are assigned a unique identifier ("SIREN" code). The datasets that we use contain the universe of French firms over the period 1994-2015.[14] These datasets contain the balance sheets and income statements of all French firms. We keep both large and smaller firms which corresponds to two different tax regimes, the Regime of Normal Real Profits (BRN) and the Simplified Regime for the Self-Employed (RSI), respectively. BRN contains firms with annual sales above 763K euros (230K euros for services) whereas smaller firms included in RSI sell at least 76.3K euros (but less than 763K euros) a year and more than 27K euros for services. However, BRN is the most relevant data source given that in 2003, BRN firms' sales share in total sales was 94.3% and is constant over time. This data has been used in previous studies, for instance in Di Giovanni et al. (2014) and we refer to their paper for more details. Importantly, these exhaustive databases allow us to build a firm's labor share, market share and other variables we directly use in our empirical framework. More information on the variables we use and build is provided in the Appendix.

Finally, we complement FICUS-FARE by making use of the LIFI survey database. This database has been used previously in di Giovanni et al. (2018), for instance.

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[14] For the period 1994-2007 and 2008-2015, we rely on FICUS and FARE, respectively.

This survey provides us with the ownership status of firms. More specifically, we use it to know whether firms are owned or not, the identity of the owner and its origin (foreign or domestic). This survey is important to us as it allows us to know whether anti-competitive firms are independent and make their own decisions or not. Because the decision to assign which firm is independent is somewhat arbitrary, we rely on different thresholds and samples and show that our results are robust to using these various methods. More details on how we create our final sample can be found in the Appendix.

4.3 Definitions

In FICUS-FARE, each firm is assigned a 5-digit principal activity code ("Code APE") by the INSEE and whose aim is to pin down in which industry the firm mostly operates. Because the precise breakdown of sales across products is not available for the French data, the relevant market for a firm is its 5-digit industry code. Therefore, throughout the paper, we will denote a firm's market share by its market share in the relevant 5-digit industry code.

Our definition of sector follows the NAF Rev. 2 classification. There is a many to one matching between the 5-digit APE codes and the 2-digit NAF Rev. 2 sectors. Every firm is thus assigned to a 2-digit sector.

4.4 Concentration and Anti-Competitive Firms

There has been an increase in US concentration documented in several recent papers (Autor et al., 2017; Gutiérrez and Philippon, 2017). Concentration is usually measured by studying the evolution of the Herfindahl-Hirschman Index (HHI) or concentration ratios (CR). In Figure 3, we plot the evolution of the CR4 and CR20 ratios over 1994-2015. The concentration ratio is computed for each 5-digit industry and we then take the mean of all the industry CR at a given point in time. The pattern is clear: concentration has also increased in France.

Table 1 shows some descriptive statistics on anti-competitive cases. The third and fourth column display the share of each sector's sales and gross value-added while the fifth column shows the average number of anti-competitive firms in each sector over the period 1994-2015. There are two sectors in which no firm was convicted, namely the agricultural and the education sectors. Cartelization and more

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generally anti-competitive practices are prevalent in France and most cartels involve firms operating in the construction, wholesale and retail and transportation sectors. These three sectors account for almost 50% of total sales and 36% of total value-added in France.

In Table 2, we investigate the characteristics of anti-competitive firms versus firms that have not been officially sentenced. The Colluding firms have a much higher market share on average: 4% versus 0.007% for non-colluders. The average cumulated market share of these colluders is equal to 11%: on average, these firms represent a non-trivial fraction of a market's total sales. Colluders also sell more, spend more on intermediate goods, have more employees, use capital more intensively and are more productive, as measured by revenue TFP and labor productivity.[15] These summary statistics are most-likely the result of self-selection into colluding, whereby more productive and bigger firms are more likely to find it profitable to join a cartel (Bos and Harrington, 2010). However, our empirical framework aims to shed light on the treatment effect of anti-competitive behaviors and cartelization.

5 Empirical Framework

In this section, we describe the different econometric specifications we take to the data and potential threats to identification that we will address in a future version of our paper.

5.1 Anti-Competitive Firms and Firm-Level Outcomes

In the present version of our paper, we do not aim to directly test our theoretical predictions. Instead, we provide some evidence on the relationship between the existence of cartels and firm-level outcomes such as market shares and employment.

The main specification we estimate is:

$$y_{kt} = \beta_1 \text{AntiComp}_{it} + \beta_2 \text{AntiComp}_{it} \times \text{Colluder}_{kt} + \mathbf{Z}'_{kt}\theta + \psi_{It} + \nu_i + \varepsilon_{kt} \quad (18)$$

The variable y_{kt} contains the market share, (log) employment or (log) wages of a firm k in t. AntiComp$_{it}$ captures the existence of colluding firms in a 5-digit industry

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[15]We detail the estimation procedure used to back out revenue TFP in the Appendix.

i. This is a dummy equal to one if at least one firm was fined by the ADLC in an industry *i*. We choose the threshold value of one because firms may abuse their dominant position and this type of infringement only requires the existence of one company. Colluder$_{kt}$ is an indicator variable that takes the value 1 if firm k was fined by the ADLC. It is important to note that at this stage, we will therefore not capture whether firms belonging to the *same* cartel gain market shares and the effect on non-colluders within the same industry. $\mathbf{Z}'_{kt}$ is a set of controls, ψ_{It} are 2-digit sector-year fixed effects that control for sectoral shocks that might affect all firms in the same manner, while ν_i are 5-digit industry fixed effects. The intuition for this specification is the following: the existence of colluders can affect firms' market share but the effect might be differentiated depending on whether the firm behaves anti-competitively or not. This differentiated impact is captured by the interaction term.

The advantage of this specification is that we control for the fact that some industries might be more concentrated and as a result more prone to cartelization. For instance, specific industries in which barriers to entry are always high and limit the number of competitors might make it easier for firms to coordinate and gain market shares by colluding (Bain, 1956). However, these 5-digit industry dummies will not capture the intensity of the anti-competitive behaviors as industries with a high number of anti-competitive companies will be counted in the same way as industries with a single firm, as big or small that firm might be. We will therefore also include the total number of anti-competitive firms within a 5-digit industry to control for the fact that some industries are more severely impacted by colluding cases.

Upstream/ Downstream Linkages   We also seek to identify how cartels and anti-competitive practices more generally propagate in the economy and affect downstream and upstream sectors. To do so, we will first make use of French Input-Output (I-O) Tables to build on Antràs et al. (2012).[16] Their methodology allows us to build an upstreamness index that we can then interact with the dummy variable for whether the firm is anti-competitive or not in (18).[17]

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[16]As opposed to the US I-O Tables, the French I-O Tables are fairly more aggregated: depending on the period considered, they contain 35 or 56 sectors.

[17]The lower the upstreamness index, the closer that sector is to final demand. For instance, we expect the motor vehicles, trailers and semi-trailers sector to have a low index but the coke and refined petroleum products sector to have a high upstreamness index.

We will then estimate the direct effect of cartels on a firm's outcome operating in the same sector as that cartel but taking into account the fact that some sectors upstream and downstream might contain cartels. We then test if the shocks in other sectors have an effect.

5.2 Identification

One might worry that our analysis suffers from sample selection bias because anti-competitive firms in our sample are *discovered* firms. The issue is that there might be a myriad of other colluding companies that go unnoticed and that might be/behave fundamentally differently from discovered firms, affecting our results. Undiscovered cartel members would be classified as competitive but their characteristics and behavior might lead them to extract more market power. While this is a possibility that is impossible to rule out, we argue that, if anything, this would lead us to *underestimate* the effect of competition, or lack thereof, on our firm-level outcomes such as employment and market shares: firms assumed to be competitive that in fact collude are able to extract market power via secret agreements.

Moreover, the likelihood that firms self-select into colluding cannot be rejected: larger, more productive firms might have a strong incentive to form or join a cartel (Bos and Harrington, 2010). If this is the case, our empirical results will not reflect any treatment effect but rather a selection effect. We plan to pursue our line of research by using propensity score matching (PSM) to create a control group similar to colluding firms based on some observable characteristics such as revenue TFP, capital intensity, employment, firm level wages etc. We can then estimate an average treatment effect of colluding on firm-level outcomes by comparing our treated group to the newly created control group. Although this methodology has been used recently by Blonigen and Pierce (2016) to measure the effect of mergers and acquisitions on product market power and revenue TFP, we are not aware of other studies trying to use this method to assess the effect of anti-competitive practices on firm-level outcomes.

6 Results

In this section, we discuss the effect of colluding behaviors on firm-level outcomes. As mentioned before, the estimates are not causal.

Main Results. Table 3 displays our baseline results. The existence of anti-competitive firms within an industry leads to a drop in market share of 0.06 percentage points for firms that do not collude. Colluding firms benefit from it and their market share increases by 3.8% percentage points when there is at least one colluder in that industry.Although the effect drops to an increase of 2.8% percentage points when we control for firm size and revenue TFP, the effect remains highly significant. At first sight, anti-competitive firms therefore seem able to gain market shares. As discussed, the effect might be driven in part by the fact that some industries are more concentrated due to barriers to entry, for example. We therefore add 5-digit industry dummies in column (3). While the effect on AntiComp_{it} is now one order of magnitude lower, firms that behave illegally still largely benefit from it and this still holds when we further control for revenue TFP in column (4). In the last column of the table, we also control for the intensity of within-industry collusions by adding the total number of colluding firms in an industry and interact it with the colluder dummy. The interaction term is negative and highly significant. As expected, the higher the number of anti-competitive firms in an industry, the lower the market share of colluding firms everything else equal. However, the total effect of acting illegally on its market share remains positive and significant.

We also test whether the effect is driven by relatively more productive firms. To do so, we assign firms in four different quartiles, depending on their place in the productivity distribution. Apart from the bottom 25%, Table 4 shows that relative more productive firms that collude are able to extract more market power in the presence of other colluding firms in their industry. While the interaction term is unusually high for the first quartile, the point estimate becomes increasingly high as we move from the second to the last quartile. Though not displayed, we also tested how bunching the firms in quartiles depending on their (log) capital intensity changes our results and we found similar qualitative evidence. Finally, Table 5 shows how colluding affects a firm's employment and wages. The effects are the same qualitatively for employment. Quantitatively, a sectoral collusion decreases a firm's employment by 0.0013 percent but it increases a colluder's employment by 0.02 percent (first column). This might be because colluders are large firms that also dominate the labor market. The estimates are robust to controlling for the number of colluders in each industry. The effect on wages is not fully clear as shown in the last two columns. The point estimates on the industry dummy switch sign as we control for the number of colluders and are not significant anymore.

Robustness. We provide evidence that our results are robust to our timing assumption and to changing the identity of the colluder. In Table 6, we change the timing assumption as described in Section 4.1. In the first column, we keep the average duration of five years but we assume that firms stop colluding when the ADLC is notified of the case. As an example, this amounts to assuming that a cartel member whose cartel was reported to the ADLC in 2007, was colluding from 2003 to 2007. The results are qualitatively similar and very close in terms of point estimates. Similarly, in the last two columns, we assume that the duration of collusion is equal to two years, corresponding to the lowest quartile found by Monnier-Schlumberger and Hutin (2016). Once again, although the estimates slightly change in terms of magnitude, they remain significant and very close to our baseline results. In Table 7, we assume that the fined firm is not the colluding firm anymore. Instead, we make use of the LIFI database and assign the colluding dummy to the owner of that firm. The results remain very close to those found in Table 3 with a coefficient on AntiComp significant at the 10.2% level in the fourth column and on the last interaction in Column (5) significant at the 10.3% level. Therefore, our results do not seem to be driven by our timing assumption or by the identity of the colluder.

7 Conclusion

In this preliminary work, we develop a framework with heterogeneous firms and endogenous markups where firms are allowed to collude. Collusive practices are introduced by using a model of cross-ownership. This framework allows us to derive analytical proofs and to easily simulate our model. We also introduce a new firm-level database on cartels and anti-competitive behaviors by retrieving information from the French Antitrust Body website. Several important parts of our paper have been omitted in the present draft and will be added in future versions. We plan to complete the welfare analysis part of our model, update and complete our firm-level database on anti-competitive conduct and improve our empirical framework to causally estimate the effect of market structure distortions on firm-level outcomes.

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Figures

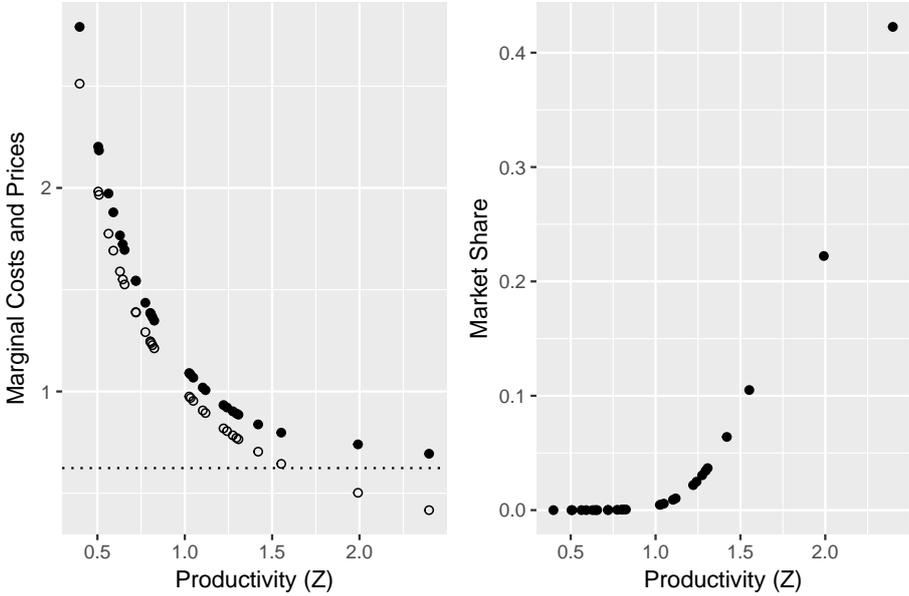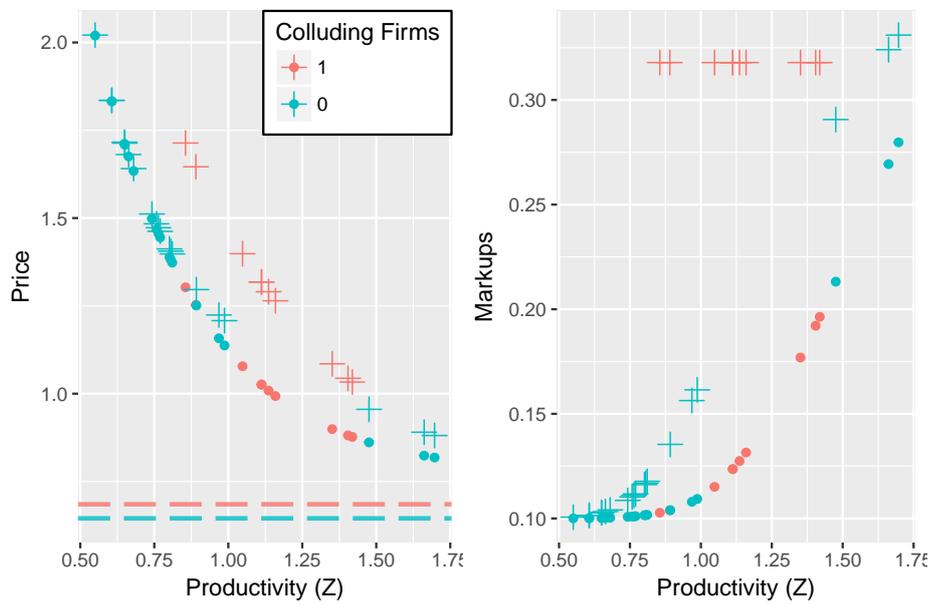Figure 1: Industry Equilibrium without collusion

Figure 2: Industry Equilibrium with collusion

All the firms in the cartel (in red) raise their price and pick the same markup (i.e. $\kappa = 1$). The firms who are not part of the cartel also raise their price (umbrella pricing) and the price index in the industry goes up, creating a decline in welfare.
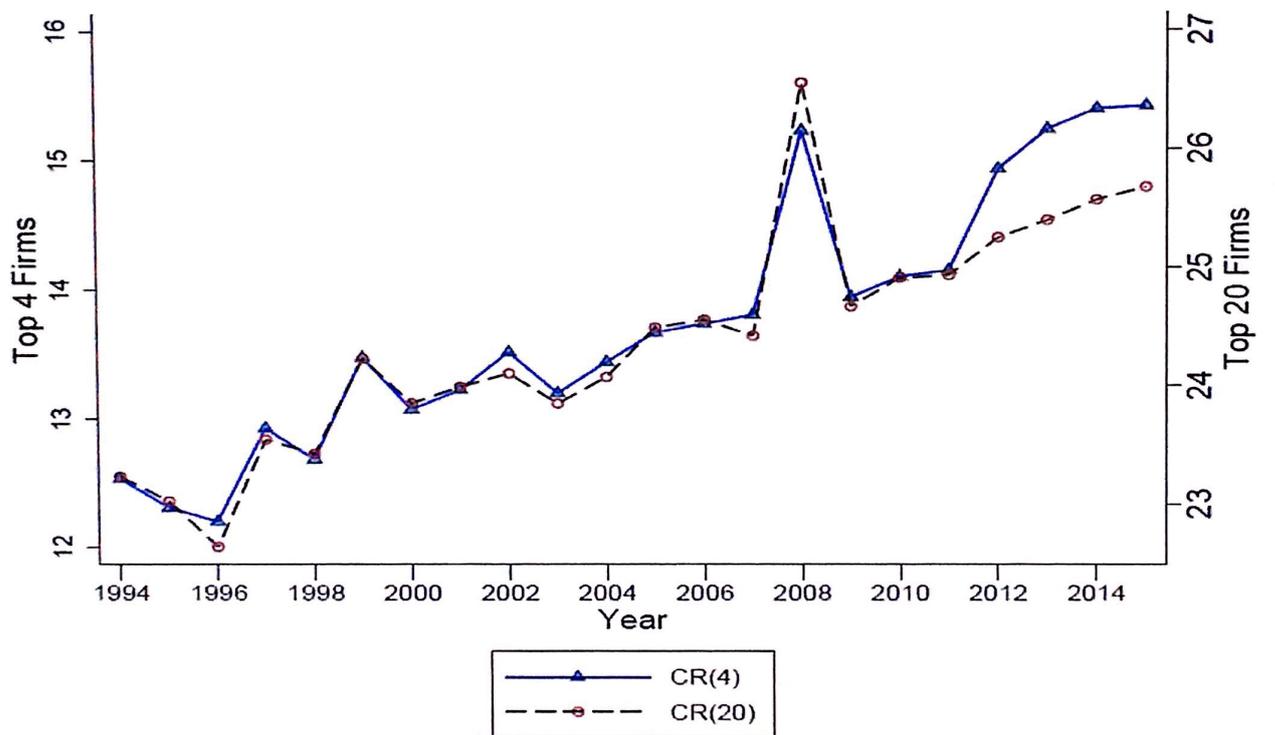
Figure 3: Concentration Ratios
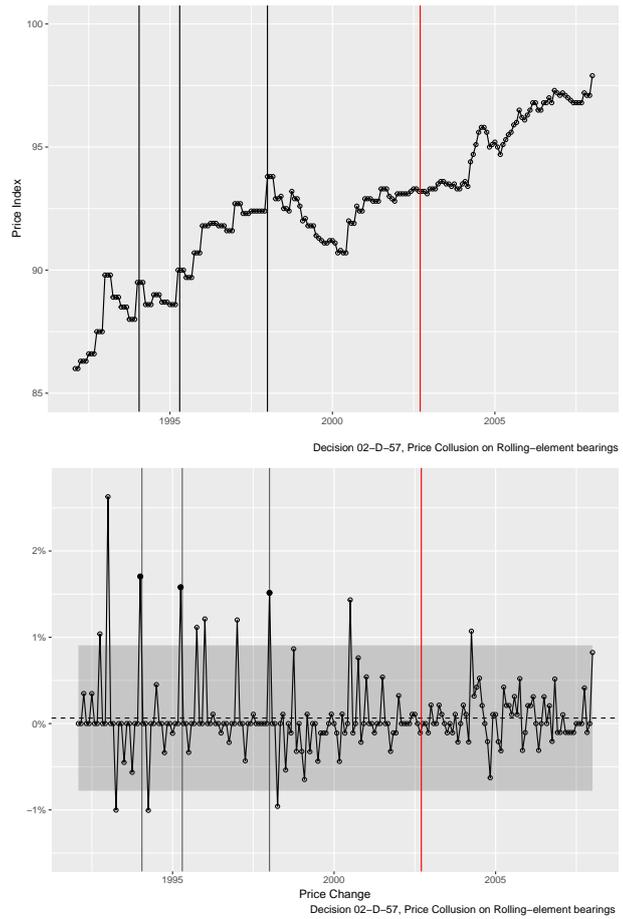Data Source: FICUS-FARE.

Figure 4: Example of Price Fixing in the ball bearings industry
Concerted price increases (black vertical lines) were revealed by the investigation. The red line represents the time when the Competition Authority gave its sentencing decision. The dark grey area represents the +/- 2 standard deviations of the mean monthly price change.

Tables

Table 1: Collusions by Sector

NAF	Sector	Sales (Share)	VA (Share)	# Collusions
01-03	Agriculture, forestry and fishing	0.0010	0.0014	0
05-09	Mining and quarrying	0.0027	0.0038	0.82
10-12	Food products, beverages and tobacco	0.0558	0.0491	10.55
13-15	Textiles, apparel, leather and related prod.	0.0108	0.0114	0.55
16-18	Wood and paper prod., and printing	0.0164	0.0178	3.27
19	Coke, and refined petroleum prod.	0.0187	0.0171	1
20-21	Chemicals and chemical products	0.0402	0.0381	5.27
22-23	Rubber and plastics prod., and other non-metallic mineral prod.	0.023	0.027	6.41
24-25	Basic metals and fabricated metal prod., except machinery and equipment	0.0295	0.0326	6.68
26-27	Electrical and optical equipment	0.0247	0.0265	2.91
28	Machinery and equipment n.e.c.	0.0163	0.0171	1.59
29-30	Transport equipment	0.052	0.037	1.5
31-33	Other manufacturing; repair and installation of machinery and equipment	0.016	0.021	1.77
35-39	Electricity, gas, and water supply	0.034	0.0437	4
41-43	Construction	0.064	0.081	48.14
45-47	Wholesale and retail trade, repair of motor vehicles and motorcycles	0.3671	0.1933	48.55
49-53	Transportation and storage	0.0538	0.083	30
55-56	Accommodation and food service activities	0.0205	0.0333	0.95
58-60	Publishing, audiovisual and broadcasting activities	0.0152	0.024	2.68
61	Telecommunications	0.0169	0.0311	1.77
62-63	IT and other information services	0.0147	0.0266	0.86
68	Real estate activities	0.0132	0.0262	0.86
69-82	Professional, scientific and administrative activities	0.0707	0.1206	15.41
85	Education	0.002	0.0037	0
86-88	Health and social work	0.0081	0.0173	5.91
90-93	Arts, entertainment and recreation	0.0068	0.0059	0.32
94-96	Other service activities	0.0056	0.010	2.77

Notes: The Sales (Share) column represents sector-level sales in total sales over the period 1994-2015. The VA (Share) column represents sector-level value-added in total value-added over the period 1994-2015. The values displayed for the number of collusions are averages over the period 1994-2015. Colluding firms are assumed to be colluding for a period of 5 years before the decision of the ADLC as explained in Section 4.

Table 2: Summary Statistics

	Full Sample		Colluding Firms		Non Colluding Firms	
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Market Share	0.000725	0.010	0.0397	0.12	0.000716	0.0099
Cumulated Market Share	X	X	0.1145	0.163	X	X
Sales	2857.859	94074.28	440436.8	2585997	2760.201	85539.76
Value-added	815.74	33044	198115.3	1416515	771.70	25214
Revenue TFP	1.842	0.43	1.96	0.37	1.84	0.43
Labor Productivity	3.77	0.72	4.15	0.78	3.77	0.72
Labor	14	454	2331	15985	14	385
Capital/Labor ratio	0.302	18.14	1.458	23.67	0.302	18.134
Intermediates	2064.66	72512	252997	1451346	2008.66	69102
# Obs.	20,167,666		4,500		20,163,166	
# Firms	2,884,325		1005		2,884,305	

Notes: The values displayed are for the period 1994-2015. Sales and value-added are in thousands of euros. Revenue TFP is obtained by estimating a production function by sector as described in Appendix B. Labor productivity is real value-added (deflated by 2-digit price indices) divided by the number of workers. Labor is the number of workers. The capital-labor ratio is expressed in real terms where capital has been deflated. Intermediates is the value of expenditures on intermediate goods in thousands of euros. The number of colluding and non-colluding firms does not add up to the total number of firms in the full sample because firms do not always collude and therefore switch from one status to the other.

Table 3: Baseline Results

Dependent Variable			Market Share$_{kt}$		
	(1)	(2)	(3)	(4)	(5)
AntiComp$_{it}$	-0.06***	-0.068***	-0.006**	-0.00544*	-0.0052**
	(0.02)	(0.02)	(0.0029)	(0.0027)	(0.0024)
AntiComp$_{it}$ × Colluder$_{kt}$	3.9***	2.9***	3.7***	3.24631***	5.679***
	(0.94)	(0.89)	(0.91)	(0.95)	(1.406)
Revenue TFP$_{kt}$		0.055		0.15**	
		(0.043)		(0.062)	
# Colluders$_{it}$					-0.0005
					(0.0007)
# Colluders$_{it}$ × Colluder$_{kt}$					-0.262***
					(0.09)
2-digit Sector × Year FE	✓	✓	✓	✓	✓
5-digit Industry FE			✓	✓	✓
Firm Size Controls		✓			
# Obs.	20,167,666	15,040,842	20,167,662	15,040,836	20,167,662

Notes: Standard errors clustered at the 2-digit sector level. *** p<0.01, ** p<0.05, * p<0.1. Firm size controls include the quantity of workers, capital and materials (in log).

Table 4: Results by Productivity Quartile

Dependent Variable	Market Share$_{kt}$			
Sample	$z_{kt} \in Q_1$	$z_{kt} \in Q_2$	$z_{kt} \in Q_3$	$z_{kt} \in Q_4$
AntiComp$_{it}$	-0.00595	-0.00213	-0.00432***	-0.0139**
	(0.00588)	(0.0.00214)	(0.00151)	(0.00626)
AntiComp$_{it}$ × Colluder$_{kt}$	6.058*	1.484*	1.978*	3.92***
	(3.07)	(0.752)	(0.964)	(1.207)
Revenue TFP$_{kt}$	0.078	0.119**	0.174***	0.184
	(0.068)	(0.0475)	(0.0602)	(0.168)
2-digit Sector × Year FE	✓	✓	✓	✓
5-digit Industry FE	✓	✓	✓	✓
# Obs.	3,760,204	3,760,194	3,760,183	3,760,181

Notes: Standard errors clustered at the 2-digit sector level. *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Table 5: Effects on Employment and Wages

Dependent Variable	ln Employment$_{kt}$		ln Wages$_{kt}$	
	(1)	(2)	(3)	(4)
AntiComp$_{it}$	-0.013*	-0.015**	0.003*	-0.0001
	(0.0067)	(0.007)	(0.0019)	(0.0028)
AntiComp$_{it}$ × Colluder$_{kt}$	2.375***	2.931***	0.091*	0.307***
	(0.25)	(0.195)	(0.052)	(0.025)
Revenue TFP$_{kt}$	0.254	1.18		
	(0.38)	(0.89)		
# Colluders$_{it}$		0.00008		0.0002
		(0.0013)		(0.00015)
# Colluders$_{it}$ × Colluder$_{kt}$		-0.055***		-0.0067***
		(0.0068)		(0.0015)
2-digit Sector × Year FE	✓	✓	✓	✓
5-digit Industry FE	✓	✓	✓	✓
# Obs.	15,040,836	15,037,090	20,167,662	20,145,535

Notes: Standard errors clustered at the 2-digit sector level. *** p<0.01, ** p<0.05, * p<0.1.

A   Data Appendix

A.1   Firm-level Database on Anti-competitive Conduct

In order to extract information on the identity of the firms fined by the ADLC we proceed as follows. First, we scrape the website of the ADLC to recover all the decision files over the period 1994-2015. These PDF documents contain information on the situation of the market impacted by anti-competitive behaviors, the notification date of the case to the ADLC, the names of the firms fined for anti-competitive behaviors, the types of infraction they committed, their sales and sometimes an estimate of the duration or date of the infraction. Some of these files contain information on when the firms were notified by the ADLC that an investigation is going to be launched. Extracting and getting data on the identity of these anti-competitive companies is straightforward to the extent that the layout is relatively similar across decision files. A salient and important example is that of the companies' name which always appear at the end of the PDF right after the word *Décide* ("Decides").

Second, for the moment, we use Python's textual analysis tools to back out the name of these companies, their sales, the date when the ADLC was first notified of the infraction and the corresponding amount of the fine for each firm. This step requires some manual cleaning as some companies, numbers and cases are misreported. We therefore go through all the files to complement the information extracted from the textual analysis and double check that our newly created dataset is not missing anything that would appear in the original PDF files but that we would miss via the textual analysis exercise. At this stage, the dataset is informative about the identity (name) of the firms that were fined by the French Antitrust Authority, their sales, the case number of the decision, the amount of the fine for each firm and the notification date of the case to the ADLC.

Third, we make use of Orbis and Python to recover information on the identification number of the firms which will then allow us to match our database to the balance-sheets data. To do so, we upload our temporary database into the Batch Search engine of Orbis to look for the SIREN number of each firm given its name. We complement this information with a Python script that allows us to obtain the SIREN number of firms based on a Bing search of that firm's name.[18] Although

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[18]We thank Arthur Guillouzouic Le Corff for sharing his code.

these methods are imperfect, they facilitate the matching with FICUS-FARE.

Finally, before matching our database with FICUS-FARE, we manually verify that the SIREN numbers obtained from Orbis and from our scraping procedure are correct. We do so by making sure that the sales (in euros) of the firm in our database correspond to those reported in FICUS-FARE. For the firms that were not matched by any means in our third step, we manually search for them in FICUS-FARE using the information on their sales and add their SIREN number directly in our database. For now, we create the full database over the period 1994-2015 by making the assumption that the average duration over which firms behaved anti-competitively is five years. This corresponds to the average amount found over the period 2003-2015 in France by Monnier-Schlumberger and Hutin (2016) and is consistent with other cartel cases in different settings (Levenstein and Suslow, 2006), as explained in detail in Section 4.1 of the paper.

In future versions of our paper, we will update this database by adding more detailed information on the duration of discovered cartels for the cases for which this information is available, add firms that were warned by the ADLC but not fined, add the total number of firms discovered in each cartel, add information on whether the firms colluded in prices or quantities.

A.2 List of Variables

We describe below the different variables used in our empirical framework. Note that our main sample consists of observations with strictly positive values for gross value-added, total and domestic sales, number of employees, labor compensation, expenditures on materials and capital.

- **Anti-Competitive Industry:** For each 5-digit industry in a given year, we count the total number of colluding firms and create a dummy variable equal to one if there is at least one firm in that industry. We choose a value equal to one because firms can abuse their dominant position. *Source: Moreau-Panon database*

- **APE Code:** 5-digit industry code. Before 2008, APE codes are available in a 4-digit format corresponding to the NAF Rev. 1 classification. We convert all these NAF Rev. 1 codes into Naf Rev. 2 codes using a correspondence table available on the INSEE website. Our matching procedure is such that each of

the 712 NAF Rev. 1 APE code is assigned to one NAF Rev. 2 APE code. Our code is available upon request. *Source: FICUS-FARE and authors' calculation*

- **Capital:** Net book value of capital. We cannot build a capital measure using the perpetual inventory method as there is a break between FICUS and FARE and no data on investments is reported in 2008. We further deflate capital expenditures by sector-level price indices from EUKLEMS (Jäger, 2017). *Source: FICUS-FARE and authors' calculation*

- **Colluder:** Dummy variable that takes the value one if the firm engaged in anti-competitive practices in a given year. *Source: Moreau-Panon database*

- **Employment:** Total number of employees working in each firm. *Source: FICUS-FARE*

- **Export Sales:** Export sales reported by the firm in thousands of euros. This variable is available in the fiscal files and is highly correlated (correlation coefficient above 0.9) with total export sales computed from the customs data. Firms are classified as exporters if they sell a positive amount abroad according to the customs. *Source: Customs data and FICUS-FARE*

- **Gross Value-Added:** This variable is directly available in FICUS-FARE and follows the accounting definition according to which it is equal to total sales minus input expenses taking into account changes in inventories. *Source: FICUS-FARE*

- **Labor Compensation:** This variable is the sum of two components separately available in the fiscal files: salaries and social benefits that are paid by the employer and that benefit the worker in the form of retirement funds, social security funds etc. *Source: FICUS-FARE*

- **Labor Share:** Consistent with Karabarbounis and Neiman (2014), Elsby et al. (2013), we construct our firm-level labor share variable as follows. In accounting, gross value-added is equal to the sum of gross operating surplus, labor compensation (as defined above) and taxes net of subsidies. We therefore do not allocate taxes net of subsidies and build the labor share as the ratio of labor compensation to gross value-added. Observations with values outside the $(0, 1)$ interval are discarded whenever our sample involves labor shares. *Source: FICUS-FARE and authors' calculation*

- **Market Shares:** A firm's market share is defined at the 5-digit level. We compute market shares by dividing a firm's total sales by the total amount sold by all the firms operating in the same market at a point in time. *Source: FICUS-FARE and authors' calculation*

- **Materials:** Materials are defined as the sum of expenditures on raw materials, final goods and other categories. We further deflate this expenditure variable by 2-digit sector intermediate goods price indices from EUKLEMS. *Source: FICUS-FARE and authors' calculation*

- **NAF Code:** 2-digit sector code according to the NACE Rev. 2 classification. Some sectors are pooled together, depending to the availability of sector-price deflators. The list of sectors is displayed in Table **??**. *Source: FICUS-FARE*

- **Ownership Status:** [TBC] Describe method and deflators *Source: LIFI*

- **Total Sales:** Total sales (domestic sales plus export sales) reported by the firm in thousands of euros. *Source: FICUS-FARE*

- **Wages:** Firm-level wages are obtained by dividing labor compensation by employment. *Source: FICUS-FARE and authors' calculation*

B   Estimation Appendix

Our estimation method relies on the seminal papers of Olley and Pakes (1992), Levinsohn and Petrin (2003) and Ackerberg et al. (2015). The idea is that output is produced by using labor, capital, materials and productivity. Total factor productivity (TFP) is a residual because it is not observed and most importantly, its absence in standard production function estimation leads to biased estimates of labor, capital and materials. This is due to the fact that these inputs are chosen depending on the productivity realizations that the firm observes (Marschak and Andrews, 1944). The way we control for it and back out productivity is by assuming that the demand for materials is a function of capital, labor and productivity as in Ackerberg et al. (2015).

Formally, we assume a Cobb-Douglas production function in log-form where output y is being produced by labor l, capital k, materials m and depends on productivity ω which is Hicks neutral. To ease the notation, we index firms by i instead

of k which denotes capital in the following application.

$$y_{it} = \alpha_l l_{it} + \alpha_k k_{it} + \alpha_m m_{it} + \omega_{it} \tag{19}$$

The Hicks neutral term ω_{it} is a function of a predictable term $_{it}$ that the firm has access to but is unobserved to the econometrician and a noise ξ_{it}. For simplicity, we assume that ω_{it} is the sum of these two components:

$$y_{it} = \alpha_l l_{it} + \alpha_k k_{it} + \alpha_m m_{it} + z_{it} + \xi_{it}$$

We follow Ackerberg et al. (2015) and assume that materials is an invertible function of labor, capital and the only unobserved term z_{it}:

$$m_{it} = \Phi_t(l_{it}, k_{it}, z_{it})$$

This implies that we can invert the demand for materials to control for productivity as a function of observables:

$$z_{it} = \Psi_t(l_{it}, k_{it}, m_{it})$$

where $\Psi_t(.) := \Phi_t^{-1}(.)$. The resulting equation is:

$$y_{it} = \alpha_l l_{it} + \alpha_k k_{it} + \alpha_m m_{it} + \Psi_t(l_{it}, k_{it}, m_{it}) + \xi_{it}$$

which we rewrite as:

$$y_{it} = f_t(l_{it}, k_{it}, m_{it}) + \xi_{it} \tag{20}$$

The estimation method consists of two steps. In the first step we non parametrically estimate equation (20). In practice, we approximate $f_t(.)$ by a third order polynomial in its arguments as well as interactions of all the terms. This gives us predicted output $\hat{f}_t(.)$. We then use the fact that:

$$z_{it} = \hat{f}_t(l_{it}, k_{it}, m_{it}) - \alpha_l l_{it} - \alpha_k k_{it} - \alpha_m m_{it} \tag{21}$$

We can now specify the law of motion of productivity which we assume follows a first-order Markov process:

$$z_{it} = h_t(z_{it-1}) + \vartheta_{it}$$

In practice, we estimate:

$$\hat{z}_{it}(\alpha_l, \alpha_k, \alpha_m) = \sum_{j=1}^{3} \beta_j \hat{z}_{it-1}^j(\alpha_l, \alpha_k, \alpha_m) + \vartheta_{it} \tag{22}$$

where we have made clear that productivity is derived from the estimation of (21) and a guess on $(\alpha_l, \alpha_k, \alpha_m)$. Estimating (22) gives us an estimate of $\vartheta_{it}(\alpha_l, \alpha_k, \alpha_m)$ which is the innovation term to productivity.

The second stage of the estimation procedure consists of using moment conditions and estimating the system by GMM:

$$E\left(\hat{\vartheta}_{it}(\alpha_l, \alpha_k, \alpha_m) \begin{pmatrix} l_{it} \\ k_{it} \\ m_{it-1} \end{pmatrix} \right) = 0 \tag{23}$$

These moment conditions are standard in the empirical IO literature. Labor, capital are assumed to be dynamic inputs so that the innovation term is uncorrelated with their value at time t. Materials are assumed to be flexible so that their demand might vary with the innovation shock in t and we must use their lagged value instead. The parameters of interest solve the moment conditions in (23).

Once we have recovered the output elasticities, we can define productivity as the Solow residual:

$$\hat{z}_{it} = y_{it} - \hat{\alpha}_l l_{it} - \hat{\alpha}_k k_{it} - \hat{\alpha}_m m_{it} \tag{24}$$

C   Mathematical Appendix

C.1   Properties of the Industry Equilibrium

This section formulates the industry equilibrium as a nested fixed point in the space of prices and derives the main results of the paper.

Lemma 1 (Nested Fixed Point). *The vector of equilibrium prices, $\mathbf{P} = (P_k)_{k=1,\dots,K}$ is the unique solution to the following nested fixed point problem*

$$\begin{cases} P_k = \Phi(P_k; z_k, P) & \forall k = 1, \dots, K \\ P = \Psi(\mathbf{P}). \end{cases}$$

Proof. For ease of notation, we drop the sector subscript i. Rearranging the firms' first order conditions on prices, we have

$$
\begin{aligned}
P_k &= \frac{1}{1-\frac{1}{\epsilon_k}}\frac{W}{z_k} \\
&= \left[1-\frac{1}{\epsilon_k}\right]^{-1}\frac{W}{z_k} \\
&= \left[1-\frac{1}{\rho}\left(1-s_k\right)-\frac{1}{\eta}s_k\right]^{-1}\frac{W}{z_k} \\
&= \left[1-\frac{1}{\rho}-\left(\frac{1}{\eta}-\frac{1}{\rho}\right)s_k\right]^{-1}\frac{W}{z_k} \\
&= \left[\left(1-\frac{1}{\rho}\right)-\left(\frac{1}{\eta}-\frac{1}{\rho}\right)\left(\frac{P_k}{P}\right)^{1-\rho}\right]^{-1}\frac{W}{z_k}
\end{aligned}
$$

As a consequence the equilibrium price vector is the solution to a set of $K+1$ non-linear equations composed of K fixed point conditions, together with the definition of the aggregate price index. Define $\Phi\left(\cdot\,;z_k,P\right):x\longrightarrow\frac{W}{z_k}\frac{1}{\left[\left(1-\frac{1}{\rho}\right)-\left(\frac{1}{\eta}-\frac{1}{\rho}\right)\left(\frac{P}{x}\right)^{\rho-1}\right]}$ and

$\Psi\left(\mathbf{P}\right)\equiv\left[\sum_{k=1}^{K}\left(\frac{1}{P_k}\right)^{\rho-1}\right]^{-\frac{1}{\rho}}$. The K response-price equations can each be written $P_k=\Phi\left(P_k;z_k,P\right)$ and the function $\Phi\left(\cdot\,;z_k,P\right)$ is strictly decreasing in its first argument and maps $\left(P\left(\frac{1}{\eta}\frac{\rho-\eta}{\rho-1}\right)^{\frac{1}{\rho-1}},+\infty\right)$ into $\left(\frac{\rho}{\rho-1}\frac{W}{z_k},\frac{\eta}{\eta-1}\frac{W}{z_k}\right)$.

Lemma 2 (Price Index). *The price index is i) more elastic to the pricing decisions of the larger firms and ii) its variations are bounded above by the largest variations in prices.*

Proof: Differenciating the definition of the price index yields

$$
\frac{dP}{P}=\left(\frac{\rho-1}{\rho}\right)\sum_k s_k.\frac{dP_k}{P_k}
$$

and therefore, the elasticity of the price index with respect to a change in a firm's individual price k is

$$
\frac{dP/P}{dP_k/P_k}=\left(\frac{\rho-1}{\rho}\right)s_k
$$

Moreover, the changes in the price index are bounded above by the largest market-share weighted proportional change in firms'prices, i.e.

$$
\left|\frac{dP}{P}\right|=\frac{\rho-1}{\rho}\max_k\left|\frac{dP_k}{P_k}\right|. \tag{25}
$$

where, by assumption 2, we have $\frac{\rho-1}{\rho}<1$.

40

Lemma 3 (Prices elasticities with respect to the price index). *The price elasticities of individual firms with respect to the price index are i) positive for all firms and ii) increasing with the size of the firm, as measured by its market share.*

Proof: Differentiate the price response equation, and obtain

$$\frac{dP_k}{P_k} = \frac{x_k}{1+x_k}\frac{dP}{P}$$

where $x_k \equiv (\rho - 1)\left(\frac{1}{\eta} - \frac{1}{\rho}\right) s_k \cdot \mu_k > 0$, where μ_k is the markup charged by firm k. To prove the second part, recall that the markups are increasing in the market share, that P_k is decreasing in the market share and that the function $x \to \frac{x}{1+x}$ is strictly increasing on $(0, +\infty)$.

Lemma 4 (Price impact of a productivity shock). *The price impact after a productivity shock, is characterized at the first order by the following equation:*

$$d\ln\mathbf{P} = -[I - \mathbf{\Omega}]^{-1} d\ln\mathbf{z}$$

Proof. The change in firm k's price in response to a small productivity shock, can be decomposed as follows

$$d\ln P_k = d\ln\mu_k + d\ln W - d\ln z_k$$

where $\mu_k \equiv \frac{\epsilon_k}{\epsilon_k - 1}$ is the markup of firm k, W the market wage and z_k the idiosyncratic productivity of firm k. The change in markup can be decomposed further

$$
\begin{aligned}
d\ln\mu_k &\equiv & \frac{d\mu_k}{\mu_k} \\
&=& \frac{1}{\mu_k}\frac{d\left[\frac{1}{\epsilon_k}\right]}{\left[1-\frac{1}{\epsilon_k}\right]^2} \\
&=& \mu_k d\left[\frac{1}{\epsilon_k}\right]
\end{aligned}
$$

Now recall that in equilibrium the elasticity is linked to the market share by the following relationship

$$\frac{1}{\epsilon_k} = \frac{1}{\rho}(1 - s_k) + \frac{1}{\eta}s_k$$

hence

$$
\begin{aligned}
d\left[\frac{1}{\epsilon_k}\right] &= \frac{1}{\rho}\left(-ds_k\right) + \frac{1}{\eta}ds_k \\
&= \left(\frac{1}{\eta} - \frac{1}{\rho}\right)ds_k
\end{aligned}
\tag{26}
$$

where the term inside the brackets is strictly positive under assumption 2. Combining these two equations we recover the result that markups increase with firm's market share

$$
d\ln\mu_k = \mu_k\left(\frac{1}{\eta} - \frac{1}{\rho}\right)ds_k
\tag{27}
$$

The equilibrium market share depends on the firm's market share $s_k = \frac{(1/P_k)^{\rho-1}}{\sum_{j=1}^{K}(1/P_j)^{\rho-1}}$. This market share is affected by the price changes as follows:

$$
\begin{aligned}
ds_k &= -(\rho-1)\frac{dP_k}{P_k}s_k \\
&+ (\rho-1)\frac{dP_k}{P_k}s_k^2 \\
&+ (\rho-1)\sum_{j\neq k}\frac{dP_j}{P_j}s_j \cdot s_k
\end{aligned}
$$

At the first order firm k's market share responds to its own price change with an elasticity of $(\rho-1)$. It increases when other firms raise their prices. Let Ω be the matrix defined by

$$
\Omega_{kj} = \begin{cases}
-\mu_k\left(\frac{1}{\eta} - \frac{1}{\rho}\right)(\rho-1)s_k(1-s_k) & j = k \\
\mu_k\left(\frac{1}{\eta} - \frac{1}{\rho}\right)(\rho-1)s_j \cdot s_k & j \neq k
\end{cases}
\tag{28}
$$

Then, the system of price responses to firms' idiosyncratic productivities shocks can be written compactly as

$$
d\ln\mathbf{P} = \Omega d\ln\mathbf{P} - d\ln\mathbf{z}
$$

and consequently the prices solve the following system

$$
d\ln\mathbf{P} = -\left[I - \Omega\right]^{-1}d\ln\mathbf{z}
\tag{29}
$$

Lemma 5. *The pass-through of productivity to prices is imperfect. In particular, we have*

$$
0 < \|T\|_\infty < 1
$$

where $T \equiv [I - \boldsymbol{\Omega}]^{-1}$ denotes the pass-through matrix in this sector.

Proof: $I - \boldsymbol{\Omega}$ has non-positive off-diagonal entries and is row-diagonally dominant as $\|1 - \boldsymbol{\Omega}_{kk}\| > \sum_{j \neq k} \boldsymbol{\Omega}_{kj}$ for all k. It is therefore an M-matrix. Consequently, its inverse is well-defined and is a positive matrix. The second part of the lemma follows from an application of the Ahlberg-Nilson-Varah bound $\frac{1}{\min_k \{|1 - \boldsymbol{\Omega}_{kk}| - r_k(I - \boldsymbol{\Omega})\}} < 1$, where $r_k(I - \boldsymbol{\Omega})$ is the sum of the non-diagonal elements of row k. Axelsson and Kolotilina show that this bound is sharp for M-matrices,

C.2 Collusion

In this section we formally derive the main properties of the collusive industry equilibrium.

Proof of Proposition 1: Markups under collusion Consider a cartel in industry i composed of two firms, k_1 and k_2. Let y denote the industry equilibrium output. We drop the subscripts i for sake of notation clarity. The objective function of firm k_1 is

$$\tilde{\Pi}\left(q_{k_1}, q_{k_2}\right) = \Pi_{k_1}\left(q_{k_1}, q_{k_2}\right) + \kappa \cdot \Pi_{k_2}\left(q_{k_1}, q_{k_2}\right)$$

subject to the inverse demands $\frac{\tilde{P}_k}{\tilde{P}} = \left(\frac{q_k}{y}\right)^{-\frac{1}{\rho}} \cdot \left(\frac{y}{c}\right)^{-\frac{1}{\eta}}$. The profits of firm k_1 are $\Pi_{k_1} = \tilde{P}_k \cdot q_{k_1} - \frac{W}{z_{k_1}} \cdot q_{k_1}$. Consider the first order condition in q_{k_1}, we have

$$
\begin{aligned}
\frac{\partial \tilde{\Pi}\left(q_{k_1}, q_{k_2}\right)}{\partial q_{k_1}} &= \frac{\partial \Pi_{k_1}\left(q_{k_1}, q_{k_2}\right)}{\partial q_{k_1}} + \kappa \cdot \frac{\partial \Pi_{k_2}\left(q_{k_1}, q_{k_2}\right)}{\partial q_{k_1}} \\
&= \left[1 - \left\{\frac{1}{\rho} + \left(\frac{1}{\eta} - \frac{1}{\rho}\right) \cdot s_{k_1}\right\}\right] P_{k_1} - \frac{W}{z_{k_1}} + \kappa \cdot \frac{\partial P_{k_2}}{\partial q_{k_1}} \cdot q_{k_2}
\end{aligned}
$$

The first two terms are exactly the same as in the FOC without collusion while the last term is the additional term created by the collusion, whereby a firm inter-

nalize only partially the positive externality on the other members of the cartels.

$$\frac{\partial P_{k_2}}{\partial q_{k_1}} \cdot q_{k_2} = \left[\left(\frac{1}{\rho} - \frac{1}{\eta}\right) \cdot P_{k_2} \cdot \left(\frac{q_{k_1}}{y}\right)^{-\frac{1}{\rho}} \cdot y^{-1}\right] \cdot q_{k_2}$$

$$= \left(\frac{1}{\rho} - \frac{1}{\eta}\right) \cdot P_{k_2} \cdot q_{k_2}^{\frac{1}{\rho}} q_{k_1}^{\frac{-1}{\rho}} \cdot \left(\frac{q_{k_2}}{y}\right)^{1-\frac{1}{\rho}}$$

$$= \left(\frac{1}{\rho} - \frac{1}{\eta}\right) \cdot P_{k_1} \cdot s_{k_2}$$

Hence the result. The parameter $\kappa \in [0,1]$ controls the degree of symmetry of the cartel agreement. If $\kappa = 1$ then a member of the cartel cares equally about her own-profits than that of other members of the cartel. In this extreme case, all the members of the cartels set the same markups, that depends only on the sum of the equilibrium market shares of the cartel members. Conversely, $\kappa = 0$ corresponds to the baseline monopolistic competition case. The proof naturally extends to the case of cartels of an arbitrary size.

Proof: Dampened Pass-through under collusion. We can generalize the expression of the pass-through of productivity shocks on prices in the presence of a cartel, the price responses solve the following system

$$d \ln \mathbf{P} = -\left(1 - \mathbf{\Omega}\left[\kappa\right]\right)^{-1} d \ln \mathbf{z} \tag{30}$$

where

$$\mathbf{\Omega}_{kj}\left[\kappa\right] = \begin{cases} \mathbf{\Omega}_{kj} & k \notin \mathcal{C} \\ \mathbf{\Omega}_{kj} + \kappa \sum_{i \in \mathcal{C} \backslash \{k\}} \left(\frac{\mu_k}{\mu_i}\right) \mathbf{\Omega}_{ij} & k \in \mathcal{C} \end{cases}$$

The pass-through is unchanged for the firms not part of the cartel, i.e. the rows $k \notin \mathcal{C}$ while there are extra terms for the firms in the cartels, the rows $k \in \mathcal{C}$. These extra terms are the rescaled versions of the pass-through without cartel for the other members of the cartels. They follow from the fact that cartel members partially respond to each other's market shares, we impact their markups

$$d \ln \mu_k = \mu_k \left(\frac{1}{\eta} - \frac{1}{\rho}\right) \left[ds_k + \kappa \cdot \sum_{j \in \mathcal{C} \backslash \{k\}} ds_j\right]$$

Apply again the ANV bound (actually a min, since it is reached by M-matrices) and notice that $a_{ii}[\kappa] > a_{ii}$ and $r_i(A[\kappa]) < r_i(A)$ where $A[\kappa] = I - \Omega[\kappa]$.

Proofs of Proposition 2. Prices in cartelized industry. 1. Using the previous notation, the price response to a cartel of intensity κ is

$$d \ln \mathbf{P} = (1 - \mathbf{\Omega}[\kappa])^{-1} \cdot \vec{\kappa} \tag{31}$$

where

$$\vec{\kappa} = \begin{cases} \kappa \mu_k \left(\frac{1}{\eta} - \frac{1}{\rho}\right) \displaystyle\sum_{i \in \mathcal{C} \setminus \{k\}} s_i & k \in \mathcal{C} \\ 0 & k \notin \mathcal{C} \end{cases}$$

is the vector with the scalar κ on each row $k \in \mathcal{C}$ and 0 otherwise. Therefore cartels operate just as negative idiosyncratic technological shocks. 4. From the nested CES structure we have $\frac{d \ln y_i}{d \ln P_i} = -\eta$. Hence, when the sector's price index go up, the share of this sector in total consumption goes down.

C.3 Alternative Market Structure: Bertrand Competition

We can alternatively solve the model under the assumption that firms engage in a static game of Bertrand Competition. In the baseline case, the markups are

$$\epsilon(s) \;=\; \rho + (\eta - \rho) \cdot s$$

and

$$\epsilon(s) = \rho + (\eta - \rho) \cdot \left[s_k + \kappa \cdot \sum_{j \in \mathcal{C} \setminus \{k\}} s_j\right]$$

for members of cartel $\mathcal{C}$. We obtain qualitatively similar effects but slightly different magnitudes. Because the firm-specific elasticities are now arithmetic means instead of harmonic means, they are at least as large as in the Cournot case. And therefore the markups in the Bertrand setting are smaller than in the Cournot setting.

D Additional Tables

Table 6: Robustness: Alternative Timing

Dependent Variable	Market Share$_{kt}$		
Timing	5 Years Before Investigation	2 Years Before Sanction	2 Years Before Investigation
	(1)	(2)	(3)
AntiComp$_{it}$	-0.007*	-0.005*	-0.007**
	(0.004)	(0.002)	(0.0035)
AntiComp$_{it}$ × Colluder$_{kt}$	2.973***	4.391***	3.838**
	(0.937)	(1.573)	(1.498)
Revenue TFP$_{kt}$	0.154**	0.154**	0.154**
	(0.063)	(0.063)	(0.063)
2-digit Sector × Year FE	✓	✓	✓
5-digit Industry FE	✓	✓	✓
# Obs.	15,040,836	15,040,836	15,040,836

Notes: Standard errors clustered at the 2-digit sector level. *** p<0.01, ** p<0.05, * p<0.1.

Table 7: Results when Colluders are the Parent Firms

Dependent Variable	Market Share$_{kt}$				
	(1)	(2)	(3)	(4)	(5)
AntiComp$_{it}$	-0.06***	-0.053***	-0.0007*	-0.0055	-0.0054*
	(0.018)	(0.015)	(0.003232)	(0.0027)	(0.003)
AntiComp$_{it}$ × Colluder$_{kt}$	4.156**	3.366**	3.786**	3.373**	5.67**
	(1.66)	(1.60)	(1.56)	(1.599)	(2.525)
Revenue TFP$_{kt}$		0.055		0.15**	
		(0.014)		(0.063)	
# Colluders$_{it}$					-0.001
					(0.0014)
# Colluders$_{it}$ × Colluder$_{kt}$					-0.323
					(0.191)
2-digit Sector × Year FE	✓	✓	✓	✓	✓
5-digit Industry FE			✓	✓	✓
Firm Size Controls		✓			
# Obs.	20,167,666	15,040,842	20,167,662	15,040,836	20,167,662

Notes: Standard errors clustered at the 2-digit sector level. *** p<0.01, ** p<0.05, * p<0.1. Firm size controls include the quantity of workers, capital and materials (in log).

E   Mergers

Our framework naturally extends to a theory of mergers and acquisition. This section sketches such as theory and characterizes the shape of the synergies required for mergers to be welfare-improving given the current market structure.

E.1   Mergers

The analysis of mergers is more involve as their welfare impacts are theoretically ambiguous. This ambiguity follows from the classic trade-off between efficiency and market power emphasized by Williamson (1968): i) an increase in the (combined) market shares taken into consideration while setting the prices, which raises markups, and, ii) productivity gains from potential synergies can reduce the marginal costs of the firms, therefore exerting a downward pressure on prices. To embedd this tradeoff in our framework, let us consider these two countervailing forces in turn.

The first channel, the market power effect, is the main force studied in our model of collusion. Little change is therefore needed, except perhaps a re-interpration of our microfoundations with a greater emphasis on control instead of financial ownership. To assess the impact of the second channel, consider two firms k_1 and k_2 in sector i that decide to merge. Without loss of generality, we suppose that firms are indexed in decreasing order of their productivities and therefore $z_{ik_1} > z_{ik_2}$. After the merger is consumed, we suppose that, at least initially, the acquiring firms does not rebrand completely all the products of the firms it has absorbed (see Allain et al. (2017) for a rebranding in the retail sector). Hence the number of firms in sector i does not change but the maximization program of the merging firms now take into account their common market share. The situation is analogous to situation of common ownership (see O'Brien and Salop (2000) or Schmalz et al). [19] The merging parties now each maximize their profits, internalizing the impact on the sister company. This mechanism is similar to the collusion case and therefore we have

$$\tilde{\epsilon}_i\left(k_1, k_2\right) = \left[\frac{1}{\rho}\left(1 - \left[s_{ik_1} + s_{ik_2}\right]\right) + \frac{1}{\eta}\left[s_{ik_1} + s_{ik_2}\right]\right]^{-1}$$

In the model, mergers perturb the equilibrium prices through two direct chan-

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[19] Alternatively, if one supose that the absorbed firm disappears then mergers would reduce welfare somewhat mechanistically by taking a variety off the market.

nels : i) an increase in the markups of the target and the acquirer $\mu_{ik}, k \in \mathcal{M}$ and ii) a decrease in marginal costs of the merging firms because of the "synergies", i.e. i.e.the increase in $z_{ik}, k \in \mathcal{M}$, that pushes price down and the markup increase due to larger market share. As emphasized in the collusion model, there is an additional indirect channel: the equilibrium response of competitors to the changes in the price level.

The equilibrium price response after the merger is

$$d \ln \mathbf{P} = (1 - \mathbf{\Omega}\,[1])^{-1} \cdot [\vec{\kappa} - d \ln] \tag{32}$$

where

$$\vec{\kappa} = \begin{cases} \mu_k \left(\frac{1}{\eta} - \frac{1}{\rho} \right) \cdot \displaystyle\sum_{i \in \mathcal{M} \backslash \{k\}} s_i & k \in \mathcal{M} \\ 0 & k \notin \mathcal{M} \end{cases}$$

The two vectors in the brackets represent the direct effects of the merger: the market power effect ($\vec{\kappa}$) and the productivity effect ($d \ln$), while the matrix $(1 - \mathbf{\Omega}\,[1])^{-1}$ embeds the general equilibrium effects generated by the merger.[20]

The welfare effects of the mergers are captured by the movements of price index in the industry. If the merger raises the price index, then the welfare of the representative consumer is reduced.

Proposition 4 (Welfare-Improving Mergers). *A merger is weakly welfare-improving if and only if*

$$\mathbb{S} \cdot (1 - \mathbf{\Omega}\,[1])^{-1} \cdot [\vec{\kappa} - d \ln z] \geq 0$$

where $\mathbb{S} = [s_i]^t$ *is the $K \times 1$ vector of the market shares.*

A sufficient condition for a merger to be welfare-improving is that the prices of both firms decrease after the merger is consumed. This is the case as long the efficiency gains are large enough.

Proposition 5 (Sufficient Condition for Welfare-Improving Mergers). *A sufficient condition for a merger $\mathcal{M}$ to be welfare improving is*

$$d \ln z_k \geq \frac{\sum_{i \in \mathcal{M} \backslash \{k\}} s_i}{\eta \frac{\rho - 1}{\rho - \eta} - s_k}, \quad \forall i \in \mathcal{M}$$

[20]We have assumed that the merger is symmetric ($\kappa = 1$). Asymmetric mergers whereby the distribution of control after the merger is not balanced can also be analyzed in our framework, at the cost of extra notations.

Proof. Remark that $d \ln z_k \geq \mu_k \left(\frac{1}{\eta} - \frac{1}{\rho} \right) \sum_{i \in \mathcal{M} \setminus \{k\}} s_i$, and then substitute for μ_i

In order to make this criterion operational as a useful screen for merger reviews, we have to make further assumptions regarding the synergies created.

E.1.1 Merging Technologies

Most mergers involve only two parties, one acquiring and one target company. In this section we consider mergers involving two firms, a *target* firm, t and an acquiring firms, a. We assume that the acquiring firm is the one with the highest productivity, which yields a simpler version of the criterion.

Corollary 1. *A sufficient condition for a two-party merger to be welfare improving is*

$$d \ln z_T \geq \frac{s_T}{\eta \frac{\rho - 1}{\rho - \eta} - s_A}$$

To analyze the trade-off in more details, and deliver a sharper criterion, we make the following assumption[21]

Example 1: Suppose that when two parties merge the productivity of the acquirer does not change while the target benefits from the acquirer's productivity, i.e. $d \ln z_t = \frac{z_A}{z_T} - 1$. Then using the fact that $z_k = \frac{W}{\mu_k P_k}$ and then the expressions linking the markups and the market share, one can express the left hand side only in terms of the market shares $\frac{1 - \left(1 - \frac{\mu \rho}{\mu \eta} \right) s_T}{1 - \left(1 - \frac{\mu \rho}{\mu \eta} \right) s_A} \left(\frac{s_A}{s_T} \right)^{\frac{1}{\rho - 1}}$. Figure 3 shows the regions where this criterion is satisfied. The figure reveals that unless synergies also improve the acquirer's productivity, only very few of the merger would be welfare enhancing. We therefore consider more general merging technologies.

Assumption 5 (Merging Technology). *When two firms k_1 and k_2 merge, their resulting productivity is*

$$m \left(z_{k_1}, z_{k_2} \right) = z_{k_1}^{\alpha} z_{k_2}^{\beta}$$

where $\alpha + \beta$ captures the level of synergies created.

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[21]See David (2015) for a search-based model of mergers with a similar functional form for the post-merger productivity. David (2015) argues that they are positive assortative matching between merging partners and that the amount of synergies can be recovered from the joint size distribution of the merging parties.

Relation with Critical Loss analysis   Critical Loss Analysis is a common criteria used in Merger reviews.[22] This criterion serves to define markets.[23] In this article the definition of markets is guided by the available data and the markets examined in the decision. Because merging firms have successfully used that criteria to argue in court for a broader market definition that the one asserted by the government. It is useful to detail how our criteria can relate to Critical Loss analysis.

Critical Loss analysis examines the counterfactual impact of a "significant and non-transitory increase in price" (SSNIP). The "Critical Loss" is defined as "the magnitude of lost sales that would (just) make it unprofitable for the hypothetical monopolist to impose a SSNIP, and compares it against the so-called Actual Loss of sales that would result from the SSNIP. If the Actual Loss, A, would be less than the Critical Loss, the SSNIP would be profitable". (Farrell Shapiro 2008). With a linear demand and constant marginal cost, Farrell and Shapiro show that the criterion can be written

$$A \geq \frac{s}{m+s}$$

where A is the counterfactual loss (confusingly called "actual loss" in the literature), s the market share and $m = \frac{p-c}{p}$ is the margin. It is possible to apply directly this criterion in our framework. The margin in our model is $m = \frac{1}{\epsilon(s)}$, hence the critical loss criterion becomes

$$A \geq \frac{s}{\frac{1}{\rho}(1-s) + \frac{1}{\eta}s + s}$$

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[22]For instance the guidelines in the United States: U.S. Dep't of Justice & Fed. Trade Comm'n, Horizontal Merger Guidelines (1992,revised1997), http://www.ftc.gov/bc/docs/horizmer.htm.

[23]see Farrell Shapiro footnote 2 The term "Critical Loss" was introduced by Barry Harris and Joseph Simons in Focusing Market Definition: How Much Substitution Is Necessary? 12 RES. L. & ECON. 207 (1989).
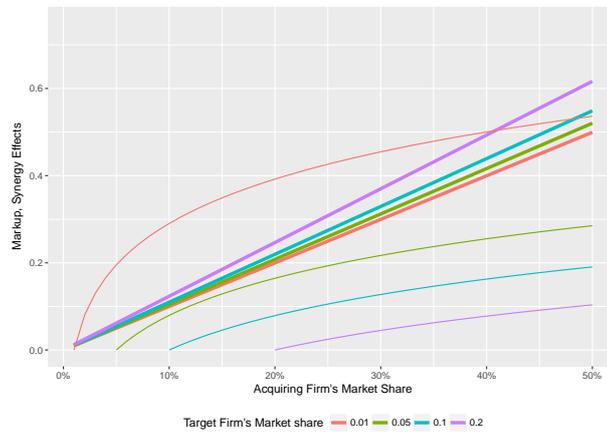
Figure 5: Merger Criterion

Example when the merging technologies is such that the productivities of both firms after the merger is the max of their initial productivities. The figure shows the synergy effects (concave) and the market power effect (linear). Under this specification only mergers involving very small target companies are welfare improving.