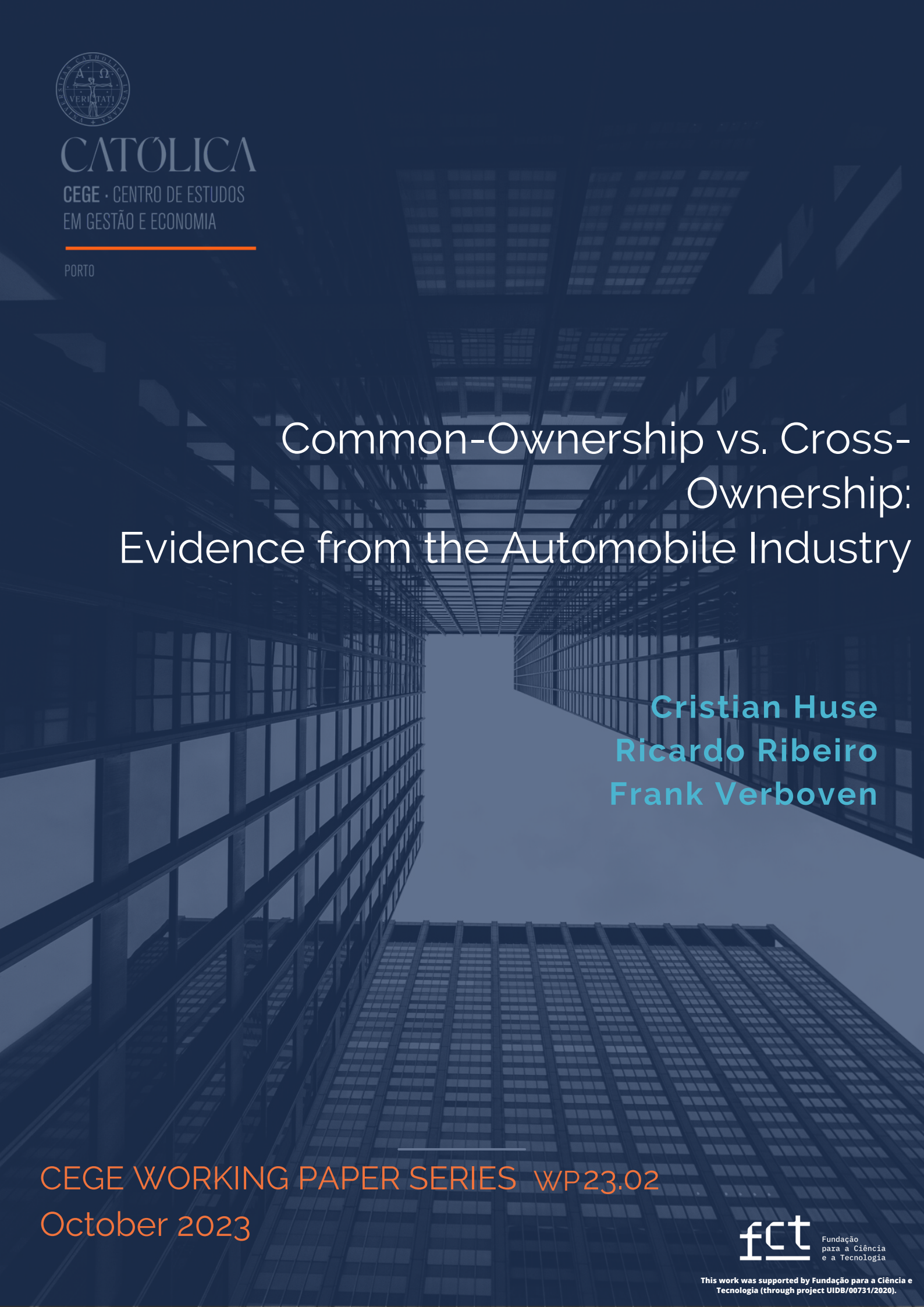


CATÓLICA

CEGE · CENTRO DE ESTUDOS EM GESTÃO E ECONOMIA

PORTO

Common-Ownership vs. Cross-Ownership: Evidence from the Automobile Industry

Cristian Huse

Ricardo Ribeiro

Frank Verboven

CEGE WORKING PAPER SERIES WP23.02

October 2023

fct Fundação para a Ciência e a Tecnologia

This work was supported by Fundação para a Ciência e Tecnologia (through project UIDB/00731/2020).

Common-Ownership *vs.* Cross-Ownership: Evidence from the Automobile Industry*

Cristian Huse
University of Oldenburg, Department of Economics

Ricardo Ribeiro
Universidade Católica Portuguesa, Católica Porto Business School, Research Centre in Management and Economics, Portugal

Frank Verboven
KU Leuven, Department of Economics and CEPR

October 2023

Abstract

Overlapping ownership has gained considerable momentum in the last decades, yet little is known about the role of its sources. We quantify the relative importance of common-ownership, by shareholders external to an industry, and cross-ownership, by firms within the industry. We focus on the global automobile industry, over the period 2007-2021, and document that common-ownership links amount to 31–39%, while cross-ownership links amount to 5–9% of automobile manufacturers' stock. We show that not accounting for these relatively modest cross-ownership links has important implications: it can increase the average weight assigned by managers to the profit of competitors by between 33–68%.

JEL Classification: L13, L41, L62

Keywords: Overlapping Ownership, Common-Ownership, Cross-Ownership, Profit Weights, Automobile Industry

* We would like to thank Anna Tzanaki for helpful comments and suggestions. Cristian Huse, University of Oldenburg, Department of Economics, Germany. Email address: cristian.huse@uol.de. Ricardo Ribeiro (corresponding author), Universidade Católica Portuguesa, Católica Porto Business School, Research Centre in Management and Economics, Portugal. Email address: rribeiro@ucp.pt. Frank Verboven, KU Leuven, Department of Economics and CEPR, Belgium. Email address: frank.verboven@kuleuven.be.

1 Introduction

The unprecedented growth and concentration of the asset management industry over recent decades (McIntyre et al., 2022) has led major asset managers to hold significant stakes in almost all the major firms of a multitude of industries. These common-ownership links may lead to a failure of Hart (1979)'s competitiveness condition, according to which shareholders unanimously agree on own-profit maximization, regardless of their preferences.[1,2] As such, the managers of firms with common shareholders may not maximize own profit, but, instead, weigh the (potential) conflicting preferences of their shareholders and (partially) internalize the externalities their strategies impose on the profits of other firms (Rotemberg, 1984; Hansen and Lott, 1996). This can decrease the incentives to compete and, naturally, lessen product market competition.[3]

In some industries, however, in addition to common-ownership links, by shareholders external to the industry, there are also (for a variety of reasons) cross-ownership links, by shareholders that are internal to the industry, i.e., firms within an industry are themselves shareholders of other firms in the industry. Examples include various industries, such as automobiles (Neto et al., 2020), banking (Termushoev and Stakhovych, 2019), media (Ferguson, 1983), electric power (Amundsen and Bergman, 2002) and insurance (La Porta et al., 1999). Cross-ownership in itself can also decrease the incentives to compete and, naturally, lessen product market competition.[4] Moreover, it also has the potential to *reinforce* common-ownership. The reason is that cross-ownership links change the distribution of ultimate holdings among external shareholders (see, for example, Ellerman, 1991; and Brito et al., 2018a).

To see why, consider, for example, an industry with three firms: firms A, B and C. To begin with, consider a shareholder structure with solely common-ownership links. In

[1] To see why, note, for example, that if firm A imposes a negative externality on firm B, a shareholder of firm A who also holds shares in firm B typically wants the manager of firm A to pursue a less aggressive strategy than the strategy desired by a shareholder with no holdings in firm B.

[2] Although non-common shareholders may favour a different firm-specific strategy, that does not mean they are harmed by common shareholding because these links may, for example, reduce the competitiveness of rival firms, and non-common shareholders benefit from a reduction of competition between the firm and its rivals (see Schmalz, 2018 for a formal model).

[3] For example, Brito et al. (2019) show that the internalization induced by common shareholders among firms with horizontal relationships (and which thereby are likely to impose a negative externality on each other) can directly lead to higher product prices and lower output levels.

[4] For example, Reynolds and Snapp (1986) and Shelegia and Spiegel (2012) show that cross-ownership links can increase prices while Bresnahan and Salop (1986) and Dietzenbacher et al. (2000) show that they can increase price-cost margins. Farrell and Shapiro (1990) show, on the other hand, that even if at the cost of higher prices, cross-ownership links can increase welfare, due to improved industry performance, while Gilo et al. (2006) show that they may not necessarily facilitate tacit collusion.

particular, consider that firm A has two shareholders: shareholders 1 and 2, with shareholder 1 being an external non-common shareholder with holdings solely in firm A and shareholder 2 being an external common shareholder with holdings in firms A and B. This shareholder structure implies, as discussed above, that the manager of firm A may (partially) internalize the externalities her strategies impose on the profit of firm B (as shareholder 2 has a direct interest in the profit of firm B), although not on the profit of firm C (as no shareholder has a direct interest in the profit of firm C).

Consider now a shareholder structure with (additionally) cross-ownership links among the firms in the industry. In particular, consider that firm A has holdings in firm B and that firm B has holdings in firm C. These cross-ownership links have several qualitative implications. First, the ultimate interest of shareholder 2 in firm B is greater than her direct holdings in the firm, because she now also has an indirect interest in the profit of firm B (via the profit of firm A). Second, although shareholder 1 has holdings solely in firm A, the cross-ownership link between firms A and B turns her ultimately into a common shareholder of firm B, because she now has an indirect interest in the profit of this firm (via the profit of firm A). Third, although none of the shareholders of firm A have direct holdings in firm C, the cross-ownership links between the three firms turn these shareholders ultimately into common shareholders of firm C, because they now have an indirect interest in the profit of this firm (via the profit of firms A and B). In other words, cross-ownership links have the potential to reinforce common-ownership in two dimensions: (a) increase the degree of internalization of the externalities that management strategies impose on the profit of the rivals in which external shareholders have direct holdings on; and (b) increase the number of firms considered in this internalization.

The prevalence and rise of common-ownership in the economy over the recent years has already been examined empirically in the literature. Recent examples include Backus et al. (2021b), Amel-Zadeh et al. (2022), and Boot et al. (2022). They all measure the degree of internalization induced by common-ownership using the profit weight formulation suggested by Rotemberg (1984), Bresnahan and Salop (1986), and O'Brien and Salop (2000), and first applied to the modern phenomenon of overlapping ownership by Azar et al. (2018). Backus et al. (2021b) and Amel-Zadeh et al. (2022) examine the set of S&P 500 firms. The former consider the holdings of S&P 500 firms by large institutional shareholders. They show that the average profit weight assigned by managers to other firms has increased from 0.2 in 1980 to almost 0.7 in 2017. The latter consider the holdings not only of institutional shareholders, but also of corporate insiders and blockholders. They show that once we account for these holdings, the profit weight assigned to other firms is, in fact, lower, with most profit weights decreasing by between 5–25%. Boot et al. (2022), in turn, examine the set of S&P Europe

350 firms. They show that the average profit weight assigned to other firms has increased from 0.08 in 2004 to 0.21 in 2015. This implies that while the average profit weight is lower than for the set of S&P 500 firms, the increase has been steeper in Europe than in the United States.

However, to the best of our knowledge, the potential reinforcing role of cross-ownership links on the internalization induced by common-ownership has not been examined empirically in the literature. We propose to fill this gap by examining the relative roles of common- and cross-ownership in the global automobile industry for the period 2007-2021. This industry is ideally suited for such a study for two reasons. First, automobile manufacturers command a substantial share of the global GDP. Thus, it is not surprising that major asset managers have holdings in the major manufacturers.[5] Second, automobile manufacturers engage in different types of partnerships (which include, among others, cross-ownership links) to share high development costs, reduce sourcing costs, gain access to new markets, establish economies of scale or gain access to complementary resources (Robertson and Karl, 1998).[6]

In particular, we document that, during our sample period, common-ownership links in the industry amount to 31–39%, while cross-ownership links amount to 6–9% of automobile manufacturers' stock. We subsequently show that accounting for these relatively modest cross-ownership links has important implications for the profit weights assigned to other firms. We find that accounting for cross-ownership links can increase the average weight assigned by managers to the profit of competitors by between 33–68%.

The remainder of the paper is organized as follows. Section 2 describes the theoretical framework used to compute the profit weights. Section 3 applies the profit weights to the

[5]In 2021, for example, the Big Three asset managers (BlackRock, Vanguard and State Street) held significant stakes in literally all the major manufacturers. These includes BAIC, BMW, Changan, Dongfeng, FAW, Ford, GM, Geely, Great Wall, Honda, Hyundai, Mazda, Mitsubishi, Nissan, Renault, SAIC, Subaru, Suzuki, Stellantis, Tata, Toyota, and Volkswagen.

[6]In fact, cross-ownership links have a long tradition in the automobile industry. Alley (1997) documents cross-ownership links between US and Japanese manufacturers as early as 1979. Examples of long-term partnerships include the holdings (some of which ended already) among Mercedes, Nissan and Renault, between Ford and Mazda, between Nissan and Renault, between Volkswagen and Suzuki, and among Toyota and a number of other Asian manufacturers (see Neto et al., 2020 for a thorough account). Other types of partnerships include joint ventures, where firms join their forces to establish a child company, and non-equity strategic alliances, where firms agree to pool their resources and capabilities together. Examples of horizontal joint ventures are the partnerships between Western car makers and their Chinese counterparts, in order to access the Chinese market (Hu et al., 2014). Vertical joint ventures comprise firms of different industries, such as in efforts to produce batteries, develop autonomous driving technology, build charging infrastructure, and introduce car-sharing services (Automotive News Europe, 2018). A leading example of strategic alliances is the joint development of car platforms, whereby firms share design, engineering, and production efforts, leading to different models sharing the same components (Autoblog, 2022). Recent cases include the joint development of the Toyota GR86 and the Subaru GTR and Volkswagen's MQB platform, whose first version was introduced in 2012, which has been used by different products of the brands Audi, Seat, Skoda, and Volkswagen itself.

global automobile industry. Section 4 concludes and discusses policy implications.

2 Theoretical Framework

There are N multi-product firms, indexed by $f \in \Im \equiv \{1, \ldots, F\}$, whose total stock is composed of voting stock and non-voting (preferred) stock. Both stocks give the holder the right to a share of the firm's profits, but only the former gives the holder the right to vote in the firm's general assembly.

There are also K shareholders, indexed by $k \in \Theta \equiv \{1, \ldots, F, \ldots, K\}$, who may engage in overlapping ownership. The set of shareholders can include not just shareholders $\Theta \setminus \Im$ that are external to the industry (and can engage in common-ownership), but also shareholders from the subset of firms that are internal to the industry (and can engage in cross-ownership).

The holdings $\phi_{kf} \in [0, 1]$ of total stock of shareholder k in firm f, regardless of whether it be voting or non-voting stock, capture her *financial rights* to the firm's profits. The holdings $\upsilon_{kf} \in [0, 1]$ of voting stock of shareholder k in firm f, capture her *voting rights* in the firm. These voting rights may not necessarily coincide with her *control rights* in the firm, $\gamma_{kf} \in [0, 1]$, which refer to her rights to influence the decisions of firm f and depend, in general, not only on her voting rights, but also on the distribution of voting rights in the firm: $\gamma_{kf} = \mathcal{F}(\upsilon_{kf} | \upsilon_{1f}, ..., \upsilon_{kf}, \ldots, \upsilon_{Kf})$.[7] For instance, shareholder k may have no control over the decision-making within firm f, i.e. $\gamma_{kf} = 0$, even while holding 49% of the voting rights in the firm, if one other shareholder holds 51%. In contrast, shareholder k may have effective control over the decision-making within firm f, i.e. $\gamma_{kf} = 1$, even while holding 10% of the voting rights in the firm, if each of the remaining shareholders is atomistic.

We assume that external shareholders hold voting rights in at least one firm of the industry. This implies that the firms in the industry are not entirely held by the firms themselves.[8] As such, we have that $\sum_{k \in \Theta \setminus \Im} \upsilon_{kf} > 0$ for at least one firm f. Because the financial rights of a shareholder in a firm denotes her holdings of total stock in the firm, regardless of whether it be voting or non-voting stock, it implies we also have that $\sum_{k \in \Theta \setminus \Im} \phi_{kf} > 0$ for at least one firm f.

2.1 Ultimate Financial, Voting and Control Rights

The automobile industry is characterized by a multitude of cross-ownership links. We follow Ellerman (1991) and Brito et al. (2018a) in computing the ultimate rights of external share-

[7] Short-sales are not allowed and so financial, voting and control rights are non-negative.

[8] Furthermore, it implies also that we can cope with settings in which a firm can hold 100% of the financial rights of a rival firm.

holders on the different firms that result from the existing cross-ownership links. We begin this analysis by focusing on the financial rights.

2.1.1 Financial Rights

The ultimate financial rights of external shareholder k in firm f, ϕ^u_{kf}, includes not just her direct financial rights in the firm, ϕ_{kf}, but also the indirect financial rights that may arise from having ultimate financial rights in a rival $g \in \Im \backslash f$ that holds, in turn, financial rights in firm f. This implies that for all $k \in \Theta \backslash \Im$ and $f, g \in \Im$, we have:

$$\phi^u_{kf} \quad = \quad \phi_{kf} + \sum\nolimits_{g \in \Im \backslash f} \phi^u_{kg} \phi_{gf}, \tag{1}$$

where $\Im \backslash f$ denotes the set $\Im$ not including firm f. The set of equations (1) implicitly determines the ultimate financial rights of each external shareholder as a function of the direct financial rights of all shareholders (internal and external).[9] Please see Appendix A for the computation details. We now address the voting and control rights.

2.1.2 Voting and Control Rights

The ultimate voting rights of external shareholder k in firm f, υ^u_{kf}, includes not just her direct voting rights in the firm, υ_{kf}, but also the indirect voting rights that may arise from having ultimate control rights in a rival $g \in \Im \backslash f$ that holds, in turn, voting rights in firm f. To see why, consider the following example, borrowed from Levy (2011). If an external shareholder fully controls firms A and B and each of the firms holds in turn 30% of the voting rights in firm C, then the external shareholder ultimately holds 60% of the voting rights in firm C. This implies that for all $k \in \Theta \backslash \Im$ and $f, g \in \Im$, we have:

$$\begin{aligned} \upsilon^u_{kf} \quad &= \quad \upsilon_{kf} + \sum\nolimits_{g \in \Im \backslash f} \gamma^u_{kg} \upsilon_{gf} \\ &= \quad \upsilon_{kf} + \sum\nolimits_{g \in \Im \backslash f} \mathcal{F}\left(\upsilon^u_{kg} | \upsilon^u_{F+1g}, ..., \upsilon^u_{kg}, \ldots, \upsilon^u_{Kg}\right) \upsilon_{gf}. \end{aligned} \tag{2}$$

If the ultimate control rights of external shareholders in any given firm (implied by the vector of their ultimate voting rights) are non-negative and sum up to one, the set of equations (2) implicitly determines the ultimate voting rights of each external shareholder as a function

[9] Brito et al. (2018a) show that the ultimate financial rights of external shareholders implied by the set of equations (1) are non-negative and sum up to one for any given firm f, making clear that a cross-ownership of financial rights changes the distribution of those rights among external shareholders, as the *ultimate* financial rights of external shareholder k in firm f, ϕ^u_{kf}, are not necessarily equal to the *direct* financial rights of external shareholder k in that firm, ϕ_{kf}, but the sum of all financial interests in the firm, are: $\sum_{k \in \Theta} \phi_{kf} = \sum_{k \in \Theta \backslash \Im} \phi^u_{kf} = 1$.

of the direct voting rights of all shareholders (internal and external).[10] Please see Appendix A for the computation details.

2.2 Profit Weights

The managers of firms with overlapping shareholders may weigh the eventual conflicting objectives of their shareholders, rather than maximizing own profits. This implies that they may internalize (to some degree) the externalities their strategies impose on other firms (Rotemberg, 1984; Hansen and Lott, 1996). The quantification of this induced internalization is paramount to empirically quantify the prevalence of overlapping ownership.[11] To do so, the formulation of the weight that the manager of a firm assigns to the profit of other firms is key. This formulation is, however, non-trivial. To see why, consider, for example, that firm A has four shareholders, each holding 25% of the firm, and that one of those shareholders also holds 20% of firm B. If firm A imposes an externality on firm B, what weight would the manager of firm A assign to the profit of firm B?

The dominant formulation of these profit weights in the presence of overlapping shareholders is due to O'Brien and Salop (2000). Incorporating features from both Rotemberg (1984) and Bresnahan and Salop (1986), they assume that (a) the preferences of shareholders are captured by their (financial) returns; and (b) the managers of firms with overlapping shareholders would maximize a control-weighted sum of the returns of the firm's shareholders.[12] In the presence of both cross- and common-ownership, this implies that the manager of each firm f would maximize $\sum_{k\in\Theta\setminus\Im}\gamma^u_{kf}R_k$, where $R_k=\sum_{g\in\Im}\phi^u_{kg}\pi_g$ denotes the return of shareholder k's ultimate financial rights holdings in all the firms in the industry, and π_g denotes the profit of firm g. Naturally, this is entirely equivalent to maximizing a weighted

[10] Brito et al. (2018a) show that the ultimate voting rights of external shareholders implied by the set of equations (2) are non-negative and sum up to one for any given firm f, making clear that a cross-ownership of voting rights changes the distribution of those rights among external shareholders, as the *ultimate* voting rights of external shareholder k in firm f, υ^u_{kf}, are not necessarily equal to the *direct* voting rights of external shareholder k in that firm, υ_{kf}, but the sum of all voting rights in the firm, are: $\sum_{k\in\Theta}\upsilon_{kf}=\sum_{k\in\Theta\setminus\Im}\upsilon^u_{kf}=1$.

[11] See Brito et al. (2023) for a review of the proposals available in the literature for this quantification.

[12] Azar (2012, 2016, 2017), Brito et al. (2018a) and Moskalev (2019) microfound the dominant formulation of these profit weights through a voting model in which shareholders vote to elect the manager from two potential candidates, an incumbent and a challenger, with conceivably differing strategy proposals to the firm (or alternatively vote to express whether they approve or not of a managerial change in the firm's status quo strategic plan). Candidates are assumed to care about holding office. In turn, shareholders are assumed to care about the returns that result from the different strategy proposals and to have an additive profit-irrelevant bias for (or against) the challenger. Voting is probabilistic in the sense that the bias, while known to voters, is unobserved by candidates, who treat it as random. This microfoundation is consistent with empirical evidence establishing that shareholders' voting impacts the objective function of managers (Aggarwal et al., 2019).

sum of the profits of (potentially) all the firms in the industry, where the (normalized) weight that the manager assigns to the profit of firm g for any $f, g \in \Im$ is given by:[13]

$$w_{fg} = \frac{\sum_{k \in \Theta \setminus \Im} \gamma^u_{kf} \phi^u_{kg}}{\sum_{k \in \Theta \setminus \Im} \gamma^u_{kf} \phi^u_{kf}}. \tag{3}$$

This dominant formulation in the literature is derived from the key assumption that managers maximize a control-weighted sum of the returns of the firm's shareholders. In practice, however, operational decision variable(s) may often not be decided by top managers, but by middle managers, who may not know the extent of the holdings of the firm's shareholders in other firms. As such, we may view formulation (3) as a measure of the degree of internalization that *could* be induced by overlapping ownership if managers *fully* internalized the returns of shareholders, but this may differ from the *actual* degree of internalization induced by overlapping ownership. This cautionary remark may help to explain the ongoing debate on the effects of overlapping ownership. Reduced-form evidence suggests that overlapping ownership may impact product prices (Azar et al., 2018; and Azar et al., 2022), but without being very explicit on the underlying mechanisms.[14] Evidence from structural models has been more mixed and industry-specific. Kennedy et al. (2017) and Backus et al. (2021a) find no evidence that overlapping ownership raises product prices, while Park and Seo (2019) and Azar and Ribeiro (2022) find the opposite result.

3 Empirical Application

3.1 Data Description

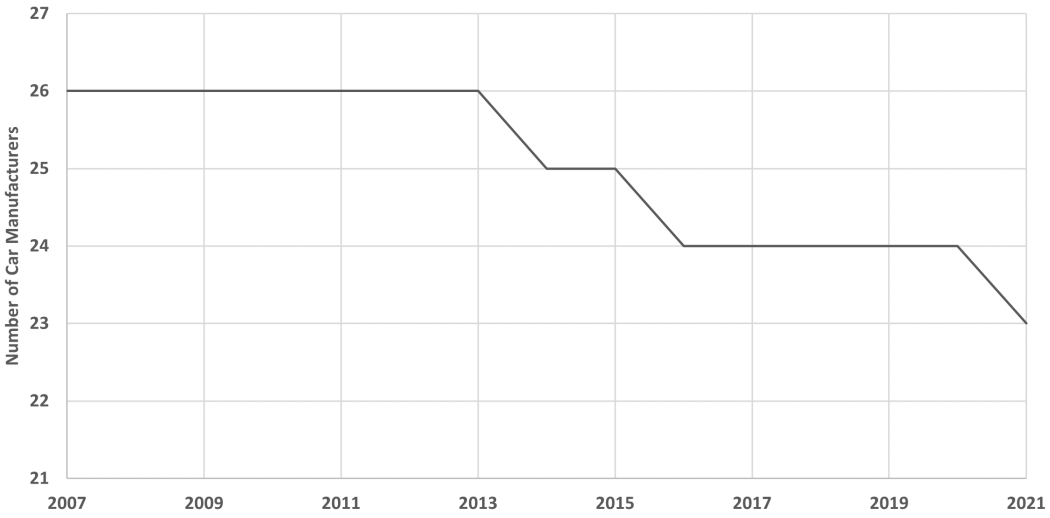
We examine the ownership patterns in the global automobile industry for the period 2007-2021. We focus on the following automobile manufacturers: BAIC, BMW, Changan, Chrysler, Daihatsu, Dongfeng, FAW, Fiat, Ford, Geely, GM, Great Wall, Honda, Hyundai, Mazda, Mercedes, Mitsubishi, Nissan, PSA, Renault, SAIC, Subaru, Suzuki, Tata, Toyota, and Volkswagen.[15] According to the International Organization of Motor Vehicle Manufacturers,

[13] This formulation has been critiqued for yielding counter-intuitive profit weights when the ownership of non-overlapping shareholders is highly dispersed. Brito et al. (2023) propose an alternative formulation of the objective function of managers, which solves this criticism.

[14] Other reduced-form evidence finds an impact of overlapping ownership on stock returns (Boller and Scott Morton, 2020) and entry (Newham et al., 2022).

[15] We do not include Kia as a stand-alone manufacturer because Kia and Hyundai are members of the Hyundai Motor Group, a South Korean chaebol, with Hyundai regarded as the *de facto* representative of the group.

Figure 1: *Number of Car Manufacturers in the Sample*



these manufacturers cover around 90% of the yearly world motor vehicle production.[16]

For each manufacturer and year, we obtain ownership information from Refinitiv Eikon, which we combine when appropriate with ownership information from annual reports and Troubled Asset Relief Program (TARP) assistance reports prepared by the Congressional Research Service for the US Congress. Please see Appendix B for additional details (including the Reuters instrument codes used). Refinitiv Eikon has a number of advantages compared to other data sources. First, in addition to 13F filings, which are only filed by large shareholders in the US, it includes both institutional and non-institutional shareholders. Amel-Zadeh et al. (2022) show that including solely institutional shareholders when calculating measures of overlapping ownership "can bias the measured level and mask the true variation of overlapping ownership of firms, whether in the same industry, or across industries".

Second, the ownership information in Refinitiv Eikon is to a large extent aggregated by asset manager and therefore requires less processing than the 13-F fillings. Notwithstanding this aggregation, it still has several separate entries for the Big Three asset managers (BlackRock, Vanguard and State Street), which report some of their subsidiary holdings separately. We consolidate those entries, since Fichtner et al. (2017) show that the Big Three do utilize coordinated voting strategies and hence follow a centralized corporate governance strategy. We also consolidate the holdings of the following shareholders of BAIC, Changan, Dongfend, FAW, and SAIC: Beijing Automotive Group Co, China Changan Automobile Group Co,

[16]The International Organization of Motor Vehicle Manufacturers provides statistics, by manufacturer, on the world motor vehicle production until 2017. For the period 2007-2017, these manufacturers account for between 87.9–93.1% of the yearly world production.

Dongfeng Motor Corporation, China FAW Co, and Shanghai Automotive Industry (Group), respectively, as they are wholly owned subsidiaries of the Government of the People's Republic of China, the Municipality of Beijing or the municipality of Shanghai.[17]

Third, Refinitiv Eikon has historical data on delisted companies, which is key because of the recent consolidation of the automobile industry. Figure 1 reports the number of automobile manufacturers in the sample over time, illustrating this consolidation: in October 2014, Chrysler and Fiat merge (giving rise to FCA); in August 2016, Daihatsu became a wholly owned subsidiary of Toyota; and in January 2021, FCA and PSA merge (giving rise to Stellantis).

We classify a shareholder of a firm as an internal shareholder (i.e., a rival automobile manufacturer) if the name of the shareholder coincides exactly with the name of the manufacturer from Refinitiv Eikon, with two exceptions: (a) for GM, we also consider the holdings of GM Asset Management; and (b) for Nissan, we also consider the holdings of Nissan Finance Co., Ltd. Both are wholly owned subsidiaries of GM and Nissan, respectively. We do not classify as internal shareholders, affiliated firms of the manufacturer and subsidiaries of external shareholders.[18]

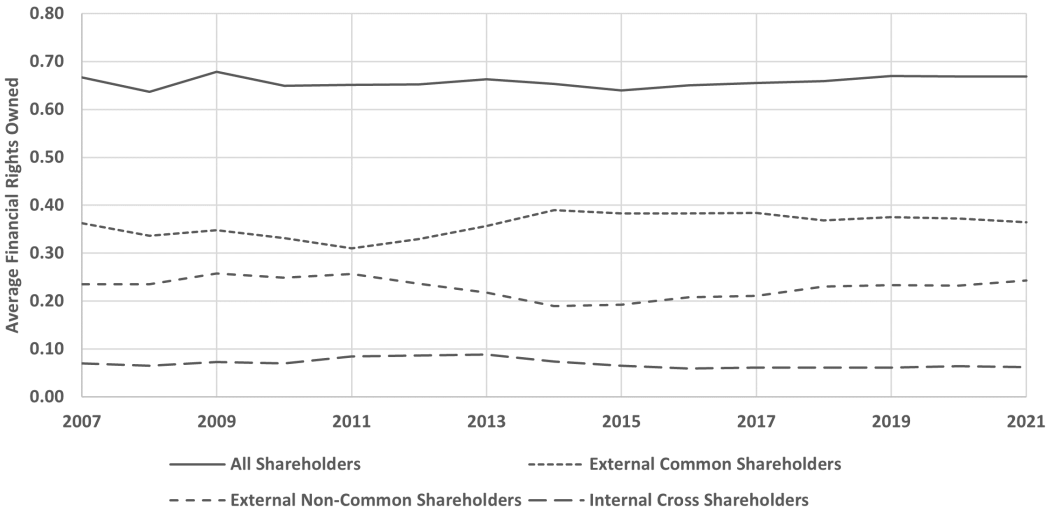
Common and Cross-Ownership Links Figure 2 reports the (arithmetic) average of the financial rights held by the shareholders collected by Refinitiv Eikon for the different automobile manufacturers in each year, discriminated across the different shareholder types. The plot shows that the shareholders collected by Refinitiv Eikon hold between 64–68% of the financial rights in the average automobile manufacturer in the sample, discriminated as follows. Between 19–26% are held by external non-common shareholders (with holdings in a single manufacturer in a given year), between 31–39% are held by external common shareholders (with holdings in at least two manufacturers in a given year, reflecting common ownership), and between 6–9% are held by internal shareholders (reflecting cross-ownership).

Table 1 reports the direct pairwise cross-ownership links in the sample. In each year, there are between 9 and 14 direct pairwise cross-ownership links, involving, on average, between 12–17% of a manufacturer's financial rights. Please see Appendix C for a more detailed description of each cross-ownership link. The links in the first part of the sample stem from

[17] We also consolidate the holdings of Li Shufu, Geely's founder, which are reported by Refinitiv Eikon under two different headings: Li (Shu Fu) and Li (Shufu).

[18] In particular, we do not consider, for Toyota, the holdings of affiliates Toyota Asset Management Co., Ltd. (before the merger in 2013 with Sumitomo Mitsui Asset Management Co Ltd) and Toyota Tsusho Corp, as Toyota stakes on both firms are only partial. Further, we also do not consider, for BAIC, the holdings of BAIC Group Industrial Investment Co Ltd, a wholly owned subsidiary of BAIC's external shareholder Beijing Automotive Group Co. Ltd. Finally, we do not consider, for Mitsubishi, the holdings of other firms of the Mitsubishi Group as each firm of the group is independent.

Figure 2: *Average Financial Rights in the Sample*



a combination of alliances aiming to emulate the successful Renault-Nissan partnership and a response to the challenges posed by the financial crisis, e.g., the quest for cost reductions and production efficiencies through technology sharing and joint development of product lines (BBC, 2012). The recovery of the global economy mid-sample led to a decrease in the number of links while challenges such as the development of electric mobility, autonomous driving, and mobility as a service led to an increase in the number of cross-ownership links in the final part of the sample (Automotive News Europe, 2018).[19]

Table 1 suggests four important patterns about this network of links. First, cross-ownership links may sometimes (but not typically) lead to full mergers (as in the cases of Toyota and Daihatsu, and Fiat and Chrysler). Second, cross-ownership links tend to be relatively persistent over time, although only three pairwise links remain active over the entire sample period: Nissan on Renault; Renault on Nissan; and Toyota on Subaru (or four pairwise links, if we include the link between Toyota and Daihatsu, which led to a full merger). Third, cross-ownership links tend to form both among firms of the same geography (as Mercedes and Renault or Toyota and Subaru) and of different geographies (as Mercedes and BAIC or Nissan and Renault). Fourth, although cross-ownership is relatively modest on average, there are several large cross-ownership links. This implies that

[19]The decrease in cross-ownership links mid-sample occurs due to a variety of reasons such as the Fiat-Chrysler merger (2014) and the Daihatsu acquisition by Toyota (2016); the end of the Volkswagen-Suzuki (2014), Ford-Mazda (2015), and Subaru-Suzuki (2016) partnerships. These were not counteracted by the creation of the Mercedes-BAIC partnership (2013), which introduced a new cross-ownership link with the aim of increasing the foothold of the German carmaker in the Chinese market and sharing development costs (CNN, 2019). Finally, partnerships which increased the number of cross-ownership links towards the end of the sample include Toyota's partnerships with Mazda (2017) and Suzuki (2020).

Table 1: *Direct Cross-Ownership Links in the Sample**

Shareholder	Firm	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Dongfeng	PSA/Stellantis								14.126	13.687	13.662	12.226	12.226	12.226	12.362	4.444
Fiat	Chrysler			20.000	20.000	58.500	58.500	58.500								
Ford	Mazda	33.407	13.782	13.782	3.500	3.500	2.078	2.078	2.077							
GM	Ford	0.033		0.017		0.005	0.004	0.005	0.003							
	Mercedes	0.002	0.002													
	PSA						7.000									
Mazda	Toyota												0.254	0.254	0.254	0.254
Mercedes	BAIC							12.000	10.566	10.083	10.083	10.083	9.554	9.554	9.554	9.554
	Chrysler	19.900	19.900													
	Nissan				3.100	3.100	3.100	3.100	3.100	3.100	3.272	3.320	3.320	3.320	3.320	3.320
	Renault				3.100	3.100	3.100	3.100	3.100	3.100	3.100	3.100	3.100	3.100	3.100	
	Tata	6.641	6.637	5.690												
Nissan	Mitsubishi										33.995	33.995	33.995	33.995	33.995	33.995
	Renault	15.000	15.000	15.000	15.000	15.000	15.000	15.000	15.000	15.000	15.000	15.000	15.000	15.000	15.000	15.000
Renault	Mercedes				3.087	3.086	3.081	3.099	3.099	3.099	3.099	3.099	3.099	3.099	3.099	1.541
	Nissan	44.329	44.329	44.329	43.401	43.401	43.401	43.401	43.401	43.401	43.401	43.401	43.401	43.401	43.401	43.401
Subaru	Suzuki	1.065	1.065	1.065	1.065	1.065	1.030	1.030	1.030	1.030						
Suzuki	Subaru	1.749	1.749	1.749	1.749	1.749	1.749	1.749	1.749	1.749						
	Toyota														0.190	0.190
Toyota	Daihatsu	51.190	51.190	51.190	51.190	51.190	51.190	51.190	51.190	51.190						
	Mazda											5.054	5.054	5.054	5.054	5.054
	Subaru	8.686	16.478	16.478	16.478	16.478	16.478	16.478	16.478	16.478	16.771	16.771	16.771	16.771	19.969	19.969
	Suzuki														4.887	4.887
Volkswagen	Suzuki			19.893	19.893	19.893	19.893	19.893	19.893							
Number of Direct CO Links		11	10	11	12	13	14	14	14	11	9	10	11	11	13	12
Average FR of Direct CO Links		16.546	17.013	17.199	15.130	16.928	16.115	16.473	13.201	14.720	15.820	14.605	13.252	13.252	11.860	11.801

* Figures represent the (financial) holdings in percentage points of the manufacturer depicted in the shareholder's column on the manufacturer depicted in the firm's column. Chrysler denotes holdings on Chrysler LLC for the period 2007-2008, and Chrysler Group LLC for the period 2009-2013. Fiat denotes the holding of Fiat Automobiles S.p.A. for the period 2007-2013. Mercedes denotes holdings of and on Daimler AG for the period 2007-2021. PSA/Stellantis denotes holdings on Peugeot S.A. for the period 2007-2020 and Stellantis N.V. for 2021. Subaru denotes holdings of and on Fuji Heavy Industries Ltd. for the period 2007-2016 and Subaru Corp for the period 2017-2021.

from a policy perspective, cross-ownership may be a potential concern even if one ignores common-ownership.[20]

Having described the common- and cross-ownership links in the industry, we now examine whether the two link types are correlated. To do so, we pool the links for each manufacturer pair in each year and run a series of regressions, depicted in Table 2. We begin by examining whether common- and cross-ownership links (of any given manufacturer in a competitor) are correlated *per se* (independently of their magnitude). We run a probit regression relating the indicator of a cross-ownership link (of any magnitude) to the indicator of the corresponding common-ownership link (of any magnitude). See Models (1) and (2) in Table 2. We find that the correlation between the two link types is not statistically significant. We then examine whether cross-ownership links (of any given manufacturer in a competitor) are correlated with the *magnitude* of the corresponding common-ownership links. We run a probit regression relating the indicator of a cross-ownership link (of any magnitude) to the magnitude of the corresponding common-ownership link (measured as the total financial rights held by external common shareholders of the manufacturer in the competitor). See Models (3) and (4) in Table 2. We find that this correlation is statistically significant and positive. Finally, we examine whether the magnitudes of common- and cross-ownership links (of any given manufacturer in a competitor) are correlated. We run a Tobit regression (because of the large number of null cross-ownership links in the industry) relating the magnitude of cross-ownership links to the magnitude of the corresponding common-ownership links. See Models (5) and (6) in Table 2. We find that this correlation is statistically significant and positive. Naturally, correlation does not imply causation, but overall these findings suggest that cross-ownership links are, to some extent, significantly related to the magnitude of common-ownership links.

3.2 Profit Weights

At first sight, the above findings suggest that cross-ownership links are relatively unimportant compared with common-ownership links. To evaluate this, we use the ownership data to compute the profit weights associated to each manufacturer pair in each year. We consider two formulations of the profit weight. First, we consider the formulation established in

[20] According to US merger rules, cross-ownership links, involving corporate control or not, are subject to both ex-ante and ex-post review. This follows the same legal standard as any other acquisition, with the exception of non-controlling cross-ownership links, which are subject to a more lenient standard under merger control rules. According to EU merger rules, cross-ownership links are subject to (ex-ante) review solely if they entail a "lasting change of control". Non-controlling cross-ownership links may in theory still be captured by antitrust rules, although in practice since antitrust enforcement became decentralised, these rules have not been applied in a case. See Tzanaki (2023) for a more detailed discussion.

Table 2: *Correlations between Cross- and Common-Ownership Links**

	(1)	(2)	(3)	(4)	(5)	(6)
Common-Ownership Link	0.517	0.484				
	(0.344)	(0.357)				
Magnitude Common-Ownership Link			1.174**	1.145**	0.174**	0.169**
			(0.284)	(0.289)	(0.052)	(0.053)
Year Fixed-Effects	No	Yes	No	Yes	No	Yes
Log L	-865.738	-864.438	-864.080	-862.801	-709.179	-708.096

* All regressions are based on 9016 manufacturer-pair fg observations. Robust standard errors in parentheses. Models (1) and (2) represent ML estimates of a probit regression relating an indicator that takes the value one if manufacturer f holds a stake in competitor g (of any magnitude) to an indicator that takes the value one if the external shareholders of manufacturer f hold stakes in competitor g (of any magnitude). Models (3) and (4) represent ML estimates of a probit regression relating an indicator that takes the value one if manufacturer f holds a stake in competitor g (of any magnitude) to the total holdings of the external shareholders of manufacturer f in competitor g. Models (5) and (6) represent ML estimates of a Tobit regression relating the holdings of manufacturer f in competitor g to the total holdings of the external shareholders of manufacturer f in competitor g. ** indicates significance at the 1% level.

equation (3), which accounts for the cross-ownership links in the industry, by distinguishing between internal and external shareholders and using the *ultimate* rights of external shareholders. Second, for comparison, we consider a formulation of the profit weight which does not account for the cross-ownership links in the industry. In this case, we do not distinguish between internal and external shareholders and consider solely the *direct* rights of shareholders, as if all shareholders (internal and external) were external to the industry. This mimics the formulation in Backus et al. (2021b), Amel-Zadeh et al. (2022), and Boot et al. (2022), and, as such, we denote it as our *baseline* profit weight.

Moreover, we consider two measures of corporate control. We consider that the control rights of shareholders are measured by their voting rights (as in, for example, Azar et al., 2018; Backus et al., 2021b; Amel-Zadeh et al., 2022; Azar et al., 2022; Azar and Ribeiro, 2022; and Boot et al., 2022). However, this measure of control rights may have two unappealing properties: it does not converge to 100% as the voting rights of a shareholder approach 50% and it does not depend on the voting rights of the firm's all other shareholders.[21] To address these two unappealing properties, we therefore also measure the control rights of shareholders by the normalized Banzhaf power indices that result from their voting rights (as in, for example, Azar et al., 2018; Brito et al., 2018a, Brito et al., 2018b; and Azar and Vives, 2022).[22] Finally, we follow the literature in assuming a one-share-one-vote rule

[21] This is because we may expect a shareholder with, for example, 10% of the firm's voting rights to have effective control if each of the remaining shareholders hold a tiny amount of the firm's voting rights.

[22] To do so, we compute, following Dubey and Shapley (1979), the normalized Banzhaf power indices using the set of observed shareholders.

and that the (unobserved) retail share of each firm is made up of an infinity of atomist shareholders. Appendix D provides the Julia code used to perform these computations.

We begin by computing first, as an illustration, the profit weights associated to five (of the typically) top automobile manufacturers: Ford, GM, Hyundai, Toyota, and Volkswagen. According to the International Organization of Motor Vehicle Manufacturers, these manufacturers cover around 45% of the yearly world motor vehicle production.[23]

Figure 3 reports the (arithmetic) average weight that *each* of the five manufacturers potentially assigns to the profit of the remaining manufacturers in the sample, in each year. Panels A1-A5 consider the case in which control rights are measured by voting rights while Panels B1-B5 consider the case in which control rights are measured by the normalized Banzhaf power indices that result from voting rights.

The plots of both panels of Figure 3 suggest that the extent of *existing* common-ownership varies substantially across manufacturers. For Hyundai and Volkswagen, the average *baseline* profit weight (i.e., not accounting for cross-ownership links) is low (below 0.03) and roughly constant across the sample while for Ford, GM and Toyota, it is (for the most cases) comparatively higher and tends to increase over time.[24] Further, the plots also suggest that accounting for the cross-ownership links in the industry is important, even when firms do not have any *direct* cross-ownership links to competitors (as it is the case, for example, with Ford and GM between 2015 and 2021), although the magnitude of the *reinforcing role* of cross-ownership varies substantially across manufacturers.

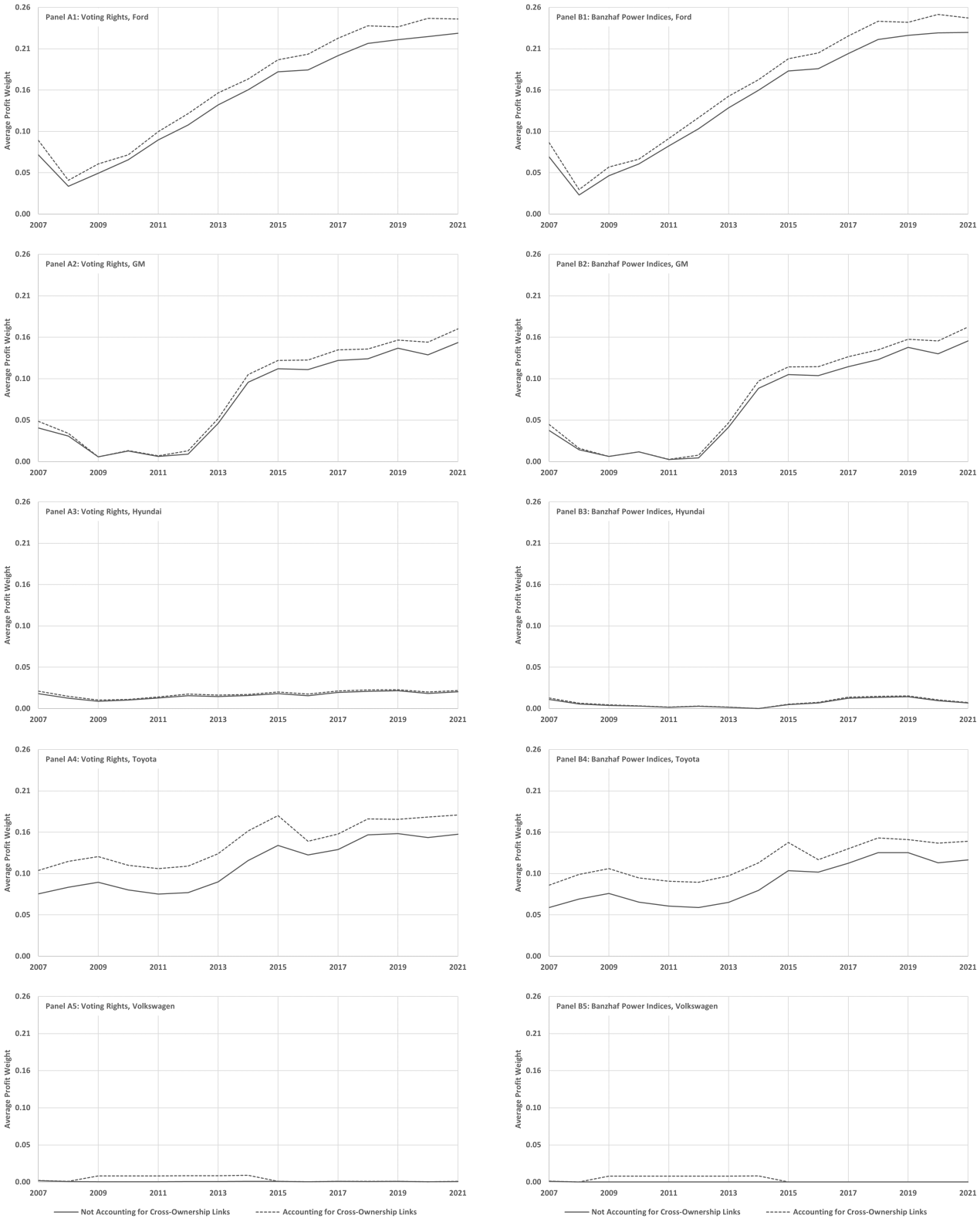
We now take a more aggregate approach in the lines of Backus et al. (2021b), Amel-Zadeh et al. (2022) and Boot et al. (2022). Figure 4 reports the (arithmetic) average potential profit weight of *all* cross-pairs of car manufacturers in the sample in each year. As before, Panel A considers the case in which control rights are measured by voting rights while Panel B considers the case in which control rights are measured by the normalized Banzhaf power indices that result from voting rights.

The plots of both panels suggest that the average baseline profit weight has increased steadily over time from just over 0.05 in 2007 to between 0.10–0.11 in 2017 (depending on how control rights are measured) and has decreased slightly since then. Hence, profit weights in the global automobile industry are lower when compared to the set of S&P 500 firms (as

[23] The International Organization of Motor Vehicle Manufacturers provides statistics, by manufacturer, on the world motor vehicle production until 2017. For the period 2007-2017, these manufacturers account for between 42.6–47.6% of the yearly world production.

[24] There are two broad exceptions to this characterization: (a) the average baseline profit weight of Ford exhibits a sharp decrease in 2008 due to the financial crisis; and (b) the average profit weight of GM also exhibits a sharp decrease (to the point of becoming almost zero) in the period between the 2008 financial crisis (which led GM to fill for a government-backed Chapter 11 reorganization in June 2009) and the Treasury stock sales announced in April 2013.

Figure 3: *Average Profit Weights of Top Automobile Manufacturers*



reviewed in the introduction). This is consistent with the evidence in Boot et al. (2022), as US asset managers typically hold smaller stakes in non-US firms. Further, the plots also suggest that accounting for the cross-ownership links in the industry is important. Not doing so, i.e., computing profit weights as if all shareholders (internal and external) were external to the industry, underestimates the average profit weight. In particular, the average profit weight accounting for cross-ownership links is between 33% and 68% *higher* (depending on the years and on how control rights are measured).

To examine this bias in more detail, Figure 4, Panels C and D report the distribution of the percentage change in profit weights due to accounting for cross-ownership links, for all individual firm-pairs across all years.[25] They do so for three levels of the baseline profit weights: zero profit weights, positive profit weights less than or equal to 0.5, and positive profit weights greater than 0.5.

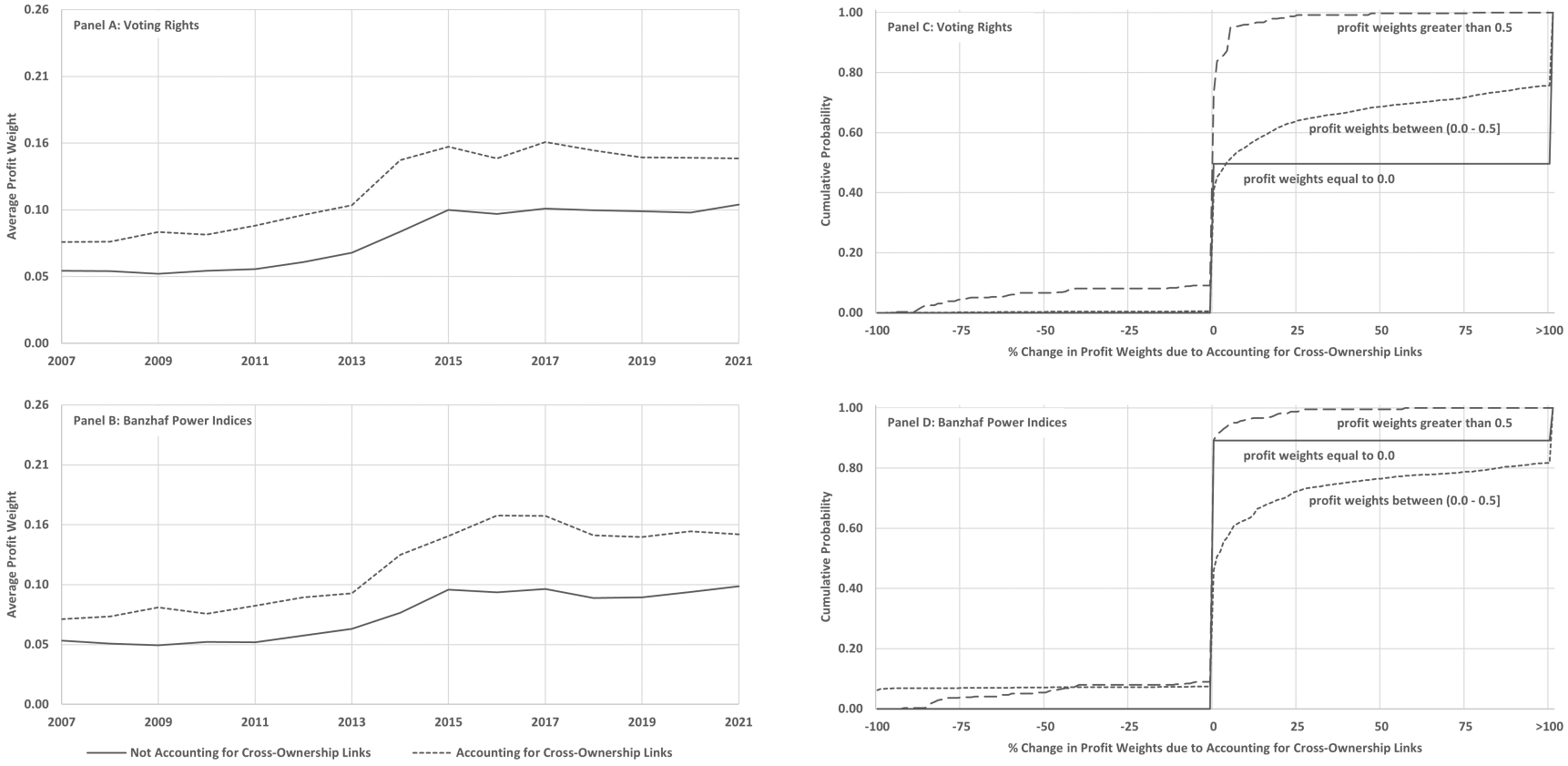
Figure 4, Panel C considers the case in which control rights are measured by voting rights. The results confirm that cross-ownership links do alter the extent of *existing* common-ownership. In particular, we find that when we account for cross-ownership links, the share of *positive* baseline profit weights that do change is sizeable: 60% for baseline profit weights between zero and 0.5 (which account for 87% of the profit weights), and 36% for baseline profit weights greater than 0.5 (which account for 4% of the profit weights). Further, the changes are mostly positive,[26] which implies that cross-ownership links typically *reinforce* the degree of internalization induced by existing common-ownership. In particular, we find that the changes in baseline profit weights between zero and 0.5 are concentrated between 1–25% (23% out of 60%) and above 100% (24% out of 60%), while the changes in baseline profit weights greater 0.5 are concentrated between 1–25% (26% out of 36%). Finally, the results also confirm that cross-ownership links can induce otherwise *non-existent* common-ownership. In particular, we find that when we account for cross-ownership links, 50% of the *zero* baseline profit weights (which account for 8% of the profit weights) do change and become positive. These results are (qualitatively) robust to measuring control rights by the normalized Banzhaf power indices that result from voting rights, as depicted in Figure 4, Panel D.

Naturally, automobile manufacturers in the sample may not be active in all markets. For that reason, we may not, as such, directly infer competition concerns from the profit weights for the whole industry. In order to examine this issue, we make use of country-level

[25] The percentage change associated to individual firm-pairs for which profit weights are zero regardless of whether we account or not for cross-ownership links, is depicted as zero in Figure 4, Panels C and D.

[26] Accounting for cross-ownership links changes the distribution of (financial and voting) rights among external shareholders. If the change in distribution is such that, for example, the *concentration* of common external shareholders decreases once we account for cross-ownership links, profit weights can *decrease*.

Figure 4: *Average Profit Weights of the Global Automobile Industry*



motor vehicle (volume) sales data, obtained from the market research firm JATO, to consider in more detail five (sizeable) regional markets: Australia, Brazil, China, Europe, and the US. The analysis documents that although the number of automobile manufacturers active in each market is typically (and sometimes substantially) lower than the total number of automobile manufacturers in our overall sample, we obtain the same *qualitative* patterns for the regional markets (naturally with quantitative differences across regions) as those found for the global automobile industry as a whole. Please see Appendix E for the full regional analysis and Appendix F for the list of automobile manufacturers considered in each regional market and year.

4 Conclusions

We examine the evolution of overlapping ownership in the global automobile industry over the period 2007-2021. As the industry is characterized by both common- and cross-ownership links, it is important to quantify the relative importance of these two sources of overlapping ownership.

We document that common-ownership links amount to 31–39%, while cross-ownership links amount to 6–9% of automobile manufacturers' stock. Moreover, we show that accounting for these relatively modest cross-ownership links has important implications. It increases the average weight potentially assigned by managers to the profit of competitors by between 33–68%, depending on the years and on the measure of corporate control used.

Our findings have important implications for future research. They suggest that in industries in which cross-ownership is a potentially important phenomenon, those links may provide additional useful variation in profit weights. In future research, this variation can be used to help identifying the impact of overlapping ownership on competition, and the mechanisms behind it.

Our findings also have important policy implications for merger analysis in industries characterized by common-ownership links. In general, one may distinguish between two effects (see also, for example, Azar and Tzanaki, 2022). On the one hand, existing common-ownership between merging firms reduces the incremental anti-competitive effect of a merger. On the other hand, common-ownership with non-merging competitors may raise these firms' responses. Hence, the overall effect is ambiguous. As such, concerns may arise depending on the specific merger, and would be different if one also incorporates the role of cross-ownership as an amplifier of common-ownership.

References

Aggarwal, R., Dahiya, S., and Prabhala, N. R. (2019). The power of shareholder votes: Evidence from uncontested director elections. *Journal of Financial Economics*, 133(1):134–153.

Alley, W. A. (1997). Partial ownership arrangements and collusion in the automobile industry. *Journal of Industrial Economics*, 45:191–205.

Amel-Zadeh, A., Kasperk, F., and Schmalz, M. C. (2022). Mavericks, universal, and common owners - the largest shareholders of U.S. public firms. Unpublished Manuscript, University of Oxford.

Amundsen, E. S. and Bergman, L. (2002). Will cross-ownership re-establish market power in the Nordic power market? *Energy Journal*, 23:73–95.

Autoblog (2022). Platform sharing: Why car companies build multiple models on the same chassis. Technical report, https://www.autoblog.com/article/platform-sharing-why-build-multiple-models-same-chassis.

Automotive News Europe (2018). Why alliances are more crucial than ever to auto companies' survival. Technical report, https://europe.autonews.com/article/20181202/ANE/181139995/why-alliances-are-more-crucial-than-ever-to-auto-companies-survival.

Azar, J. (2012). *A New Look at Oligopoly: Implicit Collusion through Portfolio Diversification*. PhD thesis, Doctoral Dissertation, Princeton University.

Azar, J. (2016). Portfolio diversification, market power, and the theory of the firm. Unpublished Manuscript, University of Navarra.

Azar, J. (2017). Portfolio diversification, market power, and the theory of the firm. Unpublished Manuscript, University of Navarra.

Azar, J., Raina, S., and Schmalz, M. C. (2022). Ultimate ownership and bank competition. *Financial Management*, 51(1):227–269.

Azar, J. and Ribeiro, R. (2022). Estimating oligopoly with shareholder voting models. Unpublished Manuscript, University of Navarra.

Azar, J., Schmalz, M. C., and Tecu, I. (2018). Anticompetitive effects of common ownership. *Journal of Finance*, 73(4):1513–1565.

Azar, J. and Tzanaki, A. (2022). Common ownership and merger control enforcement. In Kokkoris, I. and Lemus, C., editors, *Research Handbook on the Law and Economics of Competition Enforcement*. Edward Elgar Publishing.

Azar, J. and Vives, X. (2022). Revisiting the anticompetitive effects of common ownership. Unpublished Manuscript, University of Navarra.

Backus, M., Conlon, C., and Sinkinson, M. (2021a). Common ownership and competition in the ready-to-eat cereal. Unpublished Manuscript, NBER.

Backus, M., Conlon, C., and Sinkinson, M. (2021b). Common ownership in America: 1980-2017. *American Economic Journal: Microeconomics*, 13(3):273–308.

BBC (2012). Will carmaker alliances result in identikit cars? Technical report, https://www.bbc.com/news/business-19784691.

Boller, L. and Scott Morton, F. (2020). Testing the theory of common stock ownership. Unpublished Manuscript, NBER.

Boot, N., Seldeslachts, J., and Banal-Estañol, A. (2022). Common ownership: Europe vs. the U.S. Unpublished Manuscript, KU Leuven.

Bresnahan, T. F. and Salop, S. C. (1986). Quantifying the competitive effects of production joint ventures. *International Journal of Industrial Organization*, 4(2):155–175.

Brito, D., Elhauge, E., Ribeiro, R., and Vasconcelos, H. (2023). Modelling the objective function of managers in the presence of overlapping shareholding. *International Journal of Industrial Organization*, 87:102905.

Brito, D., Osório, A., Ribeiro, R., and Vasconcelos, H. (2018a). Unilateral effects screens for partial horizontal acquisitions: The generalized HHI and GUPPI. *International Journal of Industrial Organization*, 59:127–189.

Brito, D., Ribeiro, R., and Vasconcelos, H. (2018b). Quantifying the coordinated effects of partial horizontal acquisitions. *European Economic Review*, 110:108–149.

Brito, D., Ribeiro, R., and Vasconcelos, H. (2019). Can partial horizontal ownership lessen competition more than a monopoly? *Economics Letters*, 176:90–95.

Canis, B. and Webel, B. (2013). The role of TARP assistance in the restructuring of General Motors. Technical report, Congressional Research Service.

CNN (2019). Chinese carmakers now own 15 % of Germany's Daimler. Technical report, https://edition.cnn.com/2019/07/23/business/daimler-baic-mercedes/index.html.

Dietzenbacher, E., Smid, B., and Volkerink, B. (2000). Horizontal integration in the Dutch financial sector. *International Journal of Industrial Organization*, 18(8):1223–1242.

Dubey, P. and Shapley, L. S. (1979). Mathematical properties of the Banzhaf power index. *Mathematics of Operations Research*, 4(2):99–131.

Ellerman, D. (1991). Cross ownership of corporations: A new application of input-output theory. *Metroeconomica*, 42:33–46.

Farrell, J. and Shapiro, C. (1990). Asset ownership and market structure in oligopoly. *The RAND Journal of Economics*, 21(2):275–292.

Ferguson, J. M. (1983). Daily newspaper advertising rates, local media cross-ownership, newspaper chains, and media competition. *Journal of Law and Economics*, 26:635–654.

Fichtner, J., Heemskerk, E. M., and Garcia-Bernardo, J. (2017). Hidden power of the big three? Passive index funds, re-concentration of corporate ownership, and new financial risk. *Business and Politics*, 19(2):298–326.

Gilo, D., Moshe, Y., and Spiegel, Y. (2006). Partial cross ownership and tacit collusion. *The RAND Journal of Economics*, 37(1):81–99.

Hansen, R. G. and Lott, J. R. (1996). Externalities and corporate objectives in a world with diversified shareholder/consumers. *The Journal of Financial and Quantitative Analysis*, 31(1):43–68.

Hart, O. D. (1979). On shareholder unanimity in large stock market economies. *Econometrica*, 47(5):1057–1083.

Hu, W.-M., Xiao, J., and Zhou, X. (2014). Collusion or competition? Interfirm relationships in the Chinese auto industry. *The Journal of Industrial Economics*, 62(1):1–40.

Kennedy, P., O'Brien, D. P., Song, M., and Waehrer, K. (2017). The competitive effects of common ownership: Economic foundations and empirical evidence. Unpublished Manuscript, Bates White Economic Consulting.

La Porta, R., Lopez-De-Silanes, F., and Shleifer, A. (1999). Corporate ownership around the world. *The Journal of Finance*, 54:471–517.

Levy, M. (2011). The Banzhaf index in complete and incomplete shareholding structures: A new algorithm. *European Journal of Operational Research*, 215(2):411–421.

McIntyre, C., Bartletta, S., Bhattacharya, I., Carrubba, J., Frankle, D., Frazao, M., Heredia, L., Mörstedt, H., Reeves, K. N., Palmisani, E., Pardasani, N., Reeves, M., Schulte, T., Sheridan, B., Slack, B., and Zhu, K. (2022). From tailwinds to turbulence - global asset management 2022. Technical report, Boston Consulting Group.

Moskalev, A. (2019). Objective function of a non-price-taking firm with heterogeneous shareholders. Unpublished Manuscript, University of Michigan.

Murata, Y. (1977). *Mathematics for Stability and Optimization of Economic Systems*. Academic Press, New York.

Neto, M. S., Carmo, M. J. d., Ribeiro, E. M. S., and Cruz, W. V. G. d. (2020). Corporate ownership network in the automobile industry: Owners, shareholders and passive investment funds. *Research in Globalization*, 2:100016.

Newham, M., Seldeslachts, J., and Banal-Estañol, A. (2022). Common ownership and market entry: Evidence from pharmaceutical industry. Unpublished Manuscript, DIW Berlin.

O'Brien, D. P. and Salop, S. C. (2000). Competitive effects of partial ownership: Financial interest and corporate control. *Antitrust Law Journal*, 67(3):559–614.

Park, A. H. and Seo, K. (2019). Common ownership and product market competition: Evidence from the U.S. airline industry. *Korean Journal of Financial Studies*, 48(5):617–640.

Reynolds, R. J. and Snapp, B. R. (1986). The competitive effects of partial equity interests and joint ventures. *International Journal of Industrial Organization*, 4(2):141–153.

Robertson, D. and Karl, U. (1998). Planning for product platforms. *Sloan Management Review*, 39(4):19–31.

Rotemberg, J. J. (1984). Financial transaction costs and industrial performance. Unpublished Manuscript, Alfred P. Sloan School of Management.

Schmalz, M. C. (2018). Common ownership and fiduciary duty. Unpublished Manuscript, University of Oxford.

Shelegia, S. and Spiegel, Y. (2012). Bertrand competition when firms hold passive ownership stakes in one another. *Economics Letters*, 114(1):136–138.

Termushoev, U. and Stakhovych, S. (2019). Cross-shareholding in the Japanese banking sector, tacit collusion, and market power. Unpublished Manuscript, University of Central Asia.

Tzanaki, A. (2023). Minority shareholdings. In Healey, D., Kovacic, B., Trevisán, P., and Whish, R., editors, *Global Dictionary of Competition Law*. Concurrences.

Webel, B. and Canis, B. (2012). TARP assistance for Chrysler: Restructuring and repayment issues. Technical report, Congressional Research Service.

Appendices

A Ultimate Rights

Ultimate Financial Rights

In order to see why the set of equations (1) in the main text implicitly determines the ultimate financial rights of each external shareholder as a function of the direct financial rights of all shareholders (internal and external), let $\mathbf{F}$ and $\mathbf{F}^u$ denote the $(K-F)\times F$ matrices capturing the direct and ultimate financial rights, respectively, of external shareholders, with typical elements ϕ_{kf} and ϕ^u_{kf} representing the direct and ultimate financial rights, respectively, of external shareholder k in firm f. Let also $\mathbf{F}^*$ denote the $F\times F$ matrix capturing the direct financial rights of internal shareholders, with zero diagonal elements, $\phi_{ff}=0$, and off-diagonal elements, $0\leq\phi_{fg}\leq 1$ (if $f\neq g\in\Im$), representing the direct financial rights of firm f in firm g. We can then use matrices $\mathbf{F}$, $\mathbf{F}^u$ and $\mathbf{F}^*$ to write the set of equations (1) in vector notation, as follows:

$$\mathbf{F}^u \quad = \quad \mathbf{F}+\mathbf{F}^u\mathbf{F}^*. \tag{A.1}$$

In order to solve for $\mathbf{F}^u$ explicitly we can rewrite it as:

$$\mathbf{F}^u\left(\mathbf{I}_F-\mathbf{F}^*\right) \quad = \quad \mathbf{F}, \tag{A.2}$$

where $\mathbf{I}_F$ denotes a $F\times F$ identity matrix.

The assumption that external shareholders hold voting rights in at least one firm of the industry implies that $\sum_{k\in\Im}\phi_{kf}\leq 1$ for all firms f with strict inequality for at least one firm. This constitutes a sufficient condition for the Frobenius root of the non-negative square matrix $\mathbf{F}^*$ to be less than unit (see Theorem 12, Chapter 4, in Murata, 1977). As a consequence, the absolute value of any eigenvalue of $\mathbf{F}^*$ is less than unit and, thus, its spectral radius, which implies, in turn, that $\left(\mathbf{I}_N-\mathbf{F}^*\right)^{-1}$ exists, with typical element ϕ^*_{fg}

representing the ultimate financial rights of firm f in firm g. We can, thereby, solve for $\mathbf{F}^u$ explicitly as follows:

$$\mathbf{F}^u = \mathbf{F}\left(\mathbf{I}_N - \mathbf{F}^*\right)^{-1}, \tag{A.3}$$

which establishes, as postulated, that the ultimate financial rights of each external shareholder can, in fact, be written as a function of the direct financial rights of all shareholders.

Ultimate Voting and Control Rights

In order to see why that the set of equations (2) in the main text implicitly determines the ultimate voting rights of each external shareholder as a function of the direct voting rights of all shareholders (internal and external), let $\mathbf{V}$, $\mathbf{V}^u$ and $\mathbf{C}^u$ denote the $(K-F)\times F$ matrices capturing the direct voting rights, ultimate voting rights and ultimate control, respectively, of external shareholders, with typical elements υ_{kf}, υ^u_{kf} and γ^u_{kf} representing the direct voting rights, ultimate voting rights and ultimate control rights, respectively, of external shareholder k in firm f. Let also $\mathbf{V}^*$ denote the $F\times F$ matrix capturing the direct voting rights of internal shareholders, with zero diagonal elements, $\upsilon_{ff}=0$, and off-diagonal elements, $0\leq\upsilon_{fg}\leq 1$ (if $f\neq g\in\Im$), representing the direct voting rights of firm f in firm g. We can use matrices $\mathbf{V}$, $\mathbf{V}^u$, $\mathbf{C}^u$ and $\mathbf{V}^*$ to write the set of equations (2) in vector notation, as follows:

$$\begin{aligned}\mathbf{V}^u &= \mathbf{V}+\mathbf{C}^u\mathbf{V}^* \\ &= \mathbf{V}+\mathcal{F}\left(\mathbf{V}^u\right)\mathbf{V}^*,\end{aligned} \tag{A.4}$$

where $\mathcal{F}(\cdot)$ denotes the function which maps the ultimate voting rights of external shareholders implied by matrix $\mathbf{V}^u$ into the corresponding ultimate control rights established in matrix $\mathbf{C}^u$. Brito et al. (2018a) show that if there exists a unique matrix $\mathbf{V}^u$ that solves $\mathbf{V}^u=\mathbf{V}+\mathcal{F}\left(\mathbf{V}^u\right)\mathbf{V}^*$, the fixed point iterates given by $\mathbf{V}^{u(i+1)}=\mathbf{V}+\mathcal{F}\left(\mathbf{V}^{u(i)}\right)\mathbf{V}^*$ converges to $\mathbf{V}^u$ as $i\to\infty$ from *any* initial condition $\mathbf{V}^{u(0)}$, as under the assumption that external shareholders hold voting rights in at least one firm of the industry $\mathbf{V}$ is not a null matrix. In the particular case of proportional corporate control, where the corporate control rights of the different shareholders are captured by their corresponding voting rights, we have that $\mathbf{C}^u=\mathcal{F}\left(\mathbf{V}^u\right)=\mathbf{V}^u$. This implies that $\mathbf{V}^u=\mathbf{V}+\mathbf{V}^u\mathbf{V}^*$, which - under the assumption that external shareholders hold voting rights in at least one firm of the industry - yields $\mathbf{V}^u=\mathbf{V}\left(\mathbf{I}_N-\mathbf{V}^*\right)^{-1}$.

B Ownership Data Sources

We obtain ownership information from Refinitiv, which we combine when appropriate with ownership information from annual reports and TARP assistance reports prepared by the Congressional Research Service for Congress. The details are as follows.

For BMW, Changan, Daihatsu, FAW, Fiat, Ford, Geely, Honda, Hyundai, Mazda, Mercedes, Mitsubishi, Nissan, PSA, Renault, SAIC, Subaru, Suzuki, Tata, Toyota, and Volkswagen, as well as for the merged entities FCA and Stellantis, ownership information is obtained solely from Refinitiv. The Reuters instrument codes used and periods considered for each of these manufacturers are the following: BMW (RIC: BMWG.DE; Period: 2007-2021), Changan (RIC: 000625.SZ; Period: 2007-2021), Daihatsu (RIC: 7262.T^G16; Period:

2007-2015), FAW (RIC: 000800.SZ; Period: 2007-2021), FCA (RIC: STLA.MI; Period: 2014-2020), Fiat (RIC: STLA.MI; Period: 2007-2013), Ford (RIC: F; Period: 2007-2021), Geely (RIC: 0175.HK; Period: 2007-2021), Honda (RIC: 7267.T; Period: 2007-2021), Hyundai (RIC: 005380.KS; Period: 2007-2021), Mazda (RIC: 7261.T; Period: 2007-2021), Mercedes (RIC: MBGn.DE; Period: 2007-2021), Mitsubishi (RIC: 7211.T; Period: 2007-2021), Nissan (RIC: 7201.T; Period: 2007-2021), PSA (RIC: PEUP.PA^A21; Period: 2007-2020),[27] Renault (RIC: RENA.PA; Period: 2007-2021), SAIC (RIC: 600104.SS; Period: 2007-2021), Stellantis (RIC: STLA.MI; Period: 2021), Subaru (RIC: 7270.T; Period: 2007-2021), Suzuki (RIC: 7269.T; Period: 2007-2021), Tata (RIC: TAMO.NS; Period: 2007-2021), Toyota (RIC: 7203.T; Period: 2007-2021), and Volkswagen (RIC: VOWG.DE; Period: 2007-2021).

For BAIC, Dongfeng, and Great Wall, ownership information is obtained from Refinitiv as well as from annual reports. The reason is as follows. The aggregate share capital of BAIC, Dongfeng, and Great Wall is divided into A-shares and H-shares. A-shares are domestic shares which can be traded (or not) on Chinese stock exchanges while H-shares are overseas-listed foreign shares. As a consequence of this capital structure, the ownership of these three automobile manufacturers combines the two shares types. The A-shares of BAIC and Dongfeng are not traded and, as such, the information regarding shareholders is obtained from their annual reports.[28] The A-shares of Great Wall are traded on the Shanghai Stock Exchange and, as such, the information regarding shareholders is obtained from Refinitiv. The Reuters instrument code used is 601633.SS, for the period 2007-2021. The H-shares of the three automobile manufacturers are traded on the Hong Kong Stock Exchange and, as such, the information regarding shareholders is also obtained from Refinitiv. The Reuters instrument codes used and periods considered for each of these manufacturers are the following: BAIC (RIC: 1958.HK; Period: 2014-2021), Dongfeng (RIC: 0489.HK; Period: 2007-2021), and Great Wall (2333.HK; Period: 2007-2021). The combination of the two types of shares makes use of the corresponding total number of shares, obtained from the firms annual reports.

For Chrysler (both Chrysler LLC, for the period 2007-2008, and Chrysler Group LLC, for the period 2009-2013), ownership information is obtained from the Chrysler's TARP assistance report prepared by the Congressional Research Service for the US Congress (Webel and Canis, 2012).

Finally, for GM, ownership information for the periods 2007-2008 and 2010-2021 is obtained from Refinitiv. The Reuters instrument code used is MTLQQ.PK^D11 for the period 2007-2008 and GM for the period 2010-2021. Ownership information for 2009 is obtained from the GM's TARP assistance report prepared by the Congressional Research Service for the US Congress (Canis and Webel, 2013).

[27] We amend the ownership information from Refinitiv between 2014 and 2020 regarding the stake of Dongfeng on PSA, because Refinitiv reports this holdings as a direct holding of the Government of People's Republic of China. In 2021, as part of the package of agreements signed by the shareholders upon the merger between PSA and FCA, Dongfeng was required to sell part of its stake in PSA. It did so in September 2021. Refinitiv reports the (reduced) stake in 2021 correctly, as a direct holding of Dongfeng and not of the Government of People's Republic of China.

[28] For BAIC, annual reports are only publicly available from 2014 onwards (inclusive), when the (H-shares of the) firm became listed on the Hong Kong Stock Exchange. We assume the holders of A-shares between 2007 and 2013 are the same as those reported in the 2014 annual report. This seems a reasonable assumption as the holders of A-shares have remained relatively constant from 2014 to 2021. With one exception. In 2013, we include also Mercedes (then Daimler) as an holder of BAIC shares (with a 12% stake) as in November 2013 Mercedes acquired this stake in long-standing partner BAIC Motor.

C Cross-Ownership Links

In this appendix, we provide a more detailed description, obtained from business press articles and firms press releases, of each cross-ownership link reported in Table 1 of the main text.

Dongfeng

In March 2014, in a financial rescue operation, Dongfeng and the French Government each acquired a 14% stake in PSA. In December 2019, PSA and FCA announced a merger that would give rise to Stellantis. The deal closed on January 2021 and, as part of a package of agreements signed by shareholders upon the merger, Dongfeng was required to sell part of its stake in PSA, which it did in September 2021.

Fiat

Following the 2008 financial crisis, Chrysler (then Chrysler LLC) filed for bankruptcy in April 2009 and restructured its operations with oversight from the Obama Administration and the bankruptcy court. Many of the assets were sold to a new legal entity, Chrysler Group LLC, in which Fiat took a management role and a 20% equity stake. In 2011, Fiat increased this stake to 58.5% which it kept until 2014 when both entities merged, giving rise to FCA.

Ford

In 1974, Ford and Mazda began a partnership that eventually led to Ford acquiring a stake in Mazda in 1979, which Ford expanded over time to a (controlling) 33.4% stake by 1996. From 2008 (amid the world financial crisis) to 2015, Ford gradually divested its stake in Mazda. And by September 2015, Ford had fully divested its interest in Mazda.

GM

GM Asset Management, GM's pension plan investment firm and wholly owned subsidiary of GM, held a stake in Ford (in 2007, 2008, and 2011 to 2014) and in Mercedes (then Daimler, in 2007 and 2008).

On February 2012, GM and PSA announced the creation of a major alliance, as part of which GM acquired a 7% in PSA. This alliance was, however, short-lived, as in December 2013, after PSA's financial woes worsened, GM sold its stake in PSA.

Mazda

In May 2015, Mazda and Toyota signed an agreement to form a long-term partnership. In August 2017, Mazda and Toyota agreed to enter a business and capital alliance, with the aim of further strengthening their partnership. As part of this capital alliance, Mazda committed to acquire a 0.254% stake in Toyota.

Mercedes

The partnership between Mercedes (then Daimler-Benz) and Tata (then TELCO) began in the 1950s to manufacture trucks. In March 2010, Mercedes (then Daimler) sold its 5.69% stake in Tata arguing to be in an "excellent position" to capitalise on the growth potential of the Indian passenger and commercial vehicle markets without the help of Tata.

In 1998, Mercedes (then Daimler-Benz) merged with Chrysler (giving rise to DaimlerChrysler). In 2007, DaimlerChrysler agrees to sell 80.1% of Chrysler to private equity firm Cerberus Capital Management LP, giving rise to two separate entities, Daimler AG and Chrysler LLC, with Daimler keeping a 19.9% stake in Chrysler. The economic collapse during the financial crisis of 2007–2008 led Chrysler LLC to file for bankruptcy in April 2009 and, with oversight from the Obama Administration as well as the bankruptcy court, restructure its operations. Many of the assets were sold to a new legal entity, Chrysler Group LLC.

In April 2010, Mercedes (then Daimler) and the Renault-Nissan alliance announced a broad strategic cooperation. As part of this strategic cooperation, Mercedes acquired a 3.1% stake in Nissan and Renault. In November 2021, Mercedes (then Daimler) decided to dissolve the ties to then Renault-Nissan-Mitsubishi alliance in favor of more individual relationships with Renault and Nissan. As a consequence, the firm sold its stake in Renault.

In November 2013, Mercedes (then Daimler) acquired a 12% stake in long-standing partner BAIC Motor, significantly deepen their already strong strategic partnership.

Nissan

In March 1999, a heavily indebted Nissan agreed to a major strategic alliance with Renault. As part of this strategic alliance, Nissan acquired, in March 2002, a 13.5% stake in Renault, which it then expanded to 15% in May 2002.

In October 2016, Nissan acquired a 34% stake in Mitsubishi, becoming its largest shareholder, with the aim of collaborating on joint purchasing, deeper localization, joint plant utilization, common vehicle platforms, technology-sharing and an expansion of the firms' combined presence in both developed and emerging markets. As a result of the acquisition, Mitsubishi become part of the global Alliance with Nissan and Renault.

Renault

In March 1999, Renault agreed to a major strategic alliance with heavily indebted Nissan to rescue it. As part of this alliance, Renault would assume part of Nissan's debt in return for a 36.6% equity stake in the company. In March 2002, Renault increased its stake in Nissan to 44.4%, which was later trimmed to around 43%.

In April 2010, the Renault-Nissan alliance and Mercedes (then Daimler) announced a broad strategic cooperation. As part of this strategic cooperation, Renault acquired a 3.1% stake in Mercedes. In March 2021, Renault announced to have sold part of its stake in Mercedes to reduce debt and leverage profits.

Subaru

In December 1999, Subaru enters a business tie-up with Suzuki, as part of which the two firms agreed to hold shares in each other. In August 2016, the firms announced the end of this business tie-up and Subaru sold its 1.03% stake in Suzuki.

Suzuki

In December 1999, Suzuki enters a business tie-up with Subaru, as part of which the two firms agreed to hold shares in each other. In August 2016, the firms announced the end of this business tie-up and Suzuki sold its 1.749% stake in Subaru.

In October 2016, Suzuki and Toyota began considering a business partnership. In October 2019, the two firms announced an agreement regarding a capital alliance to establish and promote a long-term partnership (in order to develop newer technologies and meet sweeping changes upending the global auto industry). As part of this capital alliance, Suzuki committed to acquire a 0.19% stake in Toyota after approval from the foreign competition authorities.

Toyota

In 1967, Toyota and Daihatsu agreed to form a cooperative alliance, to enhance the international competitiveness of Japan's automotive industry. As a result of this agreement, Toyota acquired a stake in Daihatsu, which it then expanded over time to a controlling stake by 1998. In 2016, the two firms reached an agreement whereby Daihatsu became a wholly-owned subsidiary of Toyota.

In October 2005, Toyota and Subaru agreed on business collaboration related to development and production. As part of this business collaboration, Toyota acquired a 8.7% stake in Subaru. In 2008, the two firms expanded their cooperative ties and Toyota increased its stake in Subaru to 16.5%. In 2021, the two firms expanded their cooperative ties even further and Toyota increased its stake in Subaru to 20%.

In May 2015, Toyota and Mazda signed an agreement to form a long-term partnership. Later on, in August 2017, the two manufacturers decided to strength their partnership by entering a business and capital alliance, with the aim of further strengthening their partnership. As part of this capital alliance, Toyota committed to acquire a 5.05% stake in Mazda by October 2017.

In October 2016, Suzuki and Toyota began considering a business partnership. In October 2019, the two firms announced an agreement regarding a capital alliance to establish and promote a long-term partnership (in order to develop newer technologies and meet sweeping changes upending the global auto industry). As part of this capital alliance, Toyota committed to acquire a 4.9% stake in Suzuki after approval from the foreign competition authorities.

Volkswagen

In December 2009, Suzuki and Volkswagen announced that they reached a common understanding to establish a close long-term strategic partnership with the aim of achieving synergies in the areas of rapidly growing emerging markets as well as in the development and manufacturing of innovative and environmentally friendly compact cars). As part of this business collaboration, Volkswagen acquired a 19.9% stake

in Suzuki. Soon after this acquisition, the relationship began to fray, with Suzuki accusing Volkswagen of withholding information it had promised to share, while Volkswagen objecting to a Suzuki deal to buy diesel engines from Fiat. In November 2011, Suzuki gives notice to Volkswagen of the termination of the partnership, but Volkswagen does not reply. As a result, Suzuki files for arbitration at the International Court of Arbitration of the International Chamber of Commerce (ICC). In August 2015, the ICC holds the termination of the partnership between Suzuki and Volkswagen valid.

D Julia Code

In this appendix, we provide the Julia code used to compute the two formulations of the profit weights associated to each manufacturer pair in each year, allowing also for our two alternative measures of corporate control.

We begin by describing the code to compute the normalized Banzhaf power indices that result from voting rights. We then describe the code to compute ultimate financial and control rights. Finally, we describe the code to compute our two formulations of the profit weights.

Banzhaf Power Indices

The code below computes the normalized Banzhaf power indices that result from the *direct* or *ultimate* voting rights (measured between 0–1) depicted in matrix **a**.

```
function banzhaf(a);
    a = 1000*a;
    a = floor.(a);
    a = 10*a;
    C = zeros(size(a,1),size(a,2));
    for i = 1:size(a,2);
        q = BigInt(5000-(10000-sum(a[:,i]))/2);
        if sum(a[:,i].>q)==1;
            tmp0 = a[:,i].>q;
            tmp1 = findall(x->x>0, tmp0);
            C[tmp1[1],i] = 1;
        else;
            tmp0a = [1:1:size(a,1);];
            tmp0b = [tmp0a a[:,i]];
            tmp = tmp0b[a[:,i].!=0,:];
            tmp2 = size(tmp,1);
            if isempty(tmp)==0;
                den = big(2)^(tmp2-1);
                tmp3 = tmp[:,2];
                tmp4a = tmp[sortperm(tmp[:, 2]),:];
                tmp4 = tmp4a[:,2];
                dlast = zeros(1+BigInt(sum(tmp4)),1);
```

```
            dlast[1] = 1;
            d = zeros(1+BigInt(sum(tmp4)),size(tmp3,1));
            for r = 1:size(tmp3,1);
                tmp5 = sum(tmp4[1:r]);
                d[1,r] = dlast[1];
                for j = 1:BigInt(sum(tmp4));
                    if j<tmp4[r];
                        d[j+1,r] = big(dlast[j+1]);
                    else;
                        d[j+1,r] = big(dlast[j+1]) + big(dlast[j+1-BigInt(tmp4[r])]);
                    end;
                end;
                dlast = d[:,r];
            end;
            cw = zeros(1+BigInt(sum(tmp4)),size(tmp3,1));
            for r = 1:size(tmp3,1);
                for j = 0:(BigInt(sum(tmp4))-BigInt(tmp4[r]));
                    if j<tmp4[r];
                        cw[j+1,r] = big(d[j+1,size(tmp3,1)]);
                    else;
                        cw[j+1,r] = big(d[j+1,size(tmp3,1)])-big(cw[j+1-BigInt(tmp4[r]),r]);
                        if cw[j+1,r]<0;
                            cw[j+1,r] = 0;
                        end;
                    end;
                end;
            end;
            for r = 1:size(tmp3,1);
                num = 0;
                for j = (q-BigInt(tmp4[r])):(q-1);
                    num = num + big(cw[j+1,r]);
                end;
                C[BigInt(tmp4a[r,1]),i] = num/den;
            end;
        else;
            C[:,i] = zeros(size(a,1),1);
        end;
    end;
end;
tmp = sum(C, dims=1);
CN = zeros(size(C,1),size(C,2));
for i = 1:size(a,2);
    if tmp[i]==0;
```

```
            CN[:,i] = C[:,i];
        else;
            CN[:,i] = C[:,i]./(ones(size(C,1),1)*tmp[i]);
        end;
    end;
    return CN;
end;
```

Ultimate Financial and Control Rights

The code below computes the ultimate financial rights from the *direct* financial rights depicted in matrices $\mathbf{F}$ and $\mathbf{F}^*$.

```
Fu = F*inv(I-Fstar);
```

The code below computes the ultimate control rights (measured by voting rights) from the *direct* voting rights depicted in matrices $\mathbf{V}$ and $\mathbf{V}^*$.

```
Cu = V*inv(I-Vstar);
```

The code below computes the ultimate control rights (measured by the normalized Banzhaf power indices that result) from the *direct* voting rights depicted in matrices $\mathbf{V}$ and $\mathbf{V}^*$.

```
Cu0 = V*inv(I-Vstar);
Vu0 = V + Cu0*Vstar;
mdiff = 1;
while mdiff > 1e-15;
    tmpb0 = [Cu0; Vu0];
    Cu1 = banzhaf(Vu0);
    Vu1 = V + Cu1*Vstar;
    mdiff = maximum(abs.(Vu1-Vu0));
    Cu0 = Cu1;
    Vu0 = Vu1;
end;
```

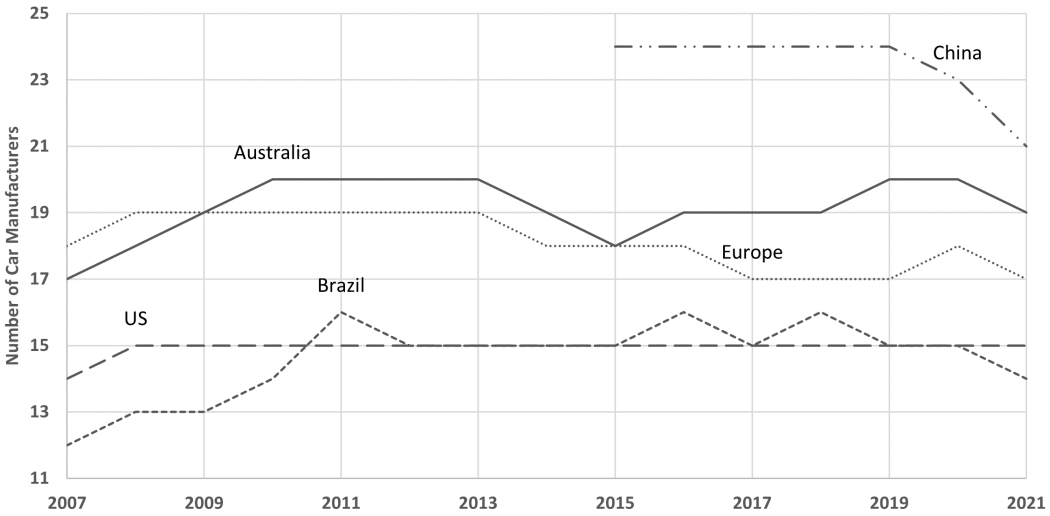
Profit Weights

The code below computes the matrix of profit weights, according to the dominant formulation suggested by Rotemberg (1984), Bresnahan and Salop (1986) and O'Brien and Salop (2000), from the matrices of *ultimate* financial and control rights, $\mathbf{F}^u$ and $\mathbf{C}^u$, so to account for the cross-ownership links in the industry.

```
L = Cu'*Fu;
W = diagm(0 => 1 ./diag(L))*L;
```

The code below computes the matrix of profit weights, according to the dominant formulation suggested by Rotemberg (1984), Bresnahan and Salop (1986) and O'Brien and Salop (2000), from the matrix of *direct* financial rights, $\mathbf{F}^{all}$, which stacks the direct financial rights of both internal and external shareholders (as if all shareholders were external to the industry) and from the matrix of direct control rights, $\mathbf{C}^{all}$, computed

Figure E.1: *Regional Number of Car Manufacturers*



from the matrix of direct voting rights, $\mathbf{V}^{all}$, which also stacks the direct voting rights of both internal and external shareholders (as if all shareholders were external to the industry).

```
L = Call'*Fall;
W = diagm(0 => 1 ./diag(L))*L;
```

E Regional Automobile Market Analysis

As automobile manufacturers are not necessarily active in all markets, we may not directly infer competition concerns from the profit weights for the whole industry. Thus, we now consider in more detail five (sizeable) regional markets: Australia, Brazil, China, Europe, and the US. We make use of country-level motor vehicle (volume) sales data, obtained from the market research firm JATO. The dataset includes the (volume) sales of every new passenger car model sold during 2007-2021 for a collection of different countries.[29] Using this data, we redo the profit weight analysis above. More specifically, we first select all car models with sales in the 99th percentile in the regional market and year (hence only removing models with very low sales). We then identify the manufacturers of the selected car models, and match that with our original set of car manufacturers. As such, we account for those manufacturers that are, at least to some extent, competitively active in the regional market in a particular year.

Figure E.1 reports the number of automobile manufacturers considered in each market over time. It documents how the number of automobile manufacturers active in each market is typically (and sometimes substantially) lower than the total number of automobile manufacturers in our overall sample. Please see Appendix F for the list of automobile manufacturers considered in each market and year.

Figure E.2 reports the (arithmetic) average potential profit weight of the cross-pairs of car manufacturers active in each regional market in each year. As before, we report formulations of the profit weight that

[29] For Europe, we aggregate the (volume) sales of passenger car models sold across the European Economic Area and the UK (with the exception of Bulgaria, Iceland, Liechtenstein, Malta, and Norway, which are not included in the data obtained from JATO). For China, the data obtained from JATO covers solely the period 2015-2021.

account and do not account for the cross-ownership links in the industry. Panels A1-A5 consider the case in which control rights are measured by voting rights while Panels B1-B5 consider the case in which control rights are measured by the normalized Banzhaf power indices that result from voting rights.

The plots of those two panels of Figure E.2 suggest the same *qualitative* patterns for the regional markets as those found for the global automobile industry as a whole. First, the average baseline *regional* profit weight has increased steadily over time from just (roughly) 0.05 in 2007 to between 0.10–0.12 in (almost all cases) 2017 and has decreased slightly since then. This implies that profit weights in the regional automobile markets are also lower when compared to the set of S&P 500 firms. Finally, the plots also suggest that accounting for the cross-ownership links in more granular regional markets is also important. In particular, we find that the average regional profit weight accounting for cross-ownership links is between 44–199% higher in Australia, between 28–99% higher in Brazil, between 33–68% higher in China, between 44–172% higher in Europe, and between 33–198% higher in the US, depending on the years and on how control rights are measured.

To examine these biases in more detail, Figure E.2, Panels C1-C5 and D1-D5 report the distribution of the percentage change in profit weights due to accounting for cross-ownership links, for all individual firm-pairs across all years. Figure E.2, Panels C1-C5 considers the case in which control rights are measured by voting rights. The results confirm the same *qualitative* patterns as those identified for the global automobile industry as a whole. In particular, and although the quantitative results depend on the region, we find that (a) cross-ownership links do alter the extent of existing common-ownership: the share of positive baseline profit weights that do change when we account for cross-ownership links is sizeable (between 58–68% for baseline profit weights between zero and 0.5, which account for between 91–97% of the profit weights, and between 48–71% for baseline profit weights greater than 0.5, which account for between 2–6% of the profit weights); (b) the changes are mostly positive: the changes in baseline profit weights between zero and 0.5 are concentrated between 1–25% (between 23–28% out of 58–68%) and above 100% (between 20–27% out of 58–68%) while the changes in baseline profit weights greater 0.5 are concentrated in increases between 1–25% (between 18–40% out of 48–71%); and (c) cross-ownership links can induce otherwise non-existent common-ownership: when we account for cross-ownership links, between 8–90% of the zero baseline profit weights (which account for between 0–7% of the profit weights) do change and become positive. These results are (qualitatively) robust to measuring control rights by the normalized Banzhaf power indices that result from voting rights, as depicted in Figure E.2, Panels D1-D5.

F Regional Markets

Australia

BMW (2007-2021), Chrysler (2007-2013), FCA(2014-2020); Fiat (2007-2013), Ford (2007-2021), Geely (2010-2021), GM (2007-2021), Great Wall (2009-2014; 2019-2021), Honda (2007-2021), Hyundai (2007-2021), Mazda (2007-2021), Mercedes (2007-2021), Mitsubishi (2007-2021), Nissan, (2007-2021), PSA (2007-2020), Renault (2007-2021), SAIC (2016-2021), Stellantis (2021); Subaru (2007-2021), Suzuki (2007-2021), Tata (2008-2021), Toyota (2007-2021), Volkswagen (2007-2021).

Figure E.2: *Regional Average Profit Weights*

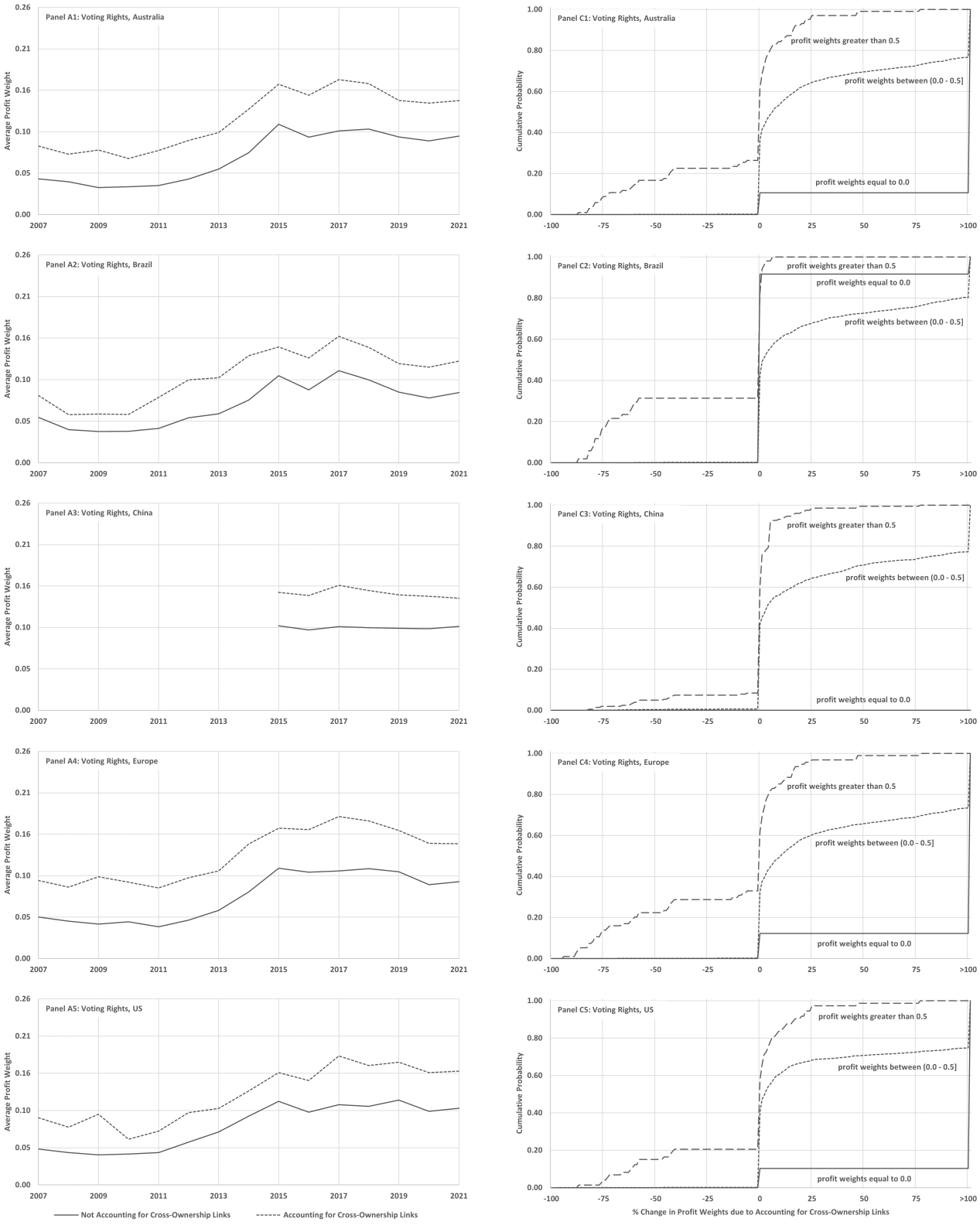
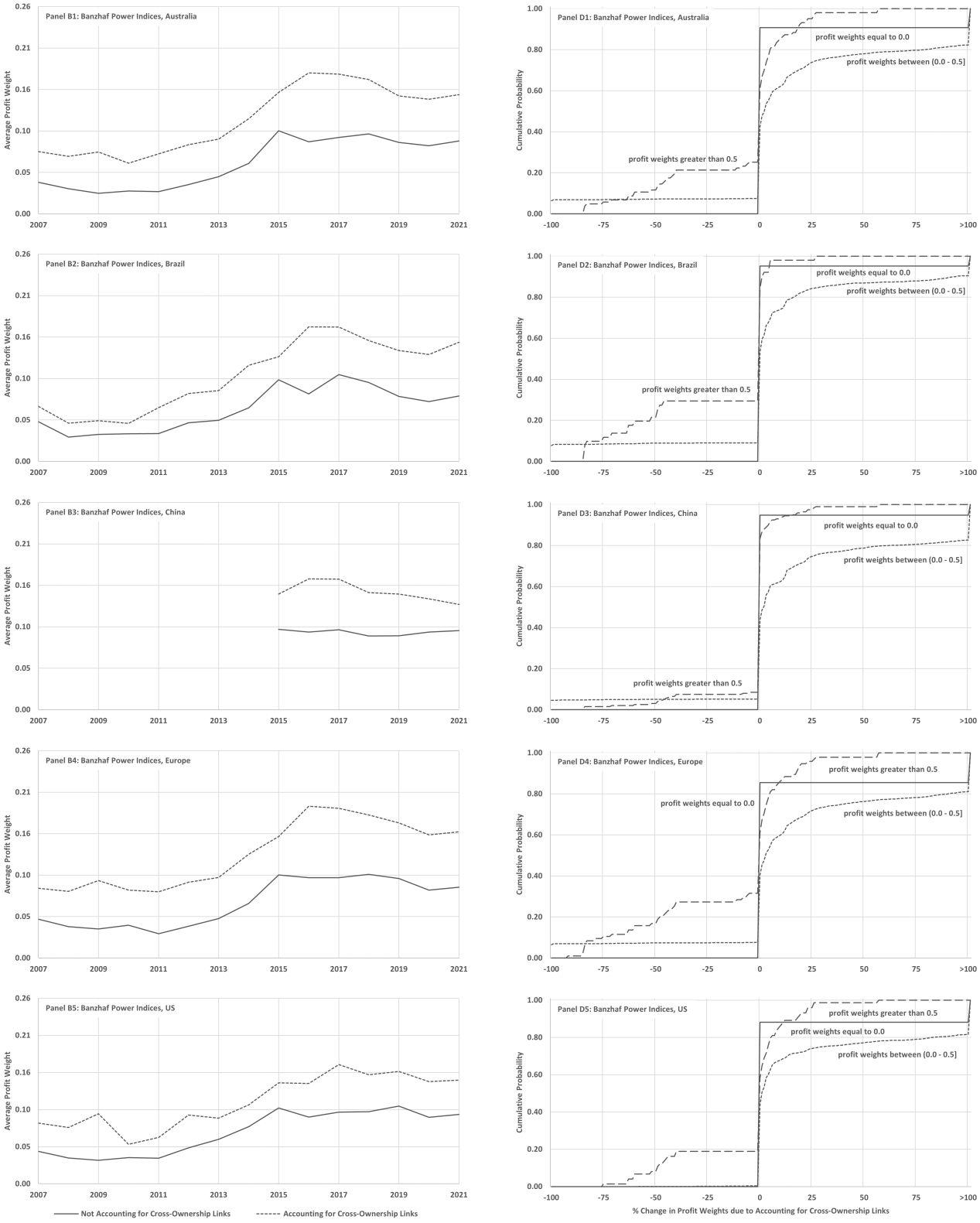


Figure E.2: *Regional Average Profit Weights (Cont.)*



Brazil

BMW (2009-2021), FCA (2014-2020); Fiat (2007-2013), Ford (2007-2021), Geely (2011; 2016; 2018-2021), GM (2007-2021), Honda (2007-2021), Hyundai (2007-2021), Mercedes (2007-2021), Mitsubishi (2007-2021), Nissan (2007-2021), PSA (2007-2020), Renault (2007-2021), Stellantis (2021), Suzuki (2011-2018), Tata (2008; 2010-2021), Toyota (2007-2021), Volkswagen (2007-2021).

China

BAIC (2015-2021), BMW (2015-2021), Changan (2015-2021), Dongfeng (2015-2021), FAW (2015-2021), FCA (2015-2020), Ford (2015-2021), Geely (2015-2021), GM (2015-2021), Great Wall (2015-2021), Honda (2015-2021), Hyundai (2015-2021), Mazda (2015-2021), Mercedes (2015-2021), Mitsubishi (2015-2021), Nissan (2015-2021), PSA (2015-2020), Renault (2015-2019), SAIC (2015-2021), Stellantis (2021), Subaru (2015-2021), Suzuki (2015-2020), Tata (2015-2021), Toyota (2015-2021), Volkswagen (2015-2021).

Europe

BMW (2007-2021), Chrysler (2007-2009; 2011-2013), Daihatsu (2007-2010), FCA (2014-2020), Fiat (2007-2013), Ford (2007-2021), Geely (2010-2021), GM (2007-2016), Honda (2007-2021), Hyundai (2007-2021), Mazda (2007-2021), Mercedes (2007-2021), Mitsubishi (2007-2021), Nissan (2007-2021), PSA (2007-2020), Renault (2007-2021), SAIC (2020-2021), Stellantis (2021), Subaru (2007-2021), Suzuki (2007-2021), Tata (2008-2021), Toyota (2007-2021), Volkswagen (2007-2021).

US

BMW (2007-2021), Chrysler (2007-2013), FCA (2014-2020), Fiat (2012), Ford (2007-2021), Geely (2010-2021), GM (2007-2021), Honda (2007-2021), Hyundai (2007-2021), Mazda (2007-2021), Mercedes (2007-2021), Mitsubishi (2007-2021), Nissan (2007-2021), Stellantis (2021), Subaru (2007-2021), Suzuki (2007-2009), Tata (2008-2011; 2013-2021), Toyota (2007-2021), Volkswagen (2007-2021).