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2017

ESSAYS ON OWNERSHIP STRUCTURE AND FIRM PERFORMANCE

Verbeck Jr, Channing

Princeton, NJ : Princeton University

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ESSAYS ON OWNERSHIP STRUCTURE AND FIRM PERFORMANCE

CHANNING PIERCE VERBECK JR.

A DISSERTATION

PRESENTED TO THE FACULTY

OF PRINCETON UNIVERSITY

IN CANDIDACY FOR THE DEGREE

OF DOCTOR OF PHILOSOPHY

RECOMMENDED FOR ACCEPTANCE

BY THE DEPARTMENT OF ECONOMICS

ADVISOR: JAN DE LOECKER

JUNE 2017

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Abstract

This dissertation studies the relationship between firm ownership structures and performance. In the first chapter I document the subsidiary ownership structure of firms using a unique dataset, which I apply to the question of what determines the internal organization of firms. I refer to "ownership structure" as it relates to the linkages between multinationals and their subsidiaries: "firms owning firms." This dataset is novel in its comprehensive map of the global network structure of ownership across firms in different countries and industries, allowing for the description of both the evolution of ownership structures over time and complex ownership structures, such as indirect ownership, ownership chains, and fractional ownership. I document the anatomy of ownership structure for a panel of European plastics manufacturers, providing descriptive and reduced-form evidence on observed ownership patterns and their determinants. I find that while most firms have a simple ownership structure, firms with relatively complex ownership structure are becoming more complex over time. I then apply my data to two approaches in the literature for explaining ownership structure.

The second chapter takes a first step toward addressing the question of whether features of ownership structure have implications for real economic output by studying how changes in ownership structure impact productivity. I pair ownership data with detailed balance sheet and income statement data for European primary plastics manufacturers in order to estimate firm productivity. I build on the stylized fact documented in Braguinsky et al. (2015) that manufacturing firms which experience a change in ownership become more productive after the ownership change, and I investigate the extent to which this effect varies with complex features of ownership structure. I show that direct ownership changes (in which a firm gets a new direct controlling shareholder) have a larger impact on productivity than indirect ownership changes (in which the global owner of a firm changes, but the direct owner does not). I also provide reduced-form evidence that the increase in productivity from a direct ownership change is larger when the new controlling shareholder takes a majority share of voting rights than when the new controlling shareholder acquires only a minority share. The results suggest a role for complex ownership structures in determining real economic outcomes, and they imply the need for a full model of the ownership structure decision of the multinational firm.

The third chapter studies the relationship between firm-level financial constraints and total factor productivity, through the lens of acquisitions. Recent work by Erel, Jang, and Weisbach (2015) documents that acquisitions appear to relieve the financial constraints of target firms. I extend this line of inquiry by linking firm-level measures of financial constraints to firm performance in the post-acquisition period. I set out to answer two questions. First, does the financial health of the acquirer or target at the time of acquisition have implications for post-acquisition performance of the target? Second, do acquisitions and the market for corporate assets more generally play a role in addressing misallocation of capital? Using a panel of European manufacturing firms with yearly financial, production, and ownership data, I apply standard approaches from the corporate finance literature to show that acquired firms that appear financially constrained tend to exhibit larger increases in productivity than firms that do not appear financially constrained. I also show that firms that appear financially constrained are more likely to be acquired. These results are suggestive of a theory of financing efficiencies as a source of gains from mergers and acquisitions.

Acknowledgments

I thank Jan De Loecker, Jakub Kastl, and Myrto Kalouptsidi for their advice and support in this project. I thank Adrien Matray and Motohiro Yogo for additional helpful discussions. I would also like to thank all participants in the Princeton Applied Micro student workshop for their comments and feedback, including Ioannis Branikas, Sungki Hong, Giulia Brancaccio, Daniel Goetz, Richard Katzwer, Olivier Darmouni, and Juha Tolvanen. I thank Nick Buchholz and Eduardo Morales for being a part of my dissertation committee. I thank Bobray Bordelon at the Princeton University Library for initial assistance and conversations related to the Orbis database. Thanks also to Laura Hedden for administrative support throughout my time at Princeton.

I am indebted to my graduate student peers for their camaraderie and support. I forged many friendships with the classmates in my cohort, who made the hours in Fisher Hall pass more quickly. I also especially thank Kyle Bond and Bing Zheng for spending countless hours watching soccer matches, Matthew de Courcy-Ireland and Matthew Hernandez for allowing me to get out of the economics bubble, and my housemates Jakob Schlockermann and David Zhang for the many late-night Fifa matches.

I would like to thank my grandparents, Yuna and Joe, who were always ready to generously volunteer home-cooked meals, moving assistance, or a place to unwind on the weekends. I would like to thank my parents, Nancy and Chan, who have provided encouragement and advice not just during my five years at Princeton but throughout my entire education. Finally, I would like to thank my fiancée Sardius for her unwavering support and love.

To my parents.

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Chapter 1

Determinants of Ownership Structure

1.1 Introduction

The field of empirical industrial organization has long focused on the organization of firms within industries, using notions of market power and competition to analyze oligopolistic markets. Less is known about the economic significance of subsidiary ownership structure within the multinational firm itself. The main players in the global economic landscape are large multi-tiered corporations with long ownership chains of affiliates spanning across countries and industries. Beyond large multinationals, even smaller and domestic firms often organize as multiple affiliates within an ownership network. While often overlooked by researchers, there is a deep interdependence between the internal organization of firms and the organization of markets. The ownership structure decision can be abstracted to a firm's decision of where to allocate their assets, total employment, and production, which then affects allocations directly. Horizontal market structure and competition may also be impacted by the extent of common ownership within an industry (Azar et al. (2016)). While several competing theories exist, the literature has come to no conclusion as to whether the determinants of these ownership structures are primarily financial in nature, or on the nature of their relevance for real economic outcomes. This is in part due to a lack of suitable

data on the internal organization of firms. A necessary first step toward understanding the relationship between firm organization and market structure is to understand ownership structures themselves, which is becoming possible due to the increasing availability of link-level ownership micro-data.

In this chapter I document the subsidiary ownership structure of firms using a unique dataset, which I apply to the question of what determines the internal organization of firms. I refer to "ownership structure" as it relates to the linkages between corporations and their subsidiaries: "firms owning firms."[1] I construct a unique panel dataset on firms' ownership structures at the level of shareholder-subsidiary linkages. This dataset is novel in its comprehensive map of the global network structure of ownership across firms in different countries and industries, as well as the evolution of this structure of ownership over time. It also allows for the description of complex ownership structures, such as indirect ownership, ownership chains, and fractional ownership.

I document the anatomy of ownership structure for a panel of European plastics manufacturers, providing descriptive and reduced-form evidence on observed ownership patterns and their determinants. In contrast to previous descriptive papers on the internal ownership structure of firms which use datasets of large public firms or multinationals (e.g. La Porta et al. (1999); Lewellen and Robinson (2014)), my data include small private firms, which allow me to characterize ownership structure from a comprehensive industry-level perspective. I present a number of stylized facts about the ownership structures of firms in this industry. Most firms have a simple ownership structure; 51% of firms in my sample have no parent firms, and 58% of firms with parent firms have an ownership network which is entirely domestic. I demonstrate that firms with complex ownership structures are becoming more complex over time, while the median firm remains fairly simple. I document evidence that the ownership share held by a parent is increasing in the length of the relationship between the parent and subsidiary. I present estimates of a logit regression which marks a first

[1] This is a subset of the concept of ownership structure in the broader corporate governance sense, which relates to the composition of shareholders of corporations.

approach at the question of what drives the internal organization of firms. Finally, I apply my data to two approaches in the literature for explaining ownership structure, notably the determination of boundaries of the firm (Antras et al. (2009)), and taxation explanations for ownership structure (Desai et al. (2002)).

To begin this chapter, I first survey several existing theories the literature has used to study firm ownership structure. The question of why firms organize themselves the way they do has been studied in various contexts, through the lens of organizational economics, industrial organization, international trade, and corporate finance. This chapter is primarily descriptive in nature, and as such contributes to several literatures concerned with the ownership structure of firms primarily through the introduction of a new dataset. Most directly, it contributes to the segement of the corporate finance literature which studies the ultimate control of corporations (Faccio and Lang (2002); La Porta et al. (1999)). While these papers tend to focus on large listed firms across many countries, I take a different angle by describing the ownership structure of firms within a specific industry, including small private firms. Second, it provides empirical evidence toward the various theories which attempt to explain firm ownership structure: e.g. the study of firm boundaries in organizational economics and the literature which provides institutional explanations such as taxation. More broadly, this chapter concerns the study of multinational firms, prevalent in the international trade, development, and industrial organization literatures. The main contribution of this chapter is in highlighting the usefulness of an underutilized source of ownership data. I summarize the data sources commonly used to study ownership structure. I then describe the construction of the data used in this chapter, and I contrast it with the weaknesses of existing data.

The rest of the chapter is organized as follows. Section 1.2 provides a broad overview of the approaches to understanding subsidiary ownership structure in different literatures. Section 1.3 discusses the construction of the ownership data used in this chapter, and contrasts it with those sources frequently utilized in the literature. Section 1.4 describes features of the

ownership dataset, and section 1.5 applies this dataset to two tests of theories of determinants of ownership structure posed by the literature. Section 1.6 concludes.

1.2 Theories on Determinants of Ownership Structure

The study of what drives firm organization lies along the intersection of industrial organization, organizational economics, international trade, and corporate finance.

1.2.1 Vertical Integration and the Boundaries of the Firm

A well-trod line of research has been the issue of defining the boundaries of the firm; in particular, why firms choose to integrate with their subsidiary affiliates rather than simply making transactions at arm's length. Since the seminal work of Coase (1937), organizational economics brings to bear two primary theories on the question of whether and why firms integrate vertically: the transaction cost theory and the property rights theory. Each theory aims to explain vertical integration as an optimal response to contracting frictions.

The transaction cost theory (Williamson (1971, 1975)) builds on the assumption of Coase that any transaction made at arm's length is potentially costly. Taking as a given that any market transaction involves implicit uncertainty and contractual incompleteness, integration reduces the cost of potential holdups by resolving disputes within the firm. Vertical integration is thus preferred in cases where transactions are complex or uncertain, and arm's-length trade for more simple transactions. A shortcoming of this theory is that it doesn't provide a counter balancing *cost* of integration and intrafirm transactions to explain why vertical integration is not even more prevalent.

The property rights model of firm boundaries (Grossman and Hart (1986); Hart and Moore (1990)) adds explicit assumptions about the nature and limits of contracting. Contracts are assumed to be incomplete, and ownership of assets is a source of bargaining power once outside contingencies occur. If a firm decides to integrate with its downstream suppliers

by acquiring residual rights of control, it may disincentivize the acquired part from making relationship-specific investments. The allocation of property rights (organizational structure) is therefore chosen to minimize inefficiency in the face of this incompleteness.

The empirical industrial organization literature has long studied vertical integration decisions of firms and their implications (e.g. Hortacsu and Syverson (2007); Atalay et al. (2014)). However, Bresnahan and Levin (2012) notes these approaches often not make direct use of the contract-theory based theories of the firm. As data on organizations improves, this should encourage new empirical tests of the transaction costs and property rights theories and their relation to market structure. Models of the insourcing/outsourcing decision for multinationals in the trade literature have made more direct use of these models (see for example Antras and Helpman (2004); Feenstra and Hanson (2005)).

1.2.2 Corporate Finance and Corporate Governance

A wide array of approaches to the determinants of ownership structure have been undertaken in the corporate finance literature, though it remains largely scattered and without a unifying theory.

Ownership structure is studied in a more literal sense in the field of corporate governance. Dating back to Berle and Means (1932), this literature models the relationship between shareholders and managers as a principal-agent problem, termed the separation of ownership and control (Jensen and Meckling (1976)). While the Berle and Means model of the modern firm has been shown to be overly simplistic and possibly out of date, the concept of separation of ownership and control has been used to explain complex ownership structures such as ownership chains and pyramidal groups (Claessens et al. (2000)). The theory has sometimes lagged behind the empirical evidence; La Porta et al. (1999) and Faccio and Lang (2002) describe the static structure of ownership across global corporations, noting that the heterogeneity in the data leave many unanswered questions.

Foley and Manova (2015) review the recent advances in applying corporate finance theories to the multinational firm. This literature emphasizes the role of internal ownership structures in allowing a firm to utilize internal capital markets in order to avoid financial frictions in various locales. This theory would suggest that multinational firms are better suited to expanding into markets with weak financial markets. A secondary literature explores financial incentives for organizing as a business group across diversified subsidiaries in developing countries (Khanna and Yafeh (2007)). Another application of corporate finance theory, proposed by Antras et al. (2009), applies a Holmstrom and Tirole (1997) moral hazard framework to the question of where firms set their boundaries (see section 1.5.1 for more details and a reproduction using Orbis data).

1.2.3 Taxation and Institutions

A separate literature explains subsidiary ownership structure as a corporation's means of dealing with institutional idiosyncrasies, such as cross-country differences in taxation of foreign income. In deciding how to organize international activities, firms face a wide heterogeneity and complexity of laws governing corporate taxation of foreign income. A substantial literature studies the resulting taxation explanations for the location decisions of multinational firms (e.g. Barrios et al. (2012)).

These incentives also shift how firms choose to organize their internal structures using ownership chains or tax havens. Mintz and Weichenrieder (2010) show a link between the use of indirect ownership and bilateral withholding taxes between the host and destination countries. They find that subsidiaries owned by a global owner in a country with higher withholding taxes on dividends are more likely to be controlled indirectly through an intermediate firm in another country.[2] It is also assumed that firms choose transfer prices for within-firm transactions in order to minimize tax payments, reducing the intrafirm prices

[2]Desai et al. (2002) perform a similar study, which I reproduce using Orbis data in section 1.5.2.

charged by subsidiaries in high-tax countries to affiliates in tax havens.[3] Desai et al. (2006) document the prevalence of the use of these tax havens for U.S. multinationals, and show that larger, more international firms, and those with exentsive intrafirm trade and high R&D intensities are most likely to use tax havens.

Other institution-based explanations for the organization of multinationals include expropriation risks, limited liability, protection of creditor rights, and corruption. While these and the taxation explanations are intuitively palatable, they can only explain complexities in cross-border ownership linkages; in fact, many firms have exclusively domestic ownership networks.

1.3 Data

1.3.1 Availability of Suitable Ownership Data

The scope of the literature on the real economic importance of ownership structure has been limited by the difficulty in obtaining suitable data. In order to evaluate the economic impacts of a change in ownership structure of a given firm, one needs data to identify the changes in ownership structure and measurements of production both before and after this change. In this section I will list the sources of ownership data which have been utilized in the literature.

Much of the discussion of ownership in the industrial organization literature focuses on studying the effect of mergers on firm market power and efficiency. The U.S. Census Bureau's *Longitudinal Business Database* (LBD) has been used as a source of ownership data in a number of studies focusing on the United States. The LBD provides a mapping between establishments (plants) and the firms which own them, allowing researchers to identify changes in ownership for a plant as a change in the firm ID of the owner.[4] Typically such studies will

[3]Hines Jr and Rice (1994) and Altshuler and Grubert (2003) provide theory and evidence to support the existence of this phenomenon.

[4]See McGuckin and Pascoe (1988) for some discussion of the data and use of firm ID to identify ownership changes. Examples of papers which use the data include Lichtenberg and Siegel (1987), McGuckin and Nguyen (1995), and Kulick (2016)

merge LBD ownership data with plant-level data from the *Census of Manufacturers*, which provides detailed production data in five-year intervals. These data give researchers access to plant revenues and output, book values of equipment, and expenditures on labor and material inputs, which enable accurate calculation of quantity-based productivity measures.

While the use of the LBD is sufficient for measuring the binary action of when a plant gets a new owner, this approach to ownership data leaves some to be desired. Despite the complexities of the network structure of ownership across countries and industries, the LBD ownership data provide only a single parent/owner for a given plant. To the extent that complex ownership structures are relevant to economic outcomes, further data on the size of ownership networks and the control exerted by any given shareholder-subsidiary link would be advantageous.[5]

Another source of data on U.S. firms is the Bureau of Economic Analysis's *Survey of U.S. Direct Investment Abroad*, which presents data on the operations of U.S. multinationals which have equity holdings in foreign countries. This survey provides annual data for a multinational's operations aggregated at the country-year level for value-added, employment, exports, and other measures.[6] In addition, it includes detailed ownership data describing the ownership linkages which connect each multinational's affiliates and the corresponding equity interest. Lewellen and Robinson (2014) conduct a description of the internal ownership structure of U.S. multinational firms using these data, which also highlights some of its weaknesses. For one, since multinationals can report aggregate totals affiliates at the country level, it is not possible to observe the number of affiliates in a given country (or any ownership features therein). Additionally, the minimum size cutoff for the survey varies widely from year to year in such a way that makes it difficult to study the evolution of ownership over

[5]The reliance on a single firm ID can sometimes be insufficient to describe the evolution of complex ownership structures. Davis et al. (2014) describe issues tracking firms in the LBD, in which firm IDs disappear for various reasons and render analysis at the firm ID level difficult.

[6]See Mataloni (1995) for some discussion of the data and its uses. Examples of papers which use the data include Desai et al. (2006) and Branstetter et al. (2006).

time.[7] Perhaps the most apparent weakness is the scope; by only covering foreign affiliates of U.S. multinationals, this dataset misses out on the ownership structure of any firm whose network of owners is entirely domestic.

Other sources are used with less frequency. Studies of mergers and acquisitions often use the SDC Thomson Platinum (Ahern and Harford (2014)), typically merged with Compustat for financial data on public firms. Worldscope has been used in studies of corporate ownership and control (La Porta et al. (1999)), but this database contains only a small fraction of even listed firms in the covered countries. In many cases, a country-specific dataset from a national statistical agency is used (Faccio and Lang (2002), Braguinsky et al. (2015)).

1.3.2 Construction of Ownership Dataset

To address the shortcomings of these sources I use a dataset of European firms with a yearly full description of firms' ownership structure through links to direct and indirect parents. The data come from Orbis, a financial database of global firms collated by Bureau Van Dijk (BVD). Orbis provides balance sheet and other financial data for over 206 million active firms across the world using a variety of information providers. These data are accumulated from many sources (including official registers, annual reports, and private correspondence). A key benefit of using Orbis for European firms is its coverage of private firms using reports from regulatory bodies in Europe; more than 99 percent of firms represented in Orbis are private.

The critical feature of Orbis is its Ownership Database, advertised as a complete source for owner and subsidiary links worldwide with over 69 million active and 454 million archived links providing information on over 66 million companies. The Ownership Database contains a list of all direct shareholders and subsidiaries for any firm in the Orbis dataset, along with corresponding *ownership shares* representing the share of voting rights controlled in each

[7] Lewellen and Robinson (2014) use only the BEA benchmark surveys from years 1994, 1999, 2004 and 2009, which require that multinationals report all affiliates (countries) with sales, asses or net income in excess of $3 million, $7 million, $10 million, and $30 million respectively

link.[8] There are two important features of this dataset which enable me to construct a picture of ownership structure. First, each shareholder and subsidiary of a given firm is subsequently searchable in the Orbis Ownership Database. By recursively searching the shareholders of shareholders, I can therefore construct a full picture of the network structure of ownership emanating from a set of initial firms. The Orbis Ownership Database is global, allowing me to construct a full "upstream" picture of ownership across all countries and industries, starting with the set of firms in the plastic industry based in EU countries. Second, Orbis maintains in its online database all archived ownership links since January 2003, allowing one to query the database for a static picture of ownership at any point in time from 2003 to 2016. Merging yearly queries of the Ownership Database allows for the creation of an ownership panel, capturing time variation in both the number of ownership links and ownership share of any given link. To see further detail on how the dataset is created, see Appendix 1.A. Other papers have relied on the Orbis Ownership Database (e.g. Kalemli-Ozcan et al. (2014); Alfaro and Chen (2015)), but to my knowledge none have traced the full network structure of ownership, or combined the yearly datasets of archived links in order to form a panel.

For each firm, Orbis also contains up to ten years of time-series income statement and balance sheet data from 2005-2015, including input and output variables necessary to estimate productivity measures. While Orbis attempts to provide a global census of firms, it should be noted that the wide variety of primary sources and the difference in reporting standards across represented countries means that it can only be an approximation.[9] Alfaro and Chen (2015) compare the coverage of Orbis against benchmarks using the OECD Structural and Demographic Business Statistics (SDBS), and finds that Orbis' coverage is highly satisfactory for most non-developing countries. Given that the alternative of obtaining national census data for each country individually is impractical, Orbis represents the most

[8] In this paper, definitions of ownership rely on measures of voting rights as opposed to cash-flow rights. This is consistent with the literature which studies the control of the modern organization, for example La Porta et al. (1999).

[9] Note that Bureau Van Dijk also offers a product specific to European firms called Amadeus. However, since tracing any ownership chain which exits Europe would not be possible using Amadeus, this product is not useful for constructing a complete network of ownership.

comprehensive global financial dataset and well-suited to the task of measuring productivity across firms in many countries.

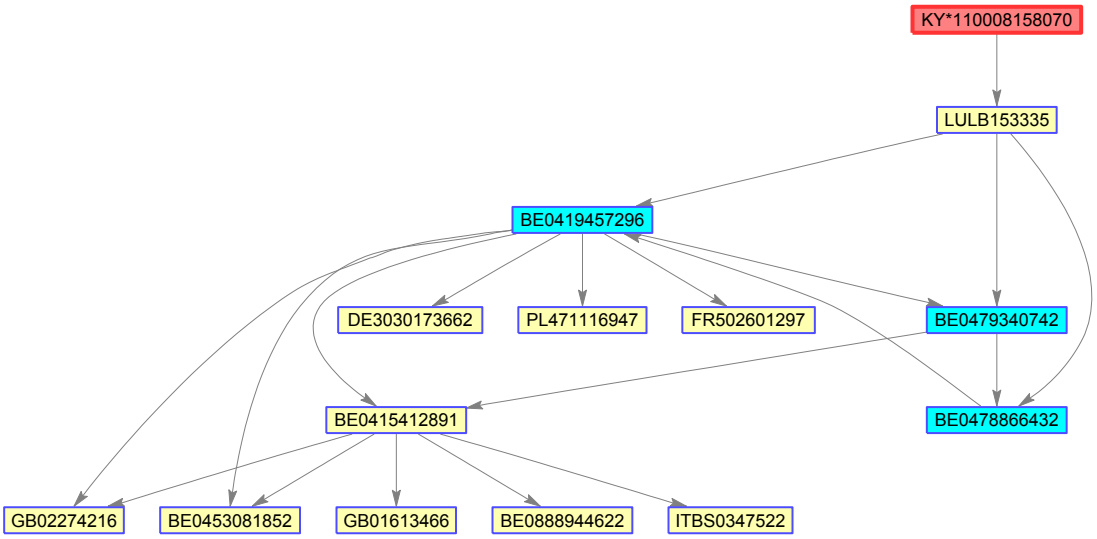
1.3.3 Definitions

I refer to any firm owned by another firm as a *subsidiary*, and any entity which owns another firm as a *shareholder*; the term *affiliate* can refer to a firm which is either a subsidiary or a shareholder. Firms may either be self-owned, or have one or more *parent firms* as shareholders.[10]

The network structure of ownership visible in the Orbis Ownership Database allows for the identification not only of a firm's immediate shareholder owners, but also the ultimate owners at the top of the ownership chain. A firm's *direct owner* at a given control threshold is the largest direct shareholder which meets the minimum share of voting rights at that threshold. A firm's *indirect,* or *ultimate owner* at a given threshold is found by iteratively finding the direct owner of each direct owner until a self-owned or widely held firm is reached. I refer to all shareholders which relate to a firm either directly or indirectly as that firm's *ownership network.* An *ownership chain* is any ownership network in which multiple firms own subsidiaries. In interpreting multinational subsidiary ownership structure as a network, one can refer to individual owners as *nodes*, and shareholder-subsidiary links as *edges* weighted by the ownership share. In the context of a breadth-first search of shareholders, a node is *terminal* if the firm has no direct parents.

[10]In this paper, I focus on the organization of subsidiaries within the ownership structure of conglomerate firms. Self-owned firms may be marked in the database as belonging to one or more individual shareholders (which are identified and tracked by Orbis), but I discard this information unless the shareholder is a firm. There is a substantial literature which makes use of these data on individual shareholders, for example in studying family ownership and firm performance (Anderson and Reeb (2003)).

Figure 1.1: Static snapshot example of subsidiary ownership structure



Notes: Data taken from ORBIS dataset for the year 2014. Firms labeled by Bureau Van Dijk ID (BVDID). Ultimate owner highlighted in red; ownership cycle highlighted in blue. Other links truncated. Ultimate owner identified by Orbis as a "Mutual and pension fund/Nominee/Trust/Trustee". The direct subsidiary of the ultimate owner is identified as a large industrial firm with NACE code 8290 ("Business support service activities nec").

1.4 Descriptive Evidence

The Orbis ownership database provides link-level observations, but the data is well-suited to graphical visualizations. Figure 1.1 displays a static snapshot of the subsidiary ownership structure for a multinational taken from the Orbis database, represented as a digraph in which an arrow from firm A to firm B indicates firm A's ownership of firm B. This figure itself illustrates several features of ownership structure that demonstrate the complexities of ownership structure in the data. An *ownership cycle* exists among the three firms highlighted in blue, in which each firm holds ownership shares in the next, forming a loop with no terminal node. Desai et al. (2002) posit that the use of such cycles could be used as a triangular way of avoiding repatriation taxes across borders, although the example pictured here involves only Belgian firms. The ultimate owner of the firms in the figure is a financial entity in the Cayman Islands, a tax haven. Its ownership of the entire network proceeds

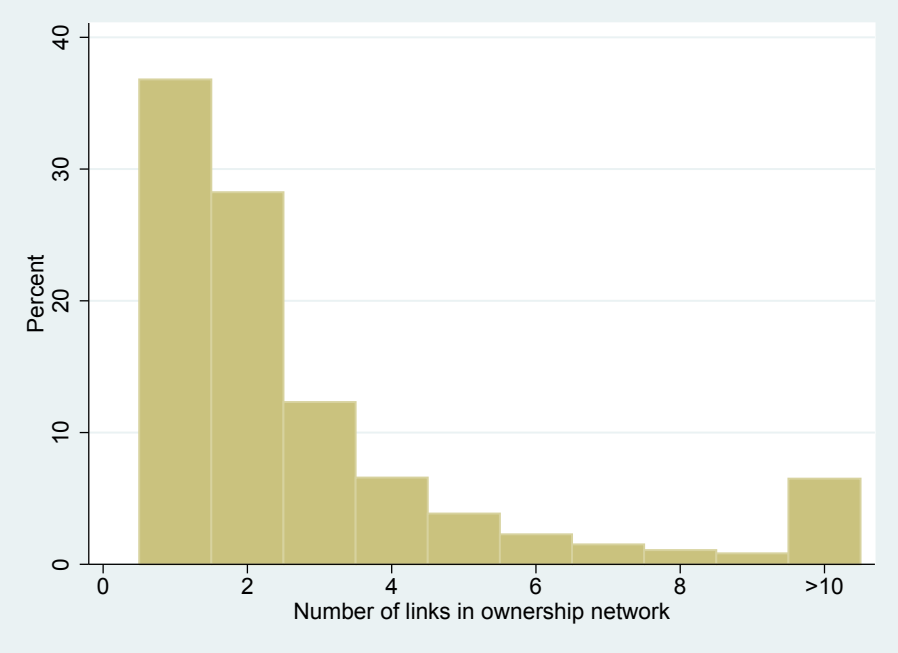
through a single direct subsidiary, a holding company in Luxembourg. This holding company exhibits another non-trivial feature of ownership structure in the form of its ownership of the firm BE0478866432; it holds both a direct ownership stake in the firm, and an indirect stake through and ownership chain via BE0479340742. These features demonstrate that the anatomy of subsidiary ownership structure is not simply a tree.

I perform the construction of the ownership database on European plastic manufacturing firms, tracing the upstream ownership networks of each firm in the base sample. For each year from 2005 to 2015, the ownership links in the database characterize the entire upstream network of ownership for firms in the European Union (EU) which match NACE Rev. 2 codes corresponding to raw plastic in primary forms or plastic products. The initial sample has 60664 firms, and the ownership database subsequently covers 40.2 million ownership links over the sample period (an average of 3.7 million links per year).[11]

Unlike papers which catalogue the organization of large public corporations and multinationals, by also including small private firms I can describe a complete picture of ownership structure spanning an industry. In doing so, the first thing to notice is that many small firms do *not* have complex ownership structure. A full 51% of firms in the initial sample are either self-owned or held by individual shareholders rather than firms. As a first cut of the data for the firms which do have owners, I plot a histogram of the number of ownership links in each firm's ownership network in figure 1.2 from the year 2015. Most firms with owners in this industry have a relatively simple ownership structure, with the plurality of firms having only a single parent. Moreover 58% of firms with owners have an entirely domestic ownership network, which conflicts with the notion that affiliations between firms primarily exist for multinationals. This provides a broader perspective than the one available from using the U.S. BEA data, which only reveals the ownership structures of foreign affiliates of U.S. multinationals.

[11] Contrast this with Lewellen and Robinson (2014), where the estimation sample totals 668 firms and 1114 firm-years, less than two observations per firm.

Figure 1.2: Histogram of ownership network size for firms in base sample



Notes: Histogram of the number of shareholder links in the ownership network for plastic manufacturers with at least one owner. Data taken from ORBIS dataset for the year 2015.

I describe basic summary statistics of the owners of plastic firms in table 1.1, stratified by whether they are direct or indirect parents of firms in the base sample. Parents which are direct owners are more likely to be industrial firms, within the same industry, and from the same country. They are also smaller and younger than indirect owners, which are more likely to be financial. Again, there is a long right tail in the distribution of ownership complexity; the majority of firms have fairly simple ownership structures (the median firm has a single parent), there are some firms which are part of enormous ownership networks which render average statistics less useful.

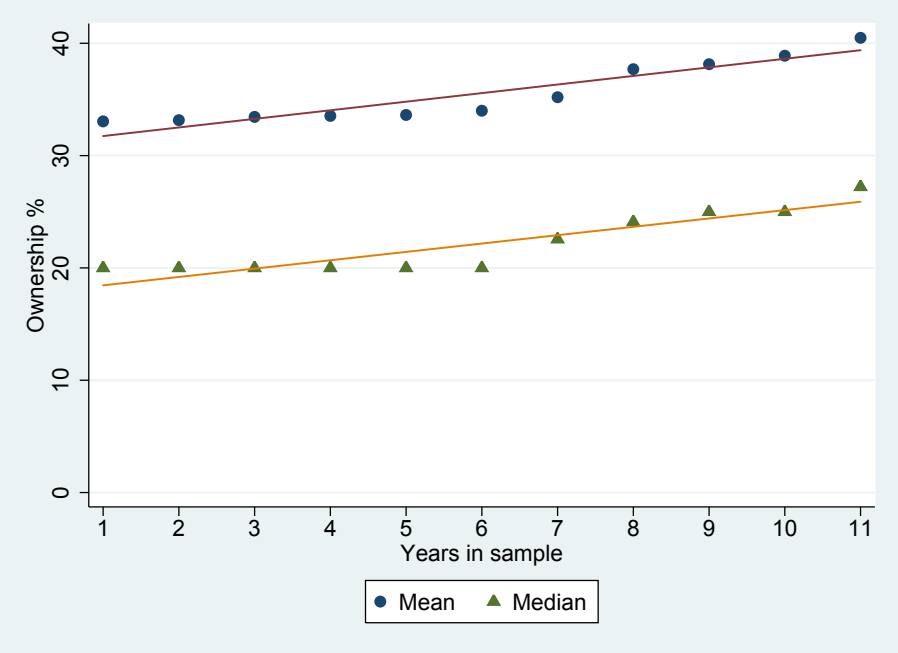
A key feature of my ownership dataset is the panel dimension. For example, this allows me to evaluate how specific ownership links between a specific subsidiary and parent evolve over time. The literature has in the past looked at the ownership share held by parents in their subsidiaries as a measure of the degree of control. However, to my knowledge there have been no attempts to fit time variation in this ownership share to study whether and why ownership links strengthen or weaken. In figure 1.3, I plot the average ownership share across

Table 1.1: Characteristics of owners

	Direct owners			Indirect owners		
	Mean	Med.	Std.	Mean	Med.	Std.
Total number of owners	1.4	1	1.5	601	3	1289
% Industrial firm	0.77	1	0.40	0.55	0.5	0.40
% Financial firm	0.16	0	0.34	0.30	0.13	0.34
# of countries represented	1.1	1	0.5	9.9	1	17.0
# of industries represented	1.1	1	0.75	24.5	2	46.2
% of owners in same country	0.74	1	0.423	0.46	0.15	0.47
% of owners in same industry	0.11	0	0.30	0.05	0	0.18
Average number of employees	767.5	22	5,177	7813.6	194.3	11462
Average total assets	679.6	7.3	10847	60937.8	96.2	102389
Average operating revenue	260.8	3.8	1711.3	3089.7	82.4	6030.7
Average age	23.2	17	21.7	30.5	23	23.2

Notes: Data is for the year 2015. All numbers are presented averages, medians, and standard deviations across all plastic manufacturers with at least one owner in 2015. The left three columns present counts and averages over all the direct owners of the plastic manufacturers in the initial sample, while the right three columns present counts and averages over all the indirect owners of the initial sample (i.e., the owners of the direct owners of the plastic manufacturers in the initial sample). The second and third rows refer to the average fraction of (direct or indirect) owners which Orbis marks as either an industrial firm or a financial firm in the 'shareholder type' field. The fourth and fifth rows count the average number of unique countries and industries found across (direct or indirect) owners; the sixth and seventh rows similarly compute the average fraction of (direct or indirect) owners which are in the same country as the initial parent. Total assets and operating revenue presented in millions of Euros.

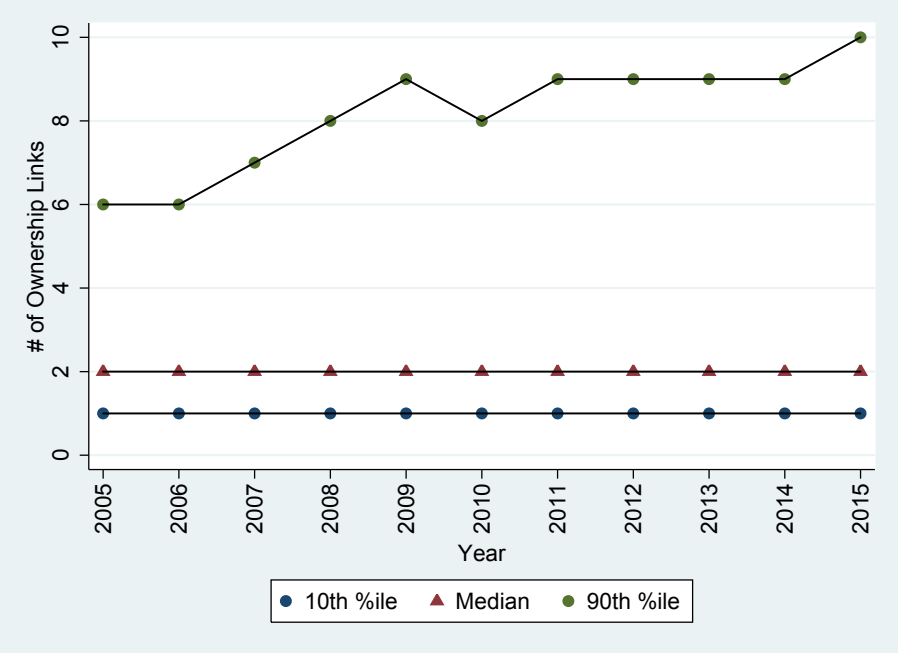
Figure 1.3: Average ownership share conditional on years in sample (length of link relationship)



Notes: Plot of the mean and median ownership share for links from ownership network of plastic manufacturers, conditional on the number of years the link has been in the sample. Only links with at least 9 years in the sample are included. Best-fit lines also plotted.

links in my ownership database conditional on how many years that link has been observed in my sample: $E\left[\%\text{ Ownership} \mid \text{Years in sample}\right]$. I require that links be in my sample for at least 9 years, in order to prevent selection due to link 'exit'. While I only observe links for the first time in 2005 (and hence do not know the true age of a link), the mean conditional on years in my sample is clearly increasing over time, which provides suggestive evidence that links that survive are increasing in ownership share over time. While some of the past literature has described patterns in ownership structure as largely static over time, this fact coupled with the ownership changes documented in the next chapter provide evidence that time variation in ownership structure exists and may be worth studying. This phenomenon would be consistent with a model in which limited initial committment in a shareholder could increase through knowledge gain on match quality (Johanson and Vahlne (1977)).

Figure 1.4: Distribution of number of links in ownership network over time



Notes: Plot of the 10th, 50th, and 90th percentile of the total number of ownership links in network for plastic manufacturers, among firms with at least one owner. Only firms with at least 9 years in the sample are included.

I can also use the panel dimension of ownership to document the fact that firm ownership structure is becoming more complex over time. In figure 1.4, I plot percentiles of the distribution of the total number of ownership links in a firms' network for plastic manufacturers. For firms less complex than the median firm, the number of links in the ownership structure does not change over time. But complex firms are becoming more complex, as evidenced by the fact that the 90th percentile for ownership link count increases from 6 links at the start of my panel to 10 links by 2015. This increase in the heterogeneity in complexity of ownership networks is consistent with the observation of Lewellen and Robinson (2014) that firms are becoming increasingly complex over time.

In table 1.2, I compute measurements of some of the complex features of ownership networks in my sample and present their summary statistics. For a given plastic manufacturer I consider their entire upstream ownership network in counting the number of owners, as well as structural features of the network such as the length of ownership chains and degrees of parental nodes. I also count the number of holding companies (those with NACE Rev 2.0

Table 1.2: Complex ownership features

	10 %ile	Median	90 %ile
Total number of owners	0	1	7
Number of terminal owners	0	1	3
Length of longest chain	0	1	3
Length of chain to ultimate owner	1	1	3
Avg. parents per non-terminal node	1	1	3.5
Max parents per non-terminal node	1	1	9
Avg. Number of parents per direct owner	0	0	2
# of holding companies in ownership network	0	0	3
# of holding companies directly owning	0	0	1
% of cross-border linkages in structure	0	0.5	1
% of cross-industry linkages in structure	0	0.85	1

Notes: Data is for the year 2015. All numbers are presented medians and first and last deciles of ownership characteristics across all plastic manufacturers in 2015. The first row counts the number of total owners (direct or indirect) of plastic manufacturers in the base sample, and the second row counts the number of owners who themselves have no parent firm. The third and fourth rows measure the length of the longest ownership chain and the length of the chain to the ultimate owner, respectively. The fifth and sixth row measures the average and maximum number of parents per node in the ownership network which is non-terminal (i.e., nodes which have parents). The seventh row computes the average number of parents of direct parent nodes. The eighth and ninth rows count the number of holding companies in the entire ownership network and among direct owners respectively. The tenth and eleventh rows find the fraction of ownership links in the network which cross country and industry boundaries, respectively.

industry code 6420) and the share of total ownership linkages which cross industry and country boundaries.

As a first approach to studying why firms choose their ownership structure, I can run a simple cross-sectional logit regression for firms in the base sample to show what explains observed ownership patterns.

$$\text{Own}_{ic} = \alpha_0 + \beta_1 k_i + \beta_2 a_i + Z_c\gamma + \epsilon_i \tag{1.1}$$

where Own_{ic} represents a dummy for features of the ownership structure for a firm i in country c, k_i is the log of firm size (assets), a_i is log firm age, and Z_c are host country-level measures which may explain ownership structure: the corporate tax rate, GDP/capita, and measures for the strength of property rights and risk of appropriation. In particular, I use

Table 1.3: Logit regression on measures of ownership for firms in the sample.

	Dependent variable	
	Has Owner	Owned Indirectly
Log Total Assets	0.134	0.464
	(0.011)	(0.0145)
Age	0.274	-0.296
	(0.038)	(0.042)
Local Corporate Tax	-0.044	0.021
	(0.005)	(0.004)
GDP/capita	0.0001	0.0002
	(.0000)	(.0000)
Property Rights	-0.047	0.019
	(0.003)	(0.004)
Risk of Appropriation	-0.024	-0.037
	(0.046)	(0.063)
N (firms)	14,700	14,700
Adj. R^2	0.1385	0.1415

Standard errors in parentheses

Note: Results from a logit regression of a dummy for the firm's ownership status on firm- and country-level measures for the year 2014, as in equation (1.1). In first specification, dependent variable is a dummy equal to 1 when the firm has an ultimate owner which is a firm, and 0 otherwise. In the second specification, dependent variable is a dummy equal to 1 when the firm has an ultimate owner which is a firm and also an indirect owner (i.e., there is an intermediate owner in between the firm and its ultimate owner). Property rights, median corporate tax rate, and GDP/capita collected from the 2014 Index of Economic Freedom.

two specifications for Own_{ic}: a dummy for whether or not the firm has an observed parent firm, and a dummy for whether the firm's parent firm is an indirect owner (i.e., the firm is owned using an ownership chain). This functional form is rudimentary, but will demonstrate which firm- and country-level variables correlate with observed ownership structures. In table 1.3, I report the results of these logit regressions. Predictably, larger firms are more likely to have parent firms, indirect or direct. Older firms are more likely to have a parent firm, but actually less likely to be owned indirectly. Indirect ownership is more common when the host country has a higher tax rate and stronger property rights. A higher risk of appropriation in the host country decreases the likelihood that a firm is owned either directly or indirectly, though the coefficient is not significant.

1.5 Determinants of Ownership Structure

In this section I will take an agnostic approach to confirming some of the reduced-form evidence relating to determinants of ownership structure already posited by the literature. Antras et al. (2009) propose a firm boundaries model with costly financial contracting for multinationals choosing the level of integration with subsidiaries, which suggests that the level of integration should be increasing in the weakness of investor protections and institutions. Desai et al. (2002) study the interaction between ownership structure and taxation, by testing whether indirectly owned firms are more sensitive to local tax rates. The fact that the two papers I use for discussion here are already empirical means that these numbers aren't important on their own per se, but reflect on the coherency of the data I have constructed and the consistency of the original results through the lens of this alternative data source.

1.5.1 Boundaries of the Firm

Antras et al. (2009) (hereafter ADF) takes a corporate finance/moral hazard approach to the question of the boundaries of the firm by writing a model of costly financial contracting. The multinational plays the role of an innovator with a new technology, who wants to find foreign entrepreneurs in order to market this technology abroad. The foreign entrepreneurs have the ability to misbehave, taking some private benefits through an action which is not perfectly observable by the innovator. Building off Holmstrom and Tirole (1997), the innovator has a costly monitoring technology which reduces the private benefit to the foreign entrepreneur. ADF add heterogeneity in the strength of institutions to this model: innovators are more likely to pursue arm's-length transactions in locales in which it is more difficult for the entrepreneurs to shirk, e.g. when local investor protections are higher.

The key comparative static testable with my data is that ownership shares by multinational parents will be decreasing in the quality of investor protections in local economies.

Given that ownership is a continuous variable on $[0, 1]$, the idea is that this will proxy for the firm's (the innovator's) incentive to vertically integrate, without needing data on arm's-length trade. As a measure of the strength creditor rights, I use data constructed by Djankov et al. (2007). I take a measure of private credit, the ratio of private credit lent by deposit banks to GDP, from Beck et al. (1999). I use the Barro and Lee (2000) dataset to get a measure of workforce schooling as the average years of schooling for anyone over the age of 25. I find measures of corporate tax rate, GDP, GDP/capita, and property rights in the 2014 Index of Economic Freedom. I use the International Country Risk Guide to get measures for the strength of a country's Law & Order and Corruption, which approximate ADF's Rule of Law and Risk of Appropriation indices. I use as a patent protection measure the index computed in Park (2008). I restrict my Orbis sample to data from 2013. I observe the percent of ownership between any shareholder and subsidiary, and regress this percent ownership on measures of investor protection.

I report the results in tables 1.4 and 1.5. The dependent variable is the ownership share by the ultimate owner of the subsidiary, and the independent variables are various measures of the strength of financial institutions. On the whole, my results seem to follow ADF very closely. The regressions based on the Orbis data confirm that parent companies own larger shares of affiliates located in countries in which protections extended to creditors are weaker and private credit is scarcer, as shown by the negative coefficients on creditor rights and private credit in the two tables. I also largely find that smaller ownership shares are maintained when the affiliate lies in a country with higher corporate tax rates. The Orbis data differs from ADF in the sign on property rights; I find a negative relationship between property rights in the affiliate's host country and a multinational's ownership share. This actually confirms the prediction of the model in ADF, as their model predicts that multinational parents should hold larger ownership shares in affiliates located in countries with weak investor protections. In sum, the ADF model of firm boundaries is largely confirmed on my Orbis ownership extract.

Table 1.4: Parent Ownership Decisions: Antras et al. (2009) Table IV, specifications (1) and (2)

Specification:	Dependent variable: ownership share			
	(1)		(2)	
	Orbis	ADF (2009)	Orbis	ADF (2009)
Creditor rights	-0.0105	-0.0091	-0.0061	-0.0101
	(0.0012)	(0.0028)	(0.0022)	(0.0035)
Workforce schooling	0.0291	0.0005	0.0395	-0.0049
	(0.0018)	(0.0024)	(0.0021)	(0.0024)
Log GDP	-0.0291	-0.0157	0.0052	-0.0116
	(0.0019)	(0.0037)	(0.0034)	(0.0046)
Log GDP per capita	0.0356	0.0309	-0.1431	0.0358
	(0.0075)	(0.0064)	(0.0147)	(0.0132)
Corporate tax rate	-0.2973	-0.2633	-0.1004	-0.3456
	(0.0441)	(0.0638)	(0.0470)	(0.0712)
Patent Protections			0.1408	-0.0142
			(0.0189)	(0.0073)
Property rights			-0.0053	0.0055
			(0.0004)	(0.0072)
Law & Order			0.1317	0.0005
			(0.0097)	(0.0061)
Corruption			0.0609	0.0054
			(0.0042)	(0.0068)
N (firm-years)	23,956	51,320	23,956	41,436
Adj. R^2	.0420	.3974	.0645	.4250

Standard errors in parentheses

Notes: This table reports results of a regression of the ownership share a firm held by its ultimate owner onto country-level characteristics of the quality of investor protections (described in section 1.5.1). Observations are ownership links. For each specification, the left-hand column presents results from a regression using Orbis data for plastic producers in the year 2013, while the right-hand column presents estimates directly out of Antras et al. (2009) Table IV (specifications (1) and (2)). Note that in my Orbis replication, I omit a proxy for foreign ownership restrictions that Antras et al. (2009) include. I also exclude year-fixed effects, as all my data come from 2013.

Table 1.5: Parent Ownership Decisions: Antras et al. (2009) Table IV, specifications (4) and (5)

Specification:	Dependent variable: ownership share			
	(4)		(5)	
	Orbis	ADF (2009)	Orbis	ADF (2009)
Private credit	-0.0002	-0.0506	-0.0004	-0.0481
	(0.0000)	(0.0135)	(0.0001)	(0.0174)
Workforce schooling	0.0296	0.0007	0.0366	-0.0030
	(0.0018)	(0.0026)	(0.0026)	(0.0026)
Log GDP	-0.0183	-0.0110	0.0105	-0.0079
	(0.0022)	(0.0035)	(0.0043)	(0.0046)
Log GDP per capita	0.0129	0.0381	-0.1551	0.0402
	(0.0086)	(0.0078)	(0.0145)	(0.0143)
Corporate tax rate	-0.1540	-0.2778	-0.0256	-0.3249
	(0.0438)	(0.0584)	(0.0453)	(0.0582)
Patent Protections			0.0129	-0.0127
			(0.0225)	(0.0078)
Property rights			-0.0031	0.0000
			(0.0005)	(0.0071)
Law & Order			0.1502	0.0009
			(0.0123)	(0.0061)
Corruption			0.0255	0.0069
			(0.0071)	(0.0069)
N (firm-years)	21,278	48,422	20,789	39,096
Adj. R^2	0.0408	0.3998	0.0639	0.4275

Standard errors in parentheses

Notes: This table reports results of a regression of the ownership share a firm held by its ultimate owner onto country-level characteristics of the quality of investor protections (described in section 1.5.1). Observations are ownership links. For each specification, the left-hand column presents results from a regression using Orbis data for plastic producers in the year 2013, while the right-hand column presents estimates directly out of Antras et al. (2009) Table IV (specifications (4) and (5)). Note that in my Orbis replication, I omit a proxy for foreign ownership restrictions that Antras et al. (2009) include. I also exclude year-fixed effects, as all my data come from 2013.

1.5.2 Taxation Explanations for Ownership Structure

We can also use ownership data to assess taxation-based explanations for the structure of ownership, by estimating the extent to which taxation in the host country affects the volume of foreign direct investment and the eventual location of taxable profits. Desai et al. (2002) (henceforth DFH) pitch a profit sharing story in which firms are able to redistribute taxable profits across borders at a cost - this could be pursued by adjusting transfer prices or otherwise employing "creative financing". Noting that indirect ownership allows multinationals several strategies to aid in the deferral of local taxes (Altshuler and Grubert (2003)), it may be the case that affiliates owned indirectly through ownership chains will exhibit greater sensitivity to local tax rates. The broad goal is to see whether a firm ownership structure contributes to the tax sensitivity of both the volume of investment and the location of taxable profits, which the authors bring these to the data using the U.S. BEA Survey of U.S. Direct Investment Abroad.

Tables 5-8 of DFH present results from simple regressions which provide some evidence of profit-shifting/tax avoidance, and the effect of local tax rates on foreign direct investment. The main regressions treat subsidiaries as observations and regress measures of investment and profitability on the difference in corporate tax rates between the parent and affiliate host countries. The model predicts that interaction terms between tax rates and indirect ownership will indicate that indirectly owned firms will exhibit a stronger FDI and profit response. As controls, I follow the authors' suggestion in using a third-order polynomial in log GDP as a rudimentary proxy for all other investment determinants.

In tables 1.6 and 1.7 below, I present my attempt at reproducing these results. In table 1.6, net income is regressed on assets, tax rates, and measures of indirect ownership. Notably, I confirm that the effect of differences in tax rates between the host and parent country have a stronger negative impact on the reported profitability of indirectly held affiliates, raising the possibility of tax avoidance. In table 1.7, log assets are regressed on tax rates and measures of indirect ownership. As in DFH, I find that a lower tax rate in the affiliate country leads

to higher levels of affiliate asset holdings (a proxy for foreign direct investment), but the regression results are not significant. The signs disagree on the interaction term between indirect ownership and country tax rate, so there is no evidence to support a story in which FDI in indirectly-owned affiliates is less sensitive to the local tax rate.

It is worth noting that the European data provides an imperfect replication of their study, as the nature of multinational taxation is far more complex within the EU: firms are subject to withholding taxes in order to prevent tax evasion exactly of this variety. However, firms have further latitude to evade taxation by means of taxation treaties. Countries negotiate with each other on the bilateral withholding tax policy, which leaves the door open for legal loopholes via the laundering of profits through an intermediate country with favorable tax treaties toward the host countries of both the multinational and its affiliate.[12] Secondly, I use reported corporate tax rates, but this is only a proxy for the tax rates actually faced by firms.

1.6 Conclusion

In this chapter, I introduced the problem of describing and modeling the subsidiary ownership structure of multinational firms. The network of ownership over affiliates spanning different countries and industries is observed to be highly complex. However, economists have not been able to completely explain why firms hold these internal ownership structures, hampered in part by a lack of suitable data. I parse some of the key theoretical approaches that various literatures have used in understanding ownership structure, and which data sources are commonly used. I then describe the construction of a novel database of ownership and firm performance which provides a new level of detail on complex features of the structure of subsidiary ownership in firms. Unlike the existing datasets, my data provide a picture of the complete network structure of ownership across all subsidiaries and the specific ownership

[12] A more proper treatment of this is found on a study of German firms in Mintz and Weichenrieder (2010), for which bilateral tax treaty data was collected.

Table 1.6: Profitability, Coordination of Tax Avoidance across Regions: Desai et al. (2002) Tables 6 and 8.

	Dependent variable: Net Income			
	Table 6		Table 8	
	Orbis	DFH (2002)	Orbis	DFH (2002)
Assets	0.0933	0.0702	0.1156	0.0628
	(0.0166)	(0.0056)	(0.0303)	(0.0061)
Assets×	-0.050	-0.0680	-0.0333	-0.0469
Country Tax Rate	(0.012)	(0.0157)	(0.0031)	(0.0168)
Indirect Ownership×			-0.0822	0.0266
Assets			(0.032)	(0.0082)
Indirect Ownership×			-0.0282	-0.0809
Assets×			(0.0034)	(0.0253)
Country Tax Rate				
N (firm-years)	341	185,813	341	185,813
Adj. R^2	0.4371	0.3548	0.7980	0.2169

Standard errors in parentheses

Notes: This table reports results of a regression of the log net income a firm held onto country-level tax rates (described in section 1.5.1). Observations are ownership links. Net income is defined as gross profits minus taxation. For each specification, the left-hand column presents results from a regression using Orbis data for plastic producers in the year 2013, while the right-hand column presents estimates directly out of Desai et al. (2002). In my Orbis regression, the independent variable for country tax rate is the difference between the local (foreign) corporate tax rate and the home corporate tax rate, whereas DFH only looks at U.S. multinationals and therefore uses only the local corporate tax rate. Third-order polynomial in GDP is included, but not reported.

Table 1.7: Investment and Tax Effects across Regions: Desai et al. (2002) Tables 5 and 7.

	Dependent variable: Log of Total Assets			
	Table 5		Table 7	
	Orbis	DFH (2002)	Orbis	DFH (2002)
Country Tax Rate	-0.1948	-0.7409	-0.4975	-0.2591
	(0.4847)	(0.3364)	(0.7532)	(0.1358)
Indirect Ownership			0.4525	0.3420
			(0.0867)	(0.0766)
Indirect Ownership×			0.1685	-0.9376
Country Tax Rate			(0.9420)	(0.2513)
N (firm-years)	3,198	20,346	2,348	20,346
Adj. R^2	0.0107	0.0108	0.0250	0.0172

Standard errors in parentheses

Notes: This table reports results of a regression of the log total assets a firm held onto country-level tax rates (described in section 1.5.1). Observations are ownership links. For each specification, the left-hand column presents results from a regression using Orbis data for plastic producers in the year 2013, while the right-hand column presents estimates directly out of Desai et al. (2002). In my Orbis regression, the independent variable for country tax rate is the difference between the local (foreign) corporate tax rate and the home corporate tax rate, whereas DFH only looks at U.S. multinationals and therefore uses only the local corporate tax rate. Third-order polynomial in GDP is included, but not reported.

links between them. Moreover, by constructing the ownership network for each year during a given sample period, I am able to describe time variation in ownership structure. I perform this construction on the set of plastic manufacturing firms in the European Union, and present descriptive statistics and stylized facts. I then take two attempts at studying determinants of ownership structure from the literature and reproduce them using my data.

As this is primarily a descriptive chapter, there are many directions for potential future research even at a descriptive level. The data extracted from Orbis for the purposes of this chapter could be readily extended to other industries, or the entire European economy. The extent of common ownership among downstream competitors is largely unknown, and only just becoming an active area of research. One could certainly get a picture of common ownership by starting with the set of firms in a given industry and tracing their upstream ownership roots. Another potential direction one could take these data is to treat the global structure of ownership as a network panel, and estimate a time-series model of link formation. The econometrics of networks is a fairly new field, but it seems to be a reasonable framework to consider the multinational firm's decision of internal ownership structure, market entry, and acquisition. More work can also be done studying how firm ownership structures have changed over time, using the panel component to the ownership data as is done to some degree in the subsequent chapter. The more ambitious goal of a full model of the internal ownership structures of multinational firms will require theoretical legwork in order to generate testable predictions, but suitable data of the network structure of ownership is a necessary condition.

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Appendix

1.A Construction of Ownership Panel

1.A.1 Network Structure of Ownership

This appendix addresses the construction of the ownership panel used in this paper, as extracted from the Bureau van Dijk Orbis Ownership Database. The Orbis database is organized as a list of shareholder-subsidiary links, discoverable by querying the database for the ownership information for any particular firm at a given point in time. In order to translate this into a structured look at the ownership structures relevant to a given industry, I employed an algorithmic search of the ownership network. My strategy is to pursue a *breadth-first search* (BFS) of ownership affiliations in the network, starting from the initial list of European firms in the plastics industry and their direct owners. A breadth-first search is defined as a strategy for discovering nodes of a graph by exploring the complete list of nodes which are directly adjacent to the currently known list of nodes, before proceeding. Orbis tracks each firm according to a permanent "Bureau van Dijk ID" (BVDID), which allows me to re-query the database for ownership information of any firm which is identified as a direct shareholder of a given firm. In this context, I employ an iterative procedure in which I pull all shareholders of the firms that were discovered in the previous iteration, until arriving at a terminal node which has no shareholders. This search is performed at eleven different points in time (once a year from December 2005 through December 2015), $t = 0, \ldots, 10$.

To summarize, the steps of the breadth-first search extraction procedure are:

1. Define a list of firms as the initial unsearched "nodes". In this case, I use European plastic producers (those which match NACE Rev. 2 four-digit code 2016 or three-digit code 222).

2. Take the list of unsearched nodes and query Orbis for the list of direct shareholders and distribution of voting rights for each such node, at each of $t = 0, \ldots, 10$.

3. Drop any newly discovered direct shareholder which owns fewer than 1% of the voting rights of its parent node. Drop also any firm which was previously a currently visited node. The remaining firms comprise the set of newly discovered nodes.

4. If the set of newly discovered nodes is non-empty, they become the list of unsearched nodes; return to step 2 and iterate. Else, finish.

This process uncovers the linkages which characterize industry ownership structure at yearly intervals from 2005 to 2015, along with data on the share of voting rights attributed to each link. By merging observed shareholder-subsidiary ownership links across time, I have constructed an ownership panel which allows for the analysis of the evolution of both individual links and broad ownership structure over time.

1.A.2 Controlling Shareholders

In the Orbis Ownership Database, the definition of control is inferred from data on the ownership share of each shareholder-subsidiary link, meant to represent the share of the subsidiary's voting rights which are controlled by the shareholder. As described in section 2.2.1, for any given firm-year, the *direct* controlling shareholder at a given control threshold (10%, 20%, 50%, or 99%) is the shareholder which controls the largest share of voting rights in excess of the control threshold. The network structure of ownership can thus be distilled into a sparser network of direct controlling shareholders for each node in the original network by

use of a *top-down pruning algorithm* which "trims" non-controlling shareholders. By tracing the direct controlling shareholders to a terminal node, I therefore I identify the *ultimate* (or *indirect*) controlling shareholder at a given control threshold.[13]

The precise definitions of control and ownership used in this paper rely on some refinements of the ownership panel constructed in the prior section.

- Each link has at most two values for 'ownership share': a *direct* percentage (meant to capture the share of voting rights controlled by a direct ownership link), and a *total* percentage (which can include implicit indirect ownership chains). I use direct ownership share to define notions of ownership at a given control threshold, and back out the total percentage using the iterative method described in the previous section.

- The Orbis Ownership Database contains shareholders of many types, including corporate entities (e.g. ownership by industrial or financial firms), individuals (e.g. employees, managers, or family ownership), or public authorities (e.g. stage/government ownership). Since the primary purpose of this study is to understand the ownership through the network structure of ownership across firms, I ignore any ownership information related to individuals or governments, and focus on corporate shareholders.

- Occasionally the assignment of controlling shareholder encounters an "ownership cycle", in which iteratively tracing direct shareholders leads to a recursive loop, commonly referred to as cross-holdings.[14] The existence of cross-holding ownership patterns demonstrate that the structure of the ownership network is not simply a tree, and complicates the construction of the panel dataset somewhat as the pruning algorithm

[13]Orbis provides a defined ultimate owner, but frequently this will be an individual shareholder (which can't be subsequently searched in the database, and wouldn't show up under my definition of ownership network). In these cases, I trace up the ownership chain and choose the highest controlling shareholder which is a firm.

[14]Claessens et al. (2000) and Faccio and Lang (2002) document the existence of such cross-holding ownership structures as a means of distributing voting rights across a group of shareholders rather than a single corporate entity, thereby separating cash-flow and voting rights. Desai et al. (2002) posit that the use of such cycles could be used as a triangular way of avoiding repatriation taxes across borders.

used to eliminate non-controlling shareholders.[15] To avoid such complications in my analysis, I exclude such ownership cycles.

1.B Sanity Checks of Ownership Panel

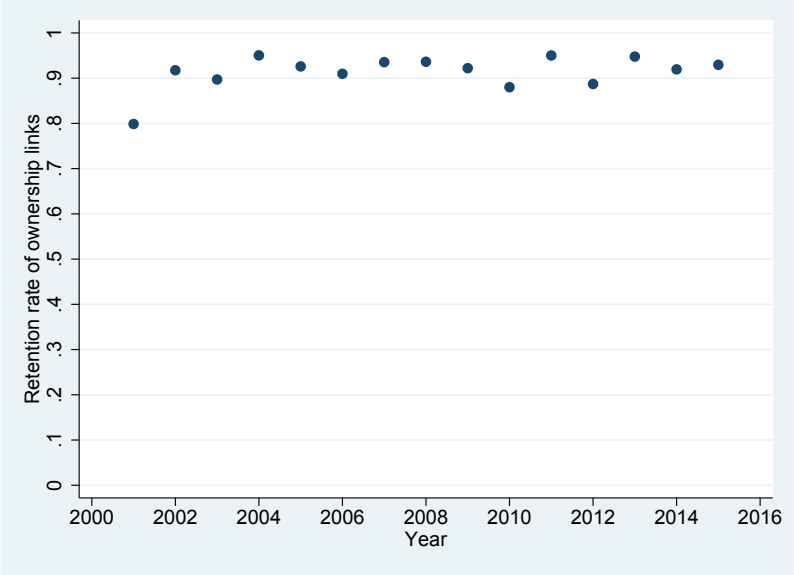
The method of pulling each firm's upstream ownership network at yearly intervals requires that Orbis's ownership data remain consistent and comprehensive throughout the sample period. As a check of this, I check how frequently ownership links remain in the sample in two separate years, and how this changes over the sample. Consider the set of links which exist at a time $t-1$. The *retention rate* of ownership links is at time t is defined as the fraction of ownership links from year $t-1$ which appear again in year t, irrespective of whether the ownership share has changed. If a link is not retained, I do not assume that the ownership link itself is severed.[16] I plot the retention rate for each year in the sample as it changes over time in figure 1.5. Though there are issues with link retention prior to the start of the sample period (2005-2015), throughout the sample period itself the retention rate remains around 90%. I take this as an indication that the yearly fidelity of the data is good enough to use for my purposes.

In constructing the ownership database, I define an ownership change as when a firm gets a new owner which was previously not a direct or indirect shareholder of the firm at any level. However, there is some concern that this definition will pick up changes to the data collection process undertaken by Bureau van Dijk; to the extent that they are adding intermittently new data sources to their products, I may not necessarily want to treat new observations as ownership changes. If for example, I observe a disproportionate swing in the number of ownership changes in a given year, it is possible that this is an artifact of

[15] I used a pruning algorithm to translate the shareholder-subsidiary link dataset extracted from Orbis into a list of all direct and indirect subsidiaries under each parent, but such an algorithm has no means of dealing with cycles.

[16] It is difficult to measure exit of any kind using the Orbis database. Orbis relies on the statistical agencies of many countries for the collection of their data, and each country has different standards for which firms have to report data in a given year. If a firm falls below this cutoff, it may disappear from the Orbis database even though it has not exited the market.

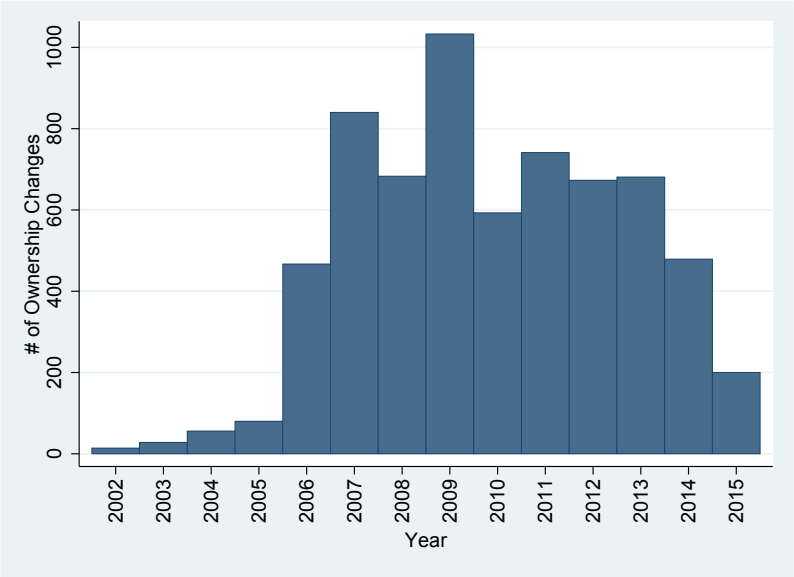
Figure 1.5: Retention rate of ownership links over time



Notes: Plot of the fraction of ownership links which are retained in each year; that is, the number of links which appear in both year t and year $t-1$ which also appear in year $t-1$.

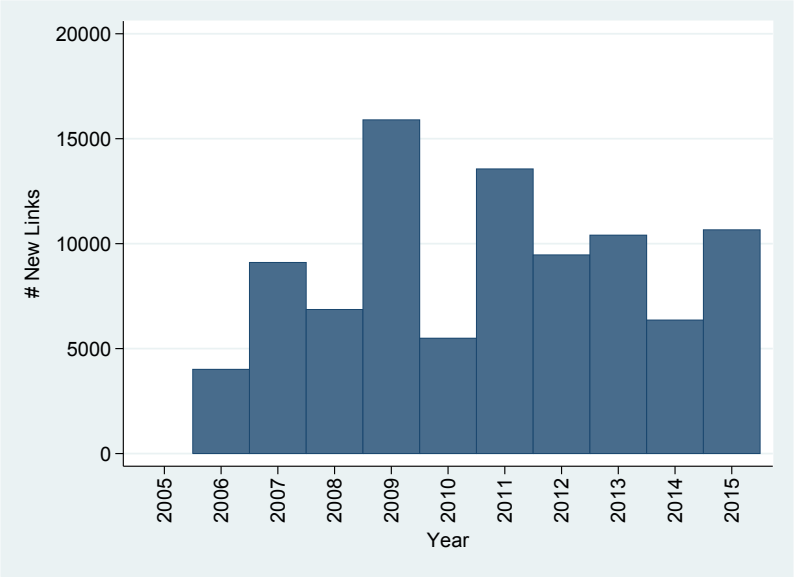
the database itself rather than the data. Or alternatively if I observe a steady increase in the number of ownership changes in each year during the sample period, it may be the case that Orbis is expanding the breadth of the database over time. To give a better idea of how ownership is changing over time, I plot the number of ownership changes each year in figure 1.6, and the number of new links being added each year in figure 1.7. While the data is not smooth, the fact that the number of ownership changes and links remains roughly constant over the sample period gives me confidence that the changes in yearly ownership network from Orbis indeed represent time variation in ownership structure.

Figure 1.6: Number of ownership changes over time



Notes: Plot of the number of ownership changes during each year of the panel (note, this covers all 60,664 firms in the universe of European plastic producers, rather than the screened sample of 17,697.

Figure 1.7: Number of new ownership links over time



Notes: Plot of the number of new ownership links during each year of the panel (note, this covers all 60,664 firms in the universe of European plastic producers, rather than the screened sample of 17,697. Ownership links counted as "new" only for firms which existed in the panel in the previous year (to avoid simply counting the shareholders of entrants as new owners).

Chapter 2

Ownership Changes, Complex Ownership Structures, and Productivity

2.1 Introduction

The ownership structure decision of the multinational firm includes the choice of where to locate production inputs and outputs, which has clear implications for the real economy. However, ownership structure also encompasses complex features such as the use of holding companies, ownership chains, and fractional ownership. Much of the industrial organization literature has assumed these complex ownership structures to be financial in nature rather than driving real economic outcomes, but until recently the difficulty of finding suitable data has prevented this question from being answered. The increasing availability of firm microdata with ownership linkages has made it possible to characterize and describe trends in the complex ownership structures of multinational firms, and to determine whether they have implications for firm productivity and performance.

This chapter takes a first step toward addressing the question of whether features of ownership structure have implications for real economic output by studying how changes in ownership structure impact productivity. Using the ownership database presented in the previous chapter, I pair data on firms' ownership with detailed balance sheet and income statement data for European primary plastics manufacturers in order to estimate firm productivity. To study the relationship between ownership and firm productivity, I build on the stylized fact documented in Braguinsky et al. (2015) that manufacturing firms which experience a change in ownership become more productive after the ownership change. I confirm this finding on my dataset using within-firm changes in productivity surrounding changes in ownership. I then extend it by investigating the extent to which this effect varies with complex features of ownership structure. In particular, I show that direct ownership changes (in which a firm gets a new direct controlling shareholder) have a larger impact on productivity than indirect ownership changes (in which the ultimate owner of a firm changes, but the direct owner does not). I also provide reduced-form evidence that the increase in productivity from a direct ownership change is larger when the new controlling shareholder takes a majority share of voting rights than when the new controlling shareholder acquires only a minority share. These results suggest a role for complex ownership structures in determining real economic outcomes, and they imply the need for a full model of the ownership structure decision of the multinational firm.

This paper relates closely to several areas of research. The question of whether the organizational structures of firms have a real economic impact in terms of the allocation of resources has long been studied in economics. One framing of this question refers to the boundaries of the firm: in particular, why firms choose to integrate with their foreign affiliates rather than simply making transactions at arm's length, and how these decisions affect the allocation of resources. The question of the importance of firm boundaries was raised by Coase (1937), and has been studied by Williamson (1979), Grossman and Hart (1986), Hart and Moore (1990) and Mullainathan and Scharfstein (2001) among others.

Despite the development of a rich literature on theoretical approaches toward answering this question, there is only limited empirical evidence relating these ownership structures and organizational choices to firm performance. In the industrial organization literature, researchers will frequently take a cross-section of all firms within a particular industry and treat them as independent without addressing the fact that many will have the same ultimate owner.[1]

One topic on which the literature has had the most success in bridging theory and empirics is the study of the effect of changes in ownership (through merger or acquisition) on firm-level performance post-ownership change. If changes in ownership are meant to reallocate the control of productive assets into the hands of more capable managers, then there should be an increase in productivity post-ownership change.[2] Lichtenberg and Siegel (1987), McGuckin and Nguyen (1995), and Maksimovic and Phillips (2001) mark early empirical attempts at studying the impacts of a change in ownership on the productivity of the acquired firm. These papers use U.S. Census plant-level data and find that targets of takeovers experience an increase in productivity after the acquisition.[3] Braguinsky et al. (2015) gather data on the production and ownership details of Japanese cotton spinning plants during the early 20th century in order to study the effects of ownership change on plant productivity. They confirm the near-stylized fact described above that plants which undergo a change in ownership experience increased productivity in the post-change years. The strategy of comparing productivity before and after an ownership change also has been applied in the

[1]For example, the traditional Herfindahl Index is typically calculated as a weighted sum of squared ownership shares across all firms in the market, and hence ignoring the possibility of common ownership. Two firms under a common owner may behave as a single unit, and hence may be important for purposes of assessing the concentration and competitiveness of a market. Azar et al. (2016) document the extent of extent of common ownership in the airline industry, and outline its effects on competition.

[2]An alternative hypothesis is that mergers and acquisitions occur for non-efficiency reasons, such as stock market misvaluation or CEO overconfidence. See Shleifer and Vishny (2003) and Malmendier and Tate (2008) for examples.

[3]A separate literature analyzes the effects of ownership changes on financial measures such as profitability or sales. For example Gugler et al. (2003) compares the profitability and sales of merging and non-merging firms in an international dataset, using Thompson's *Global Mergers and Acquisitions* database merged with firm-level accounting data from *Compustat*.

context of the effects of foreign direct investment (FDI) in the trade literature, as in Harris and Robinson (2003), Arnold and Javorcik (2009), and Guadalupe et al. (2012).

Due in part to data limitations, these approaches tend to treat ownership or acquisition as a binary treatment effect; a change in ownership is typically defined as when the firm or plant gets a new ultimate corporate owner which controls greater than some fraction of ownership share, usually 50% or 100%. A look at the ownership data reveals that there is significant heterogeneity in ownership shares held by controlling shareholders, and most owners do not hold 100% of voting rights in subsidiaries. To the extent that ownership structure contains more information, treating ownership as a binary indicator of majority shareholdership could be problematic for two reasons. First, in practice many controlling ownership relationships involve a shareholder which owns a significant plurality of the subsidiary's voting rights, but not necessarily a majority. In such cases, the corporate finance literature tends to consider a firm where the largest shareholder has at least 20% of the voting rights as having a singular controlling owner.[4] Moreover, the fact that such ownership changes constitute a decision to acquire along a continuum of voting rights suggest that there may be something to learn by studying the difference between a minority, majority, or whole acquisitions, and whether this additional heterogeneity interacts with heterogeneity in the observed productivity response to ownership change.[5] Second, parent firms may opt to own subsidiaries directly, or through various complex indirect ownership structures such as chains or the use of pyramidal holding companies. Treating an ownership change simply as a transfer to a new owner ignores the heterogeneity within acquisitions in terms of ownership structure.

I use the umbrella term *complex ownership structures* to encapsulate the scope of ownership data which is more granular than binary links to ultimate owners. By first constructing

[4]Such controlling shareholders are able to exert power over firms through the use of pyramids and participation in management. La Porta et al. (1999) and Faccio and Lang (2002) use the same cutoff threshold.

[5]In the FDI literature, some papers have looked at the performance of firms contingent on a multinational's mode of ownership and entry. Djankov and Hoekman (2000) provide a study of performance difference between whole-ownership and joint ventures in a developing country, comparing productivity growth in publicly traded firms in the Czech Republic, while Nocke and Yeaple (2007) study the productivity effects of a greenfield investment vs. acquisition for a foreign acquirer.

a new panel dataset for the network structure of ownership, my paper contributes to this literature by focusing on the economic relevance of these complex ownership structures through the lens of ownership changes.[6]

The study of complex features of ownership is sparse within the IO and trade literatures, so most of the relevant literature on these structures lies in the corporate finance literature. Claessens et al. (2000) and Faccio and Lang (2002) provide broad overviews of the anatomy of shareholder ownership structure in East Asia and Western Europe respectively. Both provide evidence that firm ownership structure is far more complex than one-to-one mappings between firm and owner, both in terms of the network structures of ownership linking firms to their ultimate owners, and the share of ownership held by that owner. This justifies the extensive literature in corporate finance on the inherent agency problems for different ownership structures (e.g., the separation of ownership and control). Laeven and Levine (2008) document the cross-sectional differences between firms which are controlled by a single large shareholder and firms with a complex structure with many blockholders. They find that the two groups differ substantially in financial measures (e.g. market value), but note that their analysis is hampered by the lack of time-series data on ownership structures. A smaller literature has sought to characterize the ownership and control of multinational firms in terms of a network structure. Altomonte and Rungi (2013) and Vitali et al. (2011) both use the Orbis Ownership Database to trace out a static network of inter-firm ownership structures. A consistent theme in the corporate finance literature on complex ownership structures is the reliance on cross-sectional variation. La Porta et al. (1999) and Faccio and Lang (2002) assert that ownership structure changes very little over time, and to my knowledge there is no other dataset which tracks time variation in ownership structure.

A goal of this chapter is to merge the aforementioned corporate finance literature documenting complex ownership structures with the techniques of the industrial organization

[6]The only paper I am aware of which studies the degree to which the productivity growth experienced by acquired firms depends on complex features of ownership structure is Schoar (2002). They find that plants which are acquired by corporate owners experience a premium in productivity growth if their new owner is diversified across many industries.

literature to assess the question of whether these structures have real economic implications. To do so I utilize the global dataset on ownership structure described in the previous chapter, building a panel dataset of the ownership structures and balance sheets of European plastic manufacturers. I then study the dynamics of firm productivity surrounding an ownership change, and in particular how these dynamics are mediated by features of complex ownership structure that characterize the new ownership link. To measure firm performance, I estimate firm-level total factor productivity using the semiparametric production function estimation method of Levinsohn and Petrin (2003). I incorporate the criticisms of De Loecker (2013) by endogenizing the productivity process to allow changes in ownership to shift future productivity. I first estimate a staggered treatment model with firm fixed effects for the evolution of firm productivity surrounding a change in ownership, finding that after an adjustment period, firms which experience an ownership change have a 10.1% increase in productivity from baseline pre-ownership change levels. To test the degree to which complex features of ownership structure mediate this transferred productivity, I then re-estimate the model including interaction terms for covariates related to complex ownership structures held by the firm's new owner. The results suggest that long-term post-ownership change productivity is increasing in the ownership share held by the new owner, and that the increase in productivity is 4.8% higher for direct ownership changes than indirect ownership changes. To address concerns of selection on observables, I also compute a difference-in-differences propensity score matching estimator to create a control group for the firms experiencing an ownership change. The results of the matching confirm a significant positive effect on post-ownership change productivity in general.

This chapter proceeds as follows. Section 2.2 describes the data by introducing relevant terminology and presenting descriptive statistics. Section 2.3 introduces the empirical framework and describes the specifics of productivity estimation. Section 2.4 presents results of key regression specifications and propensity score matching. Section 2.5 is a conclusion and discussion of future steps.

2.2 Data

2.2.1 Definitions

I describe the ownership database and define the relevant terminology in the previous chapter (see also Appendix 1.A for more details on the construction of the database, and the identification of ultimate owners). In this chapter I expand the taxonomy slightly by clarifying the minimum threshold of ownership shares required for control, and precisely defining the ownership changes studied.

Rather than identifying a single owner of each firm, the Orbis Ownership Database lists the identities of all direct shareholders, as well as the share of ownership held by each shareholder. In order to reduce the dimensionality of the data, I rely on several definitions of ownership to identify a single owner for any firm which has multiple shareholders. A minimum threshold of voting rights defines whether a shareholder is a *whole*, *majority*, or *controlling* owner of a given firm. A firm is *wholly-owned* by a given shareholder if that shareholder's share of direct voting rights is 100%, and a firm is *majority-owned* by a given shareholder if that shareholder's share of direct voting rights exceeds 50%. When a firm is owned by many dispersed shareholders, the largest shareholder has effective control if it owns a substantial block of ownership share (Faccio and Lang (2002)). Following the literature standard, I assume that a control threshold of 20% of voting rights is required for the largest shareholder to be controlling.[7] If no single shareholder exceeds the control threshold, then the firm is said to be *widely held*. For the main specifications of this paper, I define ownership using the definition of a controlling shareholder (i.e., requiring a minimum of 20% of voting rights).

Placing emphasis on the time dimension of the ownership data, I am primarily focused on changes in ownership and control. I define a *direct change in ownership* at a given threshold (whole, majority, or controlling) as when a firm gets a new owner which was not a previous

[7] I also repeat the main specifications under an alternate threshold of 10%; results do not change significantly.

owner of the firm at any level. An *indirect change in ownership* at a given threshold is defined as when the firm's direct owner does not change, but the firm gets a new ultimate owner which was not a previous owner of the firm at any level. Indirect changes are meant to represent ownership changes which occur at the level of one of a firm's upstream parents, such that the firm's direct ownership structure remains constant. In the rare instances in which a firm's direct owner changes but its ultimate owner remains the same, I do not treat this as an ownership change. Note also that if a firm's direct owner *and* ultimate owner change (i.e., if a firm's new ownership structure is an ownership chain) this is a direct change in ownership.[8] See figure 2.1 for simple visual depictions of both direct and indirect changes in ownership. In the top panel, Firm B undergoes a direct change in ownership after a controlling stake changes hands from Firm A to Firm C at time $t+1$. In the bottom panel, Firm B undergoes an indirect change in ownership after Firm C becomes its new ultimate owner through an ownership chain via Firm A at time $t+1$.

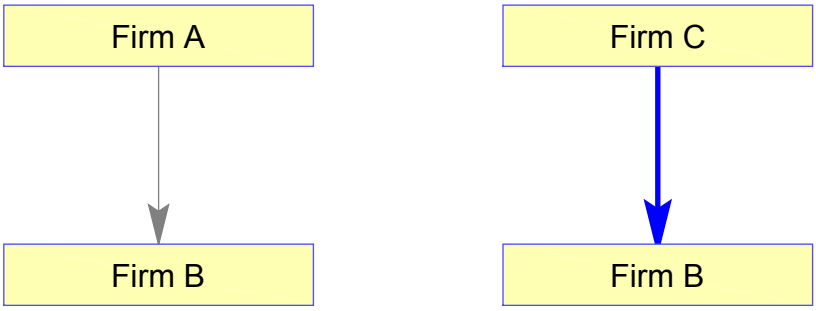
2.2.2 Descriptive Statistics

The Orbis ownership database allows us to describe static patterns in the data, as well as to analyze trends in the evolution of the ownership structure over time. For each year from 2005 to 2015, the ownership links in the database characterize the entire upstream network of ownership for firms in the European Union (EU) which match NACE Rev. 2 codes corresponding to raw plastic in primary forms or plastic products. I combine the ownership data with unconsolidated balance sheet and income statement data also in Orbis.[9] After final screening, the base sample has a total of 17697 firms spanning 21 countries.[10] The idea behind restricting myself to a particular industry is to focus on measuring productivity for

[8]Multinationals often acquire affiliates through holding companies and ownership chains; I consider this a different phenomenon than an ownership change occuring at the level of one of a firm's direct or indirect parents.

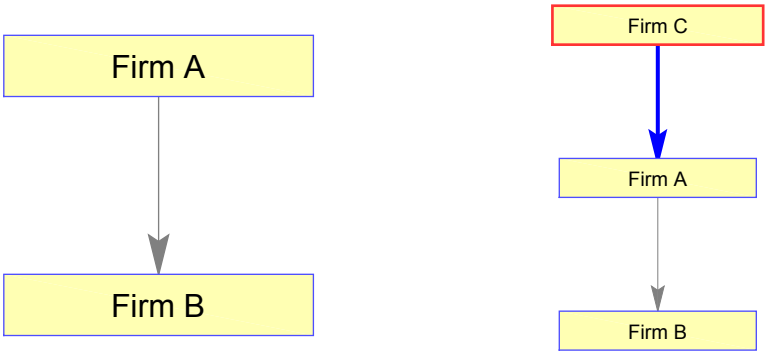
[9]The fact that accounts are unconsolidated is essential for a study in which firms are acquired and ownership structures change, which is a feature of data from most European countries. If consolidated accounts were instead reported firms might merge balance sheets after acquisition, rendering before and after comparisons flawed.

[10]See section 2.3.3 for details on this screening of the estimation sample.



time t time $t+1$

(a) Direct change in ownership



time t time $t+1$

(b) Indirect change in ownership

Figure 2.1: Illustrations of ownership changes

the manufacture of only a narrow band of products represented across a large geographic region; none of the analysis is specific to the plastics industry, and it could be replicated using many other industries. The dataset construction is described in further detail in the prior chapter; see section 1.3 for further details and basic summary statistics.

Table 2.1 presents basic summary statistics for the firms in the sample, split according to their broad ownership status. The first column presents median values of key production variables for the firms in the sample, while the remaining columns break this down into those with no direct owner parent firm(s), those with a direct/indirect owners which remain the same throughout the sample period, and those which experience an ownership change during the sample period. Firms which have a single parent firm throughout the sample appear quite similar to firms which are independent.[11] Firms which experience ownership changes during the sample are similar in terms of productivity, but often are larger than the average firm in terms of output, assets, and number of employes. The disparities in size between firms which experience an ownership change in the sample period and those with static ownership suggest that it would be difficult to treat the firms with static ownership as a direct control group. Table 2.2 summarizes ownership changes in the sample. I find a total of 2185 firms which experience a direct change in ownership, and 383 more firms which experience an indirect change in ownership. There are a handful of firms which experience multiple ownership changes during the sample period; I eliminate these from the final estimation sample. In each year, a firm has a 1.7% chance of undergoing a change in ownership, either direct or indirect. This is in line with existing literature; for some comparison, Maksimovic and Phillips (2001) find a yearly 1.95% rate of U.S. plants undergoing ownership change via mergers and acquisition.

In this chapter, a focus will be on features of complex ownership which are unique to my dataset: indirect ownership, and fractional ownership. In table 2.2 I show that while indirect ownership changes occur, the number of direct ownership changes outnumber indirect

[11] Independent firms include those firms which have individuals or family members as shareholders.

Table 2.1: Summary statistics, by firm ownership status

	Total	No Parent Firm	Has Parent Firm	
			Static	Changes
# Firms	17697	8008	7208	2481
Avg. Years in Sample	9.07	9.10	8.97	9.25
Variables (Median)				
Age	14	15	12	15
Operating Revenue	1062.51	886.27	843.15	4370.27
Tangible Fixed Assets	198.40	177.06	152.85	726.68
Number of Employees	12	11	9	33
Material Costs	513.58	418.47	409.89	2154.43
Labor Productivity	1.51	1.48	1.55	1.49

Notes: Data cover the period 2004-2015. Values in th. Euros. Firms are split into three categories, depending on their subsidiary ownership status. "No Parent Firm" firms have no parent firm at any point during the sample (these firms typically have a non-firm owner which is either an individual, family, or government entity). Firms are marked as "Has Parent Firm; Static" if they have a parent firm in the sample, but the ownership structure is unchanged throughout the period. Firms are marked as "Has Parent Firm; Changes" if they have a parent firm in the sample, and they experience an ownership change. Labor productivity is defined as the value-added per dollar spent on employees (total employee cost).

ownership changes by a factor of five. This suggests that it is relatively uncommon for the global ownership structure of a firm to change without its direct parent changing as well. Each ownership link in the Orbis ownership database is associated with an ownership share representing the voting rights held by the shareholder. In figure 2.2, I plot the distribution of these shares for ownership links within a single year of the data, to demonstrate the heterogeneity. The top panel shows the distribution of ownership share across all direct ownership links on the main sample. While a significant fraction of firms are held at a 50% or 100% share of voting rights, the majority of links in the panel represent other fractional amounts of ownership. The bottom panel focuses only on the ownership shares held by the new owner following an ownership change. Fewer than half of the ownership changes in the sample yield owners which control 100% of voting rights. To the extent that I observe new owners taking control at varying levels of ownership (as in the lower panel), I will be

Table 2.2: Summary of ownership data

	Count	Percent
Total Firms	17697	-
w/ ownership change	2481	14.0%
w/ direct ownership change	2185	12.3%
w/ indirect ownership change	383	2.2%
	Count	Percent
Total Firm-Years	160447	-
w/ ownership change	2703	1.7%
w/ direct ownership change	2249	1.4%
w/ indirect ownership change	454	0.3%

Notes: Data cover the period 2004-2015. Direct and indirect ownership changes defined in section 2.2.1.

able to see if heterogeneity in ownership share interacts withe heterogeneity in the effect on productivity.

2.3 Empirical Analysis

2.3.1 Productivity Measurement

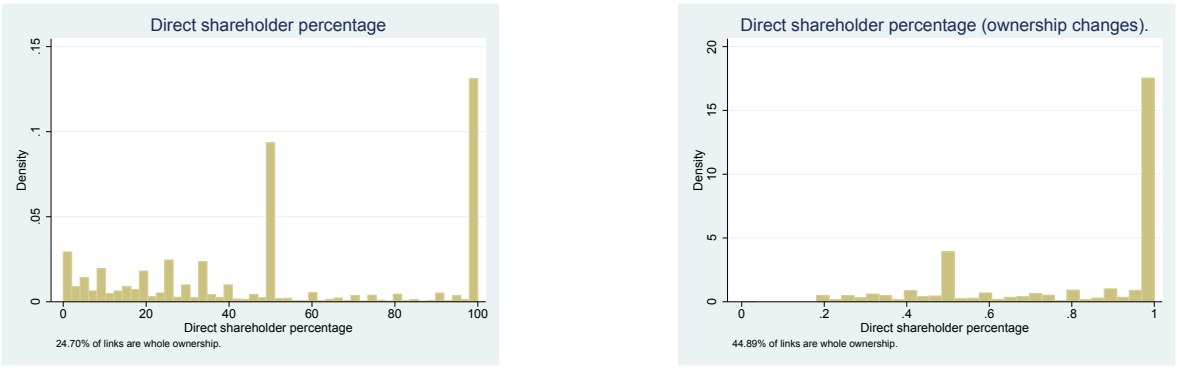
In order to study the relationship between ownership structure and real economic outcomes, I measure firm-level productivity through the estimation of a production function. I assume a Cobb-Douglas functional form for the value-added production function in labor and capital:

$$Y_{it} = A_{it} L_{it}^{\beta_l} K_{it}^{\beta_k}, \tag{2.1}$$

where the total factor productivity (TFP) term A_{it} captures factor-neutral shifts in output which are not explained by firm input choices alone. To estimate productivity, consider the production function in logs:

$$y_{it} = \beta_l l_{it} + \beta_k k_{it} + \omega_{it} + \eta_{it}, \tag{2.2}$$

Figure 2.2: Distribution of share of voting rights over ownership links



(a) All ownership links

(b) New links from direct ownership changes

Notes: Sub-figure (a) includes all ownership links over the sample, while sub-figure (b) includes only new links which are introduced in a direct ownership change. Ownership share taken from the Orbis Ownership Database's measure of direct ownership, which is meant to represent the share of voting rights held by the direct parent.

where y_{it} is the log of output (value-added), l_{it} is the log of labor (number of employees), k_{it} is the log of capital stock (tangible fixed assets), and log TFP is decomposed into an unanticipated i.i.d. shock η_{it} and a term ω_{it} which is known to the firm at time t (but unobserved by the econometrician). The term ω_{it} represents serially correlated shocks to production technology, and hence can be thought of as the productivity of firm i at time t.

The goal is to recover the firm-level productivity residual ω_{it} by estimating equation (2.2). In order to avoid the well-known simultaneity bias of a direct application of OLS (see Marschak and Andrews (1944) for early discussion), I follow the semiparametric approach first outlined by Olley and Pakes (1996), and later refined by Levinsohn and Petrin (2003). These methods attempt to proxy for ω_{it} using an inversion of monotone firm policy functions for input choices, thereby controlling for the unobserved productivity shocks. In particular, I focus on the method of Levinsohn and Petrin (2003) (LP), which uses firms' optimal choice of material input m_{it} in order to proxy for ω_{it}, and implement the estimation according to the approach of Ackerberg et al. (2006) (ACF). I also follow De Loecker (2013) and Braguinsky et al. (2015) in accounting for changes in ownership status in order to endogenize

the productivity process. Rather than assume an exogenous first-order Markov process for productivity as in LP, I assume that productivity evolves according to

$$\omega_{it+1} = g\left(\omega_{it}, \Delta\mathbf{Owner}_{it}\right) + \xi_{it+1} \tag{2.3}$$

where $\Delta\mathbf{Owner}_{it}$ consists of a vector of dummies indicating recent or upcoming change in ownership, ξ_{it+1} are exogenous innovations to productivity, and $g\left(\cdot\right)$ is estimated non-parametrically. In doing so I allow for changes in a firm's ownership to directly shift the law of motion for productivity, which is consistent with the stylized fact that firms become more productive after a change in ownership.[12] Output elasticity parameters are estimated by GMM using the moments

$$E\left[\xi_{t+1}\left(\boldsymbol{\beta}\right)\begin{pmatrix} k_{t+1} \\ l_t \end{pmatrix}\right] = 0 \tag{2.4}$$

and firm-level TFP estimates are recovered as residuals of the production function in equation (2.2). I estimate productivity separately for each four-digit NACE code.[13] Further details of this method are found in Appendix 2.A.

Note that since Orbis only reports nominal values of outputs and inputs, equation (2.2) represents a sales-generating production function and firm-level output and input prices are unobserved. I follow the traditional approach of deflating nominal values by an industry-level price index, but within-industry heterogeneity in prices will potentially bias the productivity

[12]The relationship between productivity and changes of ownership is confirmed in my data using naive OLS estimates of productivity in table 2.3.

[13]It is worth noting that while an ideal production function estimation would take place on plants producing homogenous products, where the production technology ($\boldsymbol{\beta}$) can be assumed to be constant across establishments. However, the Orbis dataset is on firms rather than plants, which may be an amalgamation of multiple plants producing different products. Moreover, I do not restrict the sample to the production of primary plastic alone; all primary plastics and plastic products manufacturers are included, which further suggest that multiproduct firms are a possibility.

measures.[14] In the context of mergers and acquisitions this can be problematic, as the consolidation of market power following an acquisition or merger can lead to price increases which are independent of increases in physical productivity. This is a concern common to most classic studies of ownership changes and productivity, though more recent papers such as Hortacsu and Syverson (2007) and Braguinsky et al. (2015) are able to focus on physical productivity given data on actual quantities produced. For the purposes of this paper, productivity will capture both cost and demand factors, and as such should not be strictly interpreted as measurements of physical efficiency; I will not attempt to separate market power and efficiency effects from ownership changes.

2.3.2 Reduced-Form Specification

The aim is to find the impact of organizational structure on firm performance. A naive approach would be to simply regress some measure of firm performance, Y, on characteristics of organizational structure Z and other firm covariates X:

$$Y_i = \alpha + \beta Z_i + \delta X_i + \epsilon_i.$$

Running such a regression would be subject to clear endogeneity concerns, as firm performance could be a driver of organizational change, or omitted firm characteristics could be driving both performance and ownership structure. Moreover, depending on the measure of ownership structure, there may be insufficient variation in the explanatory Z for the regression to be informative.

An improved approach toward relating ownership structure and firm performance would be to exploit time variation in ownership structure in the panel, explicitly focusing on changes in ownership structure at the firm level. To that end, I study the effect of changes in

[14] e.g., firms which are able to charge higher output prices will have upward bias in productivity. See Mairesse and Jaumandreu (2005) and Foster et al. (2008) as examples of studies which have access to firm-level price and output data, and thus are able to explicitly demonstrate this bias.

ownership on firm productivity by relying on a treatment framework with firm fixed effects using the productivity measurements from section 2.3.1. As a baseline, I first document the stylized fact that ownership changes tend to increase productivity for the acquired firm. This specification, which is similar to equation (5) in Braguinsky et al. (2015), is:

$$\omega_{it} = \alpha_i + \lambda_t + \beta_{pre}\Delta\text{Owner}_{it+1} + \beta_{post}^{early}\Delta\text{Owner}_{it-1} + \beta_{post}^{late}\Delta\text{Owner}_{i\{t-2,t-3,\ldots\}} + \epsilon_{it}, \quad (2.5)$$

where ω_{it} is firm-level TFP as estimated in the previous section, α_i are firm fixed effects, λ_t are year fixed effects, and ΔOwner_{it} are dummies which are equal to 1 if a firm has a change in ultimate owner in year t. Notably, I include an effect on productivity for pre-ownership change for the year before an ownership change (β_{pre}), early post-ownership change for the year after an ownership change (β_{post}^{early}), and late post-ownership change for any subsequent year (β_{post}^{late}) in order to capture the trajectory of transferred productivity surrounding changes in ownership. The dummy for an ownership change in the current year (ΔOwner_{it}) is excluded from the regression, as the ownership data is not granular enough to identify at what point during the year a change in ownership occurs.

This specification picks up within-firm changes in productivity around a change in ownership, as firm fixed effects α_i control for persistent firm characteristics and mean levels of productivity. The inclusion of firm fixed effects is important because we expect that these time-invariant firm characteristics could play a role in the selection into treatment. This is similar to a staggered difference-in-differences model in that the 'treatment' of ownership change occurs in different years for each firm. A shortcoming of this reduced-form specification is the potential endogeneity arising from the fact that the choice of organizational structure is rarely an exogenous occurrence. In order to place a causal interpretation on the relationship between ownership structure and firm performance one would need some regulatory change or plausible instrument which affects the internal ownership structure of firms, which I do not have. While I allow for selection on firm characteristics which are

time-invariant, any selection on observables or unobservables which change over time could confound any causal story.[15] I address selection on observable firm characteristics which change over time by implementing a propensity score matching estimator in section 2.4.2.

In a second set of specifications, I extend equation (2.5) by including interaction terms for features of complex ownership which characterize the new ownership structure. Leveraging the features of the constructed ownership database, I use three measures of ownership structure in separate regressions. First, to measure whether the effect of an ownership change on productivity is mediated by the degree of control held by the new owner, I use the new owner's share of voting rights for direct ownership changes. Second, to determine whether the threshold at which an ownership change is defined is relevant for assessing the effect of an ownership change on productivity, I use a dummy for whether the new owner is has *majority*-ownership (greater than 50% share of ownership). Lastly, to compare the differential effect on productivity of *direct* changes in ownership to *indirect* changes in ownership, I use a dummy for whether the ownership change is direct. Indirect ownership represents an ownership-based separation between a firm and its ultimate owner.

The estimating equations are of the form:

$$\begin{aligned}\omega_{it} = \quad & \alpha_i + \lambda_t + \beta_{pre}\Delta\text{Owner}_{it+1} + \gamma_{pre}Z_{it+1}\Delta\text{Owner}_{it+1} \\ & + \beta_{post}^{early}\Delta\text{Owner}_{it-1} + \gamma_{post}^{early}Z_{it-1}\Delta\text{Owner}_{it-1} \\ & + \beta_{post}^{late}\Delta\text{Owner}_{i\{t-2,t-3,\ldots\}} + \gamma_{post}^{late}Z_{i\{t-2,t-3,\ldots\}}\Delta\text{Owner}_{i\{t-2,t-3,\ldots\}} + \epsilon_{it},\end{aligned} \tag{2.6}$$

where Z_{it} is one of the measures of the new ownership structure from a change in ownership at time t: the share of voting rights by the new direct owner, a dummy for whether the new owner exerts majority control, and a dummy for whether the ownership change was direct. The chosen features of complex ownership for Z_{it} are arranged in such a way that larger values of Z_{it} are loosely meant to represent a higher amount of control by the new owner

[15] Recent approaches the literature has employed to get around this issue include creating quasi-experiments using failed mergers as a counterfactual, in order to generate exogenous variation in ownership structure through mergers & acquisitions (Seru (2014)).

(more ownership share, majority ownership, and direct ownership); as such, the sign on the interaction term γ will indicate whether this amount of control has a positive or negative impact on productivity changes after ownership change.

2.3.3 Sample Construction

Starting with the full set of EU firms which produce primary plastics or plastic products in the Orbis database, I perform several standard cleaning measures on the raw data. In Orbis, each firm has at most ten years of available panel data. I use only firms which are observed for at least five years, and drop any firms whose first observed year is prior to 2003.[16] I eliminate all firms which undergo multiple ownership changes in the sample. I drop all firms with only consolidated accounts, to avoid double-counting. I drop all firms with non-positive values observed for operating revenue, tangible fixed assets, material costs, labor costs, or number of employees. I remove firms which are "small", on the basis of having fewer than five employees, or fewer than one thousand euros in tangible fixed assets. To avoid occasional database errors or extreme outliers, I also drop all firms which are 0.1% outliers in their industry and year for the final observed year in operating revenue, value-added, employee costs, or material costs. I use tangible fixed assets to represent capital, the number of employees to represent labor, and material costs as the proxy in the LP production function estimation.

2.4 Results

I implement the productivity estimation described in section 2.3.1 on the set of all plastic manufacturers in EU countries. I obtain estimates for the coefficients on labor and capital,

[16]The Orbis ownership panel is unreliable prior to 2003, as links from this period of time are not archived.

$\hat{\beta}_l$ and $\hat{\beta}_k$, as 0.687 and 0.348 respectively for producers of primary plastic, and 0.644 and 0.338 respectively for producers of plastic products.[17]

2.4.1 Within-Firm Changes in Productivity

Taking these productivity estimates as inputs, I can then estimate the empirical specifications of section 2.3.2 in order to evaluate the evolution of firm productivity around changes in ownership. The results from estimating the baseline specification for any change in ultimate owner from equation (2.5) are shown in the first column of table 2.3. In the second and third columns I use as the dependent variable alternative measures of firm TFP, which serve as a robustness check to the productivity measurement specification. In the second column I use the residual from OLS estimation of equation (2.2), and the third column estimates output elasticities using the cost share of each input as a fraction of total value-added. All three specifications reflect the stylized fact documented in Braguinsky et al. (2015) that changes in ownership are followed by increases in firm productivity, although it takes time for this increase to manifest itself. Two years after undergoing a change in ownership and later, a firm's TFP increases 10.1% above pre-ownership change levels. I also find that in the year after a change in ownership, firms' productivity increases by 4.2%.

A common concern in event study-type frameworks is the possibility of pre-treatment trends. If the acquired firms were already trending upward in productivity prior to the ownership change, the significant positive effects found on the late post-ownership change period in table 2.3 may simply be a continuation of this trend. To address this concern, I re-estimate equation (2.5) using yearly dummies for an ownership change having occurred within t years (omitting, as above, the year of the ownership change itself). The result is a non-parametric estimation of the dynamics of productivity changes surrounding an ownership change. I plot these coefficients over time in figure 2.3 with 95% confidence intervals. This

[17]To get a sense of whether these numbers are reasonable, one can compare the coefficient on labor to the wage bill share of value added, 0.65 for all firms in the industry. With homogenous products and a Cobb-Douglas production function, cost minimization implies that the two numbers should be equal.

Table 2.3: Within-firm comparisons of productivity surrounding ownership change

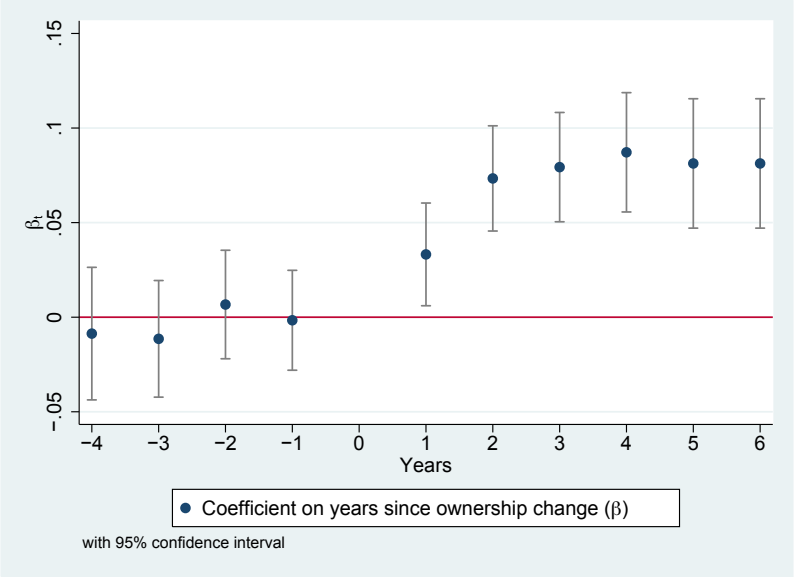
Dependent Variable:	TFP (LP/ACF)	TFP (OLS)	TFP (Cost Share)
	(1)	(2)	(3)
Pre-ownership change dummy $(s-1)$	0.008	0.017	-0.014
	(0.013)	(0.012)	(0.013)
Early Post-ownership change dummy $(s+1)$	0.042***	0.047***	0.049***
	(0.013)	(0.014)	(0.012)
Late Post-ownership change dummy $(s+2,\ s+3)$	0.101***	0.108***	0.110***
	(0.010)	(0.011)	(0.010)
Firm fixed effects	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes
N (firm-years)	109762	109762	109762
Adj. R^2	0.79	0.80	0.78

Standard errors in parentheses

$^{*}:\ p<0.01;\ ^{**}:\ p<0.05;\ ^{***}:\ p<0.1$

Notes: Data cover the period 2004-2015. This table reports results of a regression of firm performance on dummies for recent ownership change and a firm fixed effect, as in equation (2.5). Numbers reported in the table are the point estimate and robust standard errors (in parentheses, clustered by firm) on a dummy for whether the firm experienced an ownership change in the surrounding years. The dependent variable in each regression (column) is firm TFP; column (1) represents the preferred estimates, while columns (2) and (3) present results based on first-cut estimates of productivity which serve as a robustness check of the measurement specification (see further discussion in Syverson (2011)). Column (1) uses proxy estimators of firm TFP as computed in section 2.3.1 following Levinsohn and Petrin (2003) and Ackerberg et al. (2006). Column (2) uses reduced form estimates of firm TFP, based on a (biased) OLS regression of the production function in equation (2.2). Column (3) estimates output elasticities as the cost share of each input as a fraction of total value-added, in which (under the assumptions of Cobb-Douglas production function, perfect competition, homogenous goods, and no factor adjustment costs) the industry β_l should be equal to the firm-level cost-share of labor. Results robust to an alternate definition of ownership in which minimum thresholder for control is 10% of voting rights (see appendix 2.B).

Figure 2.3: Evolution of productivity changes around ownership change, non-parametric dummies



Notes: This figure reports the coefficients found by estimating equation (2.10) using yearly dummies for the years since (or prior to) a change in ownership. The horizontal axis represents the years separated from the ownership change, and the vertical axis represents the coefficient on the corresponding year dummy in a regression of productivity (computed as in section 2.3.1) on these dummies, firm fixed effects, and year fixed effects. Point estimates of the coefficients presented as dots, and vertical bands are 95% confidence intervals.

figure provides visual confirmation both of the absence of pre-ownership change trends, and the shock to target productivity post-ownership change. The pre-ownership change coefficients confirm that there is no noticeable trend in productivity prior to firms being acquired; while the signs on these coefficients are negative, none are significant. In the first year after ownership change there is a partial shock to productivity, and after two years the productivity reaches a new normal which is maintained for the next five years. Coefficients are reported in appendix 2.C.

Table 2.4 presents results from the estimation of specifications of the form of equation (2.6), which investigate the importance of features of ownership structure in the evolution of productivity around a change in ownership. Each column presents a separate regression which includes interaction terms for covariates related to complex ownership structures held by the firm's new owner. The dependent variable in each regression is firm TFP, computed

according to the semiparametric proxy estimator method described in section 2.3.1. The first column adds an interaction term for the share of voting rights held by a new owner, on a scale from 0.2 (the minimum cutoff for a new owner) to 1. I find that firms whose new owners who hold 10 percentage points more of the ownership share experience a 1.1% larger increase in productivity in the late post-ownership change period. The second column adds a dummy for whether the new owner has more than 50% of ownership share (voting rights), to compare the productivity impact under new owners which control a majority of voting rights against those which obtain a controlling minority (20% to 50% of voting rights). I find that firms with a new owner controlling a majority of voting shares experience an increase in late-period post-ownership change productivity that is 6.5% higher than firms with a new controlling owner with a minority of voting shares. This is consistent with a story in which a new owner with a greater control is able to have a larger impact on target productivity growth, but it does not rule out selection. In the third column, I consider both direct and indirect ownership changes, and add a dummy for whether the ownership change is direct. I find a significant positive effect of direct ownership changes relative to indirect ones: firms with new direct owners experience 4.8% larger increase in late-period post-ownership change productivity than those firms experience an indirect change in ownership. Each of the three specifications provide some support for complex features of ownership structure playing some role in the evolution in firm productivity surrounding an ownership change. In particular, each suggest that a stronger relationship between the new parent firm and the target result in a larger post-ownership change shock to productivity.

2.4.2 Propensity Score Matching

Lines of inquiry into the effects of mergers typically face the challenge of how to convincingly show a causal impact of ownership changes on firm performance, given the different ways that selection can play a role in which firms undergo an ownership change. The reduced-form specifications in equations (2.5) and (2.6) are able to control for any selection into ownership

Table 2.4: Within-firm comparisons of productivity surrounding ownership change

Ownership Structure (Z_{it}):	Ownership Share (1)	>50% Ownership Acquired (2)	Direct Owner (3)
Pre-ownership change dummy $(s-1)$	-0.007	0.030	0.020
	(0.045)	(0.036)	(0.019)
× Ownership Structure	0.022	-0.023	-0.007
	(0.053)	(0.039)	(0.027)
Early Post-ownership change dummy $(s+1)$	0.035	0.034	0.045
	(0.046)	(0.0307)	(0.025)
× Ownership Structure	0.006	0.007	0.012
	(0.055)	(0.040)	(0.028)
Late Post-ownership change dummy $(s+2,\ s+3)$	0.012	0.049*	0.063***
	(0.034)	(0.028)	(0.021)
× Ownership Structure	0.107***	0.065**	0.048**
	(0.041)	(0.030)	(0.023)
Firm fixed effects	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes
N (firm-years)	109762	109762	109762
Adj. R^2	0.80	0.79	0.77

Standard errors in parentheses

$^{*}:\ p<0.01;\ ^{**}:\ p<0.05;\ ^{***}:\ p<0.1$

Notes: Data cover the period 2004-2015. This table reports results of a regression of firm TFP (computed in section 2.3.1) on dummies for recent ownership change, interaction terms for a feature of ownership structure for each specification, and a firm fixed effect, as in equation (2.6). Numbers reported in the table are the point estimate and robust standard errors (in parentheses, clustered by firm) on a dummy for whether the firm experienced an ownership change in the surrounding years. The dependent variable in each regression (column) are proxy estimators of firm TFP as computed in section 2.3.1 following Levinsohn and Petrin (2003) and Ackerberg et al. (2006). Column (1) includes interaction terms for the share of ownership at which a new ownership change is made at (minimum 20%, per definition of ownership in section 2.2.1), and only considers direct ownership changes. Column (2) includes interaction terms for whether the new owner acquired at least 50% of voting rights (ownership share). Column (3) includes interaction terms for whether the ownership change was direct, as defined in section 2.2.1. Results robust to an alternate definition of ownership in which minimum thresholder for control is 10% of voting rights (see appendix 2.B).

changes that are based on firm attributes which are persistent over time by including firm-level fixed effects. For example, this allows for acquirers to target firms which are more productive, as the within-firm effect of the ownership change will still identify any post-ownership change improvements on this baseline.

The remaining worry is of selection on observables or unobservables which change over time. For example, acquirers could be targeting firms which are already in the short-term trending upward in productivity, so that any uptick in post-ownership change productivity may be incidental. One solution to this problem is to use propensity score matching (Rosenbaum and Rubin (1983)), in which each firm undergoing a change in ownership is compared to similar firm(s) which did not experience a change in ownership. The comparison firm is chosen based on a logit for the likelihood of ownership change in a given year, based on lagged firm characteristics. Ideally, propensity score matching allows one to select a control group which more accurately represents the missing counterfactual outcome. By choosing for each treated firm a matched control firm based on similarity of the probability of ownership change, the dimensionality of the match is reduced to a single dimension. This method has been employed in many situations in which selection into treatment could confound a causal interpretation, including several studies of firms.[18]

I compute a difference-in-differences propensity score matching estimator to the analysis of performance change following changes in ownership. To perform the propensity score matching, I first run a logit model with a dependent variable equal to 1 if a firm experiences a change in ownership and a 0 otherwise, on lagged values of firm size, value-added, number of employees, and firm age. The resulting predicted values are predicted probabilities of experiencing an ownership change based on observable characteristics (or, the propensity score). I then employ a nearest-neighbor matching to choose for each firm with an ownership change, another firm from the same year which never experienced an ownership change

[18]Examples of applications to firms include Girma and Görg (2007) (effect of foreign ownership on wages), Arnold and Javorcik (2009) (effect of foreign acquisition on productivity), De Loecker (2007) (effect of export entry on productivity), and Chang et al. (2013) (effect on joint vs. whole ownership on ROA).

with the closest propensity score. To confirm that the matching method produces suitably control and treatment groups for comparison (i.e., ensuring that key covariates are not statistically different between the paired samples), I perform standard balancing tests used by the propensity score matching literature. These tables and a further discussion of the balancing tests used are reported in Appendix 2.D.

After matching each treated firm to a similar control firm, I compute the average treatment effect on the treated (ATT) using a difference-in-differences (DID) matching estimator to exploit the panel nature of the data (see Heckman et al. (1997)). Denote by $\Delta\omega_{i,t}$ the change in performance in the tth year following an ownership change relative to the year of ownership change. The DID matching estimator is then written as:

$$\delta = \sum_{i \in T} \left(\Delta\omega_i - \sum_{j \in C} g\left(p_i, p_j\right) \Delta\omega_j \right) \tag{2.7}$$

where $g\left(\right)$ matches firms which were treated T to one in the remaining control group C (in this case, the nearest neighbor matching means that $g\left(p_i, p_j\right)$ will equal 1 for the matched firm). While standard matching estimators rely entirely on a story of selection on observables, Blundell and Costa Dias (2000) note that the DID matching estimator allows for the removal of any unobserved time-invariant firm characteristics.

I first apply the DID matching estimator to all changes in global ownership (direct or indirect), where the one-, two-, and three-year forward differences in productivity are compared between firms with an ownership change and their matched pair. I report the results of this procedure in table 2.5. In the preferred specification (1) using LP/ACF estimates of productivity, the difference in productivity for the treatment group (firms with a change in ownership), their matched control group, and the unmatched group (firms which were not treated, but were not matched via propensity score matching) are presented. The ATT represents the estimator in equation (2.7), computed by differencing the forward differences in productivity between firms undergoing an ownership change and their matched

control pairs. The treated firms do not differ from the control group one year after a change in ownership, while in the second and third years post-ownership change they experience a differential increase in productivity relative to the ownership change year of 2.6% and 7.4%, respectively.

Notably, a comparison of the matched to the unmatched controls reveals that the trajectory of productivity for the matched group is upward sloping in the first two years post match relative to the unmatched group. Given that matched firms are those which appear most similar to the acquired firms on pre-ownership change observables, this is consistent with a story in which acquired firms may be selected amongst targets which are already trending upward in productivity. However, three years after the change in ownership, the unmatched and matched control groups have nearly identical productivity compared to the base year, while the treatment group of firms experiencing an ownership change maintains the increase in productivity, significant at the 5% level. This bolsters the finding of Braguinsky et al. (2015) that the the impact of ownership changes on productivity may take longer to manifest, by using matching methodology to control for selection on observables which change over time

To apply propensity score matching to the question of complex ownership, (i.e., indirect vs. direct ownership), I require a matching that accommodates multiple treatment groups. The approach I employ is to follow Lechner (2001) by computing pair-wise comparisons across the multiple treatment groups (including the control) in such a way to maintain as much of the structure of binary matching estimators as possible. However, in this panel setting with infrequent treatments spread across different years within the sample, it is not feasible to pair firms which experience a direct ownership change to those experiencing an indirect ownership change in the same year.[19] I am able to individually apply pair-wise matching

[19]A handful of matches are of course possible, but regardless of the matching caliper, I am unable to ensure that the balancing condition is satisfied between the matched pairs. Bertrand and Zitouna (2008) perform this mechanical exercise almost exactly in a comparison of domestic vs. cross-border acquisitions, but does so on a larger sample by using all manufacturing firms in France (i.e., they do not restrict themselves to a single industry).

Table 2.5: Propensity score matching results for productivity change following ownership change

		1 year later	2 years later	3 years later
		ΔTFP (LP/ACF)		
(1)	Unmatched Control	0.002	0.006	0.023
	Matched Control	0.020	0.033	0.023
	Treatment	0.024	0.058	0.097
	ATT	0.005	0.026	0.074**
		(0.019)	(0.023)	(0.025)
	# of Matched Pairs	1007	1007	1007
		ΔTFP (OLS)		
(2)	Unmatched Control	0.001	0.004	0.022
	Matched Control	0.019	0.031	0.023
	Treatment	0.023	0.056	0.093
	ATT	0.004	0.025	0.070**
		(0.020)	(0.024)	(0.025)
	# of Matched Pairs	1007	1007	1007

Standard errors in parentheses

$^{*}: p < 0.01$; $^{**}: p < 0.05$; $^{***}: p < 0.1$

Notes: Data cover the period 2004-2015. This table reports results of a DID matching estimator based on propensity score matching of firms undergoing ownership change with similar firms (see section 2.4.2). Following a matching procedure, the change in productivity is compared for 'treated' firms undergoing an ownership change and similar untreated control firms, with the DID estimator from equation (2.7) representing the average treatment effect on the treated (ATT). Note that these standard errors to not take into account the fact that the propensity scores are estimated. The rows for specification (1) represent the preferred estimates, while the rows for specification (2) present first-cut estimates of productivity which serve as a robustness check of the measurement specification (see further discussion in Syverson (2011)). Specification (1) uses proxy estimators of firm TFP as computed in section 2.3.1 following Levinsohn and Petrin (2003) and Ackerberg et al. (2006). Specification (2) uses reduced form estimates of firm TFP, based on a (biased) OLS regression of the production function in equation (2.2).

between both of the groups of treated firms (direct and indirect ownership changes) and the control group of firms never experiencing an ownership change. It is worth emphasizing that the inability to match firms which experience a direct ownership change to those which experience an indirect ownership change means that I cannot rule out selection stories for an owner's decision to acquire a firm directly as opposed to indirectly. I apply the matching procedure described above separately for direct and indirect ownership changes, and report the results in table 2.6. When using direct ownership changes as the treatment, the results mirror those from the general case in table 2.5. Firms which experience an ownership change do not differ from the matched control group in productivity after one year, but do show a statistically significant differential effect when considering change in productivity two and three years after the ownership change. When using indirect ownership changes as the treatment, however, there is no statistically discernable difference between firms experiencing an indirect ownership change and their matched control group. This is consistent with the results of section 2.4.1, where indirect ownership changes provide a smaller impact on productivity than direct changes in ownership.

2.5 Conclusion

This chapter studies the interaction between ownership structure and firm performance using a novel database of ownership and firm performance which provides a new level of detail on complex features of the structure of subsidiary ownership in multinational firms. While much of the literature has assumed that ownership is suitably summarized by binary measures of control by a single direct owner due to data limitations, my dataset provides panel variation in the full network structure of ownership across subsidiaries of multinational firms, allowing for the description of complex ownership structures such as indirect ownership, ownership chains, and fractional ownership. I take a first approach at studying whether these structures have implications for real outcomes by building on the framework of Braguinsky

Table 2.6: Propensity score matching results for productivity change following indirect, direct ownership changes

Treatment		1 year later	2 years later	3 years later
(1)		ΔTFP (LP/ACF)		
	Unmatched Control	0.002	0.005	0.022
	Matched Control	0.024	0.013	0.035
Direct	Treatment	0.030	0.077	0.107
Ownership Change	ATT	0.006	0.063**	0.071**
		(0.021)	(0.025)	(0.028)
	# of Matched Pairs	778	778	778
(2)		ΔTFP (LP/ACF)		
	Unmatched Control	-0.000	0.001	0.017
	Matched Control	-0.000	-0.006	0.067
Indirect	Treatment	0.013	-0.010	0.075
Ownership Change	ATT	0.013	-0.004	0.008
		(0.038)	(0.053)	(0.050)
	# of Matched Pairs	143	143	143

Standard errors in parentheses

$^{*}: \ p < 0.01; \ ^{**}: \ p < 0.05; \ ^{***}: \ p < 0.1$

Notes: Data cover the period 2004-2015. This table reports results of a DID matching estimator based on propensity score matching of firms undergoing ownership change with similar firms (see section 2.4.2). The first set of rows (specification (1)) treat direct ownership change as the treatment variable, whereas the second set of rows (specification (2) treat indirect ownership change as the treatment variable. Following a matching procedure, the change in productivity is compared for 'treated' firms undergoing an ownership change and similar untreated control firms, with the DID estimator from equation (2.7) representing the average treatment effect on the treated (ATT). Note that these standard errors to not take into account the fact that the propensity scores are estimated. Both specifications use proxy estimators of firm TFP as computed in section 2.3.1 following Levinsohn and Petrin (2003) and Ackerberg et al. (2006).

et al. (2015), which studies how changes in firm ownership are related to productivity using within-firm changes in productivity. I first confirm the stylized fact in the literature that firm productivity increases following a change in ownership, which is robust to several specifications. By including characteristics of ownership structure captured by my dataset, I am then able to determine the degree to which the increase in productivity following an ownership change is mediated by ownership structure. In particular, I find that the effect on productivity is increasing in the share of voting rights acquired by the new owner, is larger when the new owner acquires a majority of the voting rights rather than simply a controlling stake, and that indirect changes in ownership lead to an attenuated increase in productivity.

A tertiary goal of this study is an attempt to get inside the black box of what happens to productivity during a change in ownership. By interpreting the complex features of ownership as quantitative measures of control, there may be scope to relate features of ownership structure to managerial oversight. Braguinsky et al. (2015) leverage precise data on firm-level decisions to show that this productivity shock comes in part due to gains in capacity utilization and drops in inventories. My approach is a more indirect one, and appeals to the intuition that a firm acquired by a new direct owner may receive more influence than one who receives a new ultimate owner only through an intermediary. Moreover, if a firm's new owner is able to exercise a larger fraction of voting rights, perhaps that owner will similarly have a stronger impact. At this stage the relationship is only suggestive, but it is possible that these features of ownership structure could be interpreted as a concrete representation of managerial control or other intangible inputs (Atalay et al. (2014)).

This paper shows only a glimpse at the relationship between ownership structure and firm performance. At this stage a causal interpretation is cautioned, but the results of these specifications provide suggestive evidence for the hypothesis that such features of complex ownership structure are relevant for real economic outcomes. This chapter is also only an incremental step toward understanding the full picture of ownership structure, focusing on the marginal decision of an ownership change rather than supplying any broad theory of

ownership. Regardless, a next step would likely require either some exogenous variation in structure of ownership or a full structural model of the multinational firm's decision of ownership structure.

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Appendix

2.A Productivity Estimation

Measurement of firm-level productivity requires the estimation of a production function, as introduced in section 2.3.1. As in Olley and Pakes (1996), firm dynamics are based on the models of Hopenhayn and Rogerson (1993) and Ericson and Pakes (1995). Productivity evolves according to the process $\omega_{it+1} = g(\omega_{it}, \Delta\mathbf{Owner}_{it}) + \xi_{it+1}$, with ξ_{it+1} an exogenous shock which generates the OLS simultaneity bias. The vector $\Delta\mathbf{Owner}_{it}$ contains information on the firm's ownership change history (see the exact specification in (**??**) below).[20] By timing assumption, k_t is chosen at time $t-1$; that is, capital can't react to today's productivity shock. The firm chooses l_t and m_t as non-dynamic inputs, but I assume that labor is chosen *before* materials to address the critique of Ackerberg et al. (2006). I do not employ the selection correction technique proposed by Olley and Pakes (1996), but rather I follow Levinsohn and Petrin (2003) in relying on the use of an unbalanced panel to reduce the impact of selection.[21]

Levinsohn and Petrin (2003) note that under the assumption that a firm's choice of material usage at time t is a strictly increasing function of ω_{it}, the firm's demand function for (log) material usage $m_t = m_t(\omega_t, k_t, l_t, \Delta\mathbf{Owner}_{it})$ can be inverted to find $\omega_t =$

[20] In Olley and Pakes (1996) and much of the productivity literature, productivity is assumed to follow an exogenous first-order Markov, $\omega_{it+1} = g(\omega_{it}) + \xi_{it+1}$. By endogenizing the productivity process as in De Loecker (2013) and Braguinsky et al. (2015), I allow for a firm's expectations for productivity to include the effect of an ownership change.

[21] Though the final example eliminates firms which have fewer than five years of data in the sample, the full dataset is used to estimate productivity so the panel is unbalanced.

$h_t(m_t, k_t, l_t, \Delta\mathbf{Owner}_{it})$, which suggests that one can proxy for unobserved productivity using observed levels of capital and intermediate input usage.

The method proceeds in two stages:

1. Substitute the inverse of material input demand in for ω_{it} in the value-added production function (2.2) :

$$y_{it} = \beta_l l_{it} + \beta_k k_{it} + h_t(m_{it}, k_{it}, l_{it}, \Delta\mathbf{Owner}_{it}) + \eta_{it} \tag{2.8}$$

and recover a non-parametric estimate for the predicted output term $\hat{\phi}_t$,

$$\phi_t(m_{it}, k_{it}, l_{it}) \equiv \beta_l l_{it} + \beta_k k_{it} + h_t(m_{it}, k_{it}, l_{it}, \Delta\mathbf{Owner}_{it}), \tag{2.9}$$

using a third-order polynomial expansion in labor, capital, materials, and ownership change history. Noting the critique of Ackerberg et al. (2006), no coefficients are estimated in the first stage.

2. We can step one period forward and consider innovations to productivity, denoted by $\xi_{t+1} = \omega_{t+1} - E[\omega_{t+1}|\omega_t]$. Using predicted estimates $\hat{\phi}_t$ from the first stage and candidate parameter values $\boldsymbol{\beta}$, I compute productivity estimates

$$\hat{\omega}_{it}(\beta_l, \beta_k) = \hat{\phi}_t - \beta_k k_{it} - \beta_l l_{it}, \tag{2.10}$$

and regress $\hat{\omega}_{t+1}$ on $\hat{\omega}_{it}$ and $\Delta\mathbf{Owner}_{it}$ non-parametrically according to:

$$\begin{aligned}\hat{\omega}_{it+1}(\beta_l, \beta_k, \Delta\mathbf{Owner}_{it}) = & \sum_{j=1}^{3} \delta_j (\hat{\omega}_{it}(\beta_l, \beta_k))^j \\ & + \theta_{pre}\Delta\text{Owner}_{it+1} + \theta_{post}^{early}\Delta\text{Owner}_{it-1}^{post} \\ & + \theta_{post}^{late}\Delta\text{Owner}_{i\{t-2,t-3,\ldots\}}^{post} + \xi_{it+1}\end{aligned} \tag{2.11}$$

where the vector $\Delta\mathbf{Owner}_{it}$ is expanded into dummies ΔOwner_{it} which are equal to 1 if firm i experienced an ownership change at time t. In particular, this allows changes in ownership in the recent history, and immediate future (next year) to affect the evolution of productivity. Note that these dummies are the same used in the main specifications of the paper, e.g. equation (2.5). The residuals are the innovations to productivity, $\xi_{it+1}(\boldsymbol{\beta})$. The timing assumptions of the model imply that these innovations to productivity are uncorrelated with the information set at time t (which include l_t and k_{t+1}):

$$E\left[\xi_{t+1}(\boldsymbol{\beta}) \middle| \begin{array}{c} k_{t+1} \\ l_t \end{array}\right] = 0. \tag{2.12}$$

so I can then estimate parameters in $\boldsymbol{\beta}$ using GMM with moments:

$$E\left[\xi_{t+1}(\boldsymbol{\beta}) \begin{pmatrix} k_{t+1} \\ l_t \end{pmatrix}\right] = 0. \tag{2.13}$$

Finally, I recover firm-level measurements for log total factor productivity as residuals of the value-added production function:

$$\tilde{\omega}_{it} = y_{it} - \hat{\beta}_l l_{it} - \hat{\beta}_k k_{it}. \tag{2.14}$$

2.B Alternate Thresholds for Ownership Definition

To test whether results are sensitive to the choice of the definition of ownership, I recreate the entire ownership database assuming a new definition of ownership. In the preferred results, I follow La Porta et al. (1999) in defining 20% as the minimum required share of ownership for a maximal shareholder to be deemed a firm's owner. Here, I recreate the database assuming a minimum threshold of ownership share at 10% instead of 20%. I then re-estimate equations (2.5) and (2.6) using the resulting ownership changes. Results are reported in tables 2.7 and

Table 2.7: Alternate threshold for ownership definition (10% minimum ownership share): baseline specification

Dependent Variable:	TFP (LP/ACF)	TFP (OLS)	TFP (Cost Share)
	(1)	(2)	(3)
Pre-ownership change	0.0084	0.007	-0.014
dummy $(s-1)$	(0.012)	(0.013)	(0.013)
Early Post-ownership change	0.041***	0.042***	0.048***
dummy $(s+1)$	(0.013)	(0.013)	(0.013)
Late Post-ownership change	0.099***	0.102***	0.110***
dummy $(s+2,\ s+3)$	(0.010)	(0.011)	(0.010)
Firm fixed effects	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes
N (firm-years)	109762	109762	109762
Adj. R^2	0.79	0.80	0.78

Standard errors in parentheses
$^{*}:\ p<0.01;\ ^{**}:\ p<0.05;\ ^{***}:\ p<0.1$

Notes: Table notes identical to table 2.3, except that the definition of controlling ownership is set as the largest owner with a minimum of 10% of ownership share.

2.8, respectively. The results appear very similar to those preferred specifications in the main paper.

2.C Check for pre-ownership change productivity trends

In order to check for pre-ownership change trends in productivity, I estimate an equation of the form:

$$\omega_{it} = \alpha_i + \lambda_t + \sum_{k=1}^{4} \beta_{-k} \Delta \text{Owner}_{it-k} + \sum_{k=1}^{6} \beta_k \Delta \text{Owner}_{it+k} + \epsilon_{it}. \tag{2.15}$$

Coefficients are visually depicted in figure 2.3, and reported in table 2.9.

Table 2.8: Alternate threshold for ownership definition (10% minimum ownership share): complex ownership

Ownership Structure (Z_{it}):	Ownership Share (1)	>50% Ownership Acquired (2)	Direct Owner (3)
Pre-ownership change	0.004	0.035	0.000
dummy $(s-1)$	(0.042)	(0.034)	(0.022)
× Ownership Structure	0.009	-0.028	0.013
	(0.050)	(0.037)	(0.024)
Early Post-ownership change	0.048	0.044	0.039*
dummy $(s+1)$	(0.043)	(0.034)	(0.023)
× Ownership Structure	-0.010	-0.003	0.018
	(0.052)	(0.038)	(0.025)
Late Post-ownership change	0.021	0.053**	0.066***
dummy $(s+2,\ s+3)$	(0.032)	(0.026)	(0.019)
× Ownership Structure	0.118***	0.061**	0.045**
	(0.041)	(0.028)	(0.021)
Firm fixed effects	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes
N (firm-years)	109762	109762	109762
Adj. R^2	0.80	0.79	0.77

Standard errors in parentheses

$^{*}: \ p < 0.01; \ ^{**}: \ p < 0.05; \ ^{***}: \ p < 0.1$

Notes: Table notes identical to table 2.4, except that the definition of controlling ownership is set as the largest owner with a minimum of 10% of ownership share.

Table 2.9: Investigating pre-ownership change productivity trends: yearly coefficients

Dependent Variable:		TFP (LP/ACF)	
Lead Coefficients		Lag Coefficients	
β_{-4}	-.0086	β_1	.0331**
	(0.017)		(0.013)
β_{-3}	-.0114	β_2	.0733
	(0.015)		(0.014)
β_{-2}	.0067	β_3	.0793
	(0.014)		(0.014)
β_{-1}	-.0016	β_4	.0871
	(0.013)		(0.016)
		β_5	.0812
			(0.017)
		β_6	.0694
			(0.019)
Firm fixed effects	Yes		
Year fixed effects	Yes		

Standard errors in parentheses

$^{*}: \ p < 0.01; \ ^{**}: \ p < 0.05; \ ^{***}: \ p < 0.1$

Notes: Table notes identical to table 2.3, except that estimating equation is equation (2.15).

2.D Balancing Tests for Propensity Score Matching

The key assumption of the propensity score matching procedure from section 2.4.2 is selection on unobservables, or conditional independence of being selected for treatment. Intuitively, the probability that a firm enters the treatment group must be purely random for individuals with the same values of the pre-ownership change variables used for matching. Under this assumption, in order for the matched firms to provide a suitable control group, the pre-ownership change values of the variables should be balanced between the treatment firms and the matched control firms. To confirm that matching yields a credible control group for firms which experience an ownership change, I perform a number of standard balancing tests. First, I compare the sample means of variables included in the match by performing individual t-tests for both the matched and unmatched samples. I also report the standardized bias for all matching variables, as described by Girma and Görg (2007). For each covariate x_i, this is computed as the difference in means between the treatment group firms experiencing an ownership change (group T) and the control group C of untreated firms, scaled by the average variances in the two groups:

$$bias = \frac{{}^{100}/_{N} \sum_{i \in T} \left[x_i - \sum_{j \in C} g\left(p_i, p_j\right) x_i \right]}{\sqrt{\frac{\mathrm{Var}_{i \in T}(x_i) + \mathrm{Var}_{j \in C}(x_i)}{2}}} \tag{2.16}$$

The lower this bias, the more balanced are the two matched samples in terms of this covariate; as such, we expect that the bias should be reduced after performing the matching. I also compute "Rubin's B" (the number of standard deviations between the means of covariate distributions in the two groups) and "Rubin's R" (the ratio of variances of covariates in the two groups), proposed in Rubin (2001) as composite measures of whether the covariate differences in the matched samples are small enough. For the balancing property to be satisfied, Rubin's B should be less than 25%, and Rubin's R should be in the range of $[0.5, 2]$.

Table 2.10: Results of Balancing Tests

		Mean		T-test		Bias	
Variable	Sample	Treated	Control	T	$p > \|T\|$	%Bias	%Reduced
Tangible Fixed Assets	Unmatched	5027.8	1960.3	9.63	0.000	24.6	69.6
	Matched	4735.1	3803.3	1.39	0.164	7.5	
Added Value	Unmatched	4911.8	2131.3	7.65	0.000	23.7	77.7
	Matched	4522.7	3903.5	1.35	0.178	5.3	
Number of Employees	Unmatched	125.79	43.52	12.37	0.000	9.5	99.8
	Matched	79.85	79.71	0.02	0.980	0.0	
Firm Age	Unmatched	16.69	16.72	-0.05	0.957	-0.2	88.8
	Matched	16.56	16.56	0.00	0.996	0.0	
Rubin's B: 8.7%					Rubin's R: 1.03		

Notes: Data cover the period 2004-2015. This table reports results of balancing tests comparing the treatment and matched control samples for balance. Rubin's B is the number of standard deviations between the means of covariate distributions in the two groups. Rubin's R is the ratio of varianes of covariates in the two groups.

All results are reported in table 2.10. Before performing matching, it is clear that firms experiencing an ownership change have significantly more assets, added value, and number of employees. After matching, the results of the two-sample T-test are not significant at the 10% level, although there still exists some upward bias for the treatment group in both size (assets) and production (added value). The bias from equation (2.16) is also reported, and by this metric also the matched control group seems suitably balanced to the treatment group (Rosenbaum and Rubin (1983) assume that a value of 20 is large).

Chapter 3

Firm-Level Financial Constraints, Acquisitions, and Performance

3.1 Introduction

Financial frictions are any forces which distort the allocation of assets across productive units. A large body of literature has studied the effect of the misallocation of capital on aggregate productivity. Hsieh and Klenow (2009) link misallocation to aggregate TFP using a standard model of monopolistic competition, and use firm-level micro data to calculate that the elimination of misallocation in the form of firm-specific "wedges" between the marginal products of capital and labor could increase TFP in China by 30 to 50 percent and in India by 40 to 60 percent. Many quantitative papers in the macro/development literature study the relationship between financial frictions and aggregate productivity through the misallocation channel by looking at cross-country differences in financial market imperfections and economic development (Buera et al. (2011); Midrigan and Xu (2014); Moll (2014)). Frictions also lead to the distortion of decisions at the firm level, often modeled as external financing constraints which cause firms to deviate from their first-best investments. Given that misallocation has been shown to be a primary driver of productivity differences across

countries, the extent to which these misallocations are caused by financial frictions imply a need to study these forces at the firm level.

This chapter studies the relationship between firm-level financial constraints and total factor productivity through the lens of acquisitions. Recent work by Erel et al. (2015) documents that acquisitions appear to relieve the financial constraints of target firms, showing that target firms' level of cash, sensitivity of cash to cash flow, and sensitivity of investment to cash flow all decline following an acquisition. They perform an event study of acquisitions using firm-level measures of financial constraints, and imply a theory of financing efficiencies as a source of gains from mergers and acquisitions. I extend this line of inquiry by linking firm-level measures of financial constraints to firm performance in the post-acquisition period. I set out to answer two questions. First, does the financial health of the acquirer or target at the time of acquisition have implications for post-acquisition performance of the target? Second, do acquisitions and the market for corporate assets more generally play a role in addressing misallocation of capital? Using a panel of European manufacturing firms with yearly financial, production, and ownership data, I apply standard approaches from the corporate finance literature to show that acquired firms that appear financially constrained tend to exhibit larger increases in productivity than firms which do not appear financially constrained.

This chapter contributes to several other lines of research. First, this chapter is similar to the previous one in that it addresses the relationship between changes in ownership (acquisitions) and efficiency. This relationship has been a topic of study in both the industrial organization and corporate finance literatures. Maksimovic and Phillips (2001) posit and test a model of the market for corporate assets in which productive firms purchase plants from unproductive firms, leading to post-acquisition plant-level productivity gains.[1] While the literature tends to agree that takeovers result in an increase in plant-level productivity of the acquired firm, the question of the precise mechanism by which productivity increases is

[1]Other papers taking this approach have similar findings, including McGuckin and Nguyen (2001), Yang (2008), Maksimovic et al. (2011), and Li (2013).

more of an open question. In this chapter I propose the relaxation of financial constraints as a mechanism by which post-acquisition performance improves for target firms, and provide suggestive evidence using plant-level data to support this mechanism.

Secondly, I build off the literature in corporate finance which attempts to construct firm-level measures for financial constraints using available data. Ideal indicators for whether a firm is financially constrained would be based on direct evidence on the borrowing costs faced by firms, or survey evidence on whether firms are unable to borrow. Since such data is often not readily available, the corporate finance literature has developed several approaches to constructing indirect evidence thought to be representative of whether firms are financially constrained. My application addresses its research question to the standard of this corporate finance literature, by categorizing firms as financially constrained using metrics from this literature. Criticisms and limitations of these measures and the resulting approach are worth mentioning (see the discussion in section 3.3.2), and carry through to the interpretation of my results.

Finally, this chapter contributes to the broad literature relating firm-level finances to total factor productivity. In the context of acquisitions, Davis et al. (2014) analyze the effect of private equity takeovers on plant-level productivity and employment using U.S. Census data.[2] More generally, several papers have related the financial features of firms to physical productivity, for example Coricelli et al. (2012) (leverage), Imrohoroglu and Tuzel (2014) (stock returns), and Levine and Warusawitharana (2014) (external financing).

3.2 Financial Constraints and Acquisitions

Many models in corporate finance have been proposed to explain motives for mergers and acquisitions. Erel et al. (2015) (hereafter EJW) suggest a financing theory for acquisitions, through which targets are subject to financial constraints prior to acquisition, and financing efficiences are a source of gains from an acquisition by an unconstrained acquirer. They

[2]See also Lichtenberg and Siegel (1990), Cumming et al. (2007), and Lerner et al. (2011).

then document that acquired firms change their behavior post-acquisition in such a way that suggests that they were financially constrained ex ante. EJW stop short of exploring the implications of this theory on acquisitions and subsequent firm performance.

Consider the following simple model which rationalizes and extends the finding of EJW. A borrower seeks financing from a lender for an investment project of size $I > 0$. The project can either succeed, with probability $R > 0$, or fail and yield zero. One can imagine that the borrower is a manufacturing firm, and the project is some improvement of scale, technology, or efficiency. Stiglitz and Weiss (1981) show that when there is heterogeneity in project success probability R across borrowers which is unobservable to lenders, the asymmetric information leads to credit rationing. The lender must account for the fact that he can't observe type, so even a "good" borrower faces a higher cost of capital or the market breaks down. The result is that projects with positive net present value are left unfunded.

Now, suppose we introduce an acquirer who is unconstrained (perhaps they have a large net worth, or simply a credible signal of quality). The acquirer is able to observe the borrower's type cheaply, due to industry-specific knowledge. By choosing to acquire a high-type borrower, the acquirer can relieve the credit constraints in order to enable the positive NPV project either through internally generated cash flow or newfound access to external capital. In this way, acquisitions are a method of alleviating the asymmetric information problem which leads to the credit rationing of Stiglitz and Weiss (1981).

This model would generate several implications. First, it is consistent with the EJW observation that acquisitions relieve financial constraints. Second, it would suggest that financially constrained firms would be desirable targets for acquisition. And finally, we would expect an increase in target productivity post-acquisition, in particular for firms which are shown to be financially constrained ex-ante. The latter two are testable implications which I investigate using firm-level data on ownership changes, financial constraints, and performance.

3.3 Data

An analysis of the relationship between financial constraints and productivity through acquisitions requires firm-level panel data for income statements, profit-loss accounts, and ownership information. I focus on a European subset of firms in Bureau Van Dijk's Orbis dataset, which is the same data used by EJW. Orbis is a global firm-level dataset which is an ideal source for a number of reasons. For one, Orbis combines both financial and real data, which allow me to construct measures of both financial health and productivity. Second, the focus on European firms is essential because most European countries require that all firm-level data is reported as unconsolidated, even for subsidiaries of private firms.[3] In particular, this allows me to observe financial measures of firms both before and after an acquisition, which is typically not possible using data on U.S. firms. Third, Orbis provides detailed ownership information for all European firms, which allow me to identify ownership changes and acquisitions.

I pull financial measures and ownership data for all European manufacturing firms. To focus on measures of firm performance that best approximate productive efficiency, I focus on European firms matching two industries: concrete (NACE Rev. 2.0 core code 23.6), and glass (NACE Rev 2.0 core code 23.1). Orbis provides a ten-year panel for all firm-level financial and production measures. In the final sample, I exclude firms with fewer than five years of panel data, firms with only consolidated data accounts, non-EU firms, firms with a first year prior to 2000, firms acquired multiple times, and firms with fewer than $100k total assets.

3.3.1 Acquisitions and Ownership Data

The data on acquisitions come from the Orbiss Ownership Database, advertised as a complete source for owner and subsidiary links worldwide with over 69 million active and 454 million

[3]EJW go into some further detail on this, noting Switzerland as a key exception in which not all firms are required to report data.

Table 3.1: Counts of Firms, Acquisitions

		Industry		MP (2001)
	Total	Glass	Concrete	(U.S. Data)
# Firms	388,953	1,645	3,713	-
# Firm-Years	3,489,365	15.246	34,787	-
# Acquisitions	160,906	555	1,191	-
Pr(Acquisition in Year)	3.21%	3.64%	3.42%	1.95%

Notes: Data cover the period 2004-2015. Sample was pre-screened to exclude firms with fewer than five years in the sample, firms with only consolidated data accounts, non-EU firms, firms with the first year in panel prior to 2000, firms acquired multiple times, firms with fewer than 10 employees, and firms with fewer than $100k assets. Acquisition rates compared to Maksimovic and Phillips (2001) for U.S. plants.

archived links providing information on over 66 million companies. The Ownership Database provides yearly data on the direct owners of each firm. I define the controlling owner of a firm to be the largest shareholder firm which controls at least 20% of the voting rights, following the standard definition of the corporate finance literature (Faccio and Lang (2002)). I define an acquisition to be a case in which a firm gets a new controlling owner which was not a shareholder of the firm in any previous period.[4] In doing so, I construct a panel dataset of acquisitions from 2003-2014. Unlike chapter 2, I do not consider indirect changes in ownership, in which the direct shareholders remain the same but the ultimate controlling owner does. See appendix section 1.A for further details on the collection and creation of this database. In table 3.1, I present the total counts of the number of firms, firm-years, and acquisitions. I find around a 3.5% chance that firms are acquired in a given year, which is slightly higher than the 2% acquisition rate found by Maksimovic and Phillips (2001) for U.S. plants.

[4]Rather than going to the trouble of extracting panel variation in ownership data from Orbis, EJW rely on the Zephyr acquisition database (another product by Bureau Van Dijk). This approach has the advantage of reducing the false positives of incorrectly identifying ownership changes as acquisitions. However, relying on Zephyr can potentially miss out on acquisitions which are not reported upon. Kalemli-Ozcan et al. (2014) show using some examples that all ownership data contained in Zephyr is indeed captured by Orbis' ownership database, so the acquisitions considered by EJW are contained in my data.

3.3.2 Measures of Financial Constraints

A large literature in corporate finance has studied the constraints faced by firms attempting to raise external financing, and the impact of these financial constraints on firm behavior. Ideal measurement of firm-level financial constraints requires that researchers collect direct evidence on which firms are constrained. For example, Campello et al. (2010) and Minetti and Zhu (2011) collect survey responses from firms directly, while Gilchrist et al. (2013) collect data on interest rate spreads on publicly-traded debt to measure the dispersion in firm-level borrowing costs. Another method is to observe firm responses to exogenous shocks, as Banerjee and Duflo (2014) do using variation access to targeted lending programs.

Often, direct evidence of firm-level financial constraints is not available; in these cases, the empirical corporate finance literature has relied on several indirect measures to identify financially constrained firms. The three broad categories of measures are indirect indicators, composite indexes, and observed cash and investment policies. The indicator approach relies on choosing a single variable which is thought to be representative of whether a firm faces financial constraints. A common indicator is leverage, the ratio of debt to total assets.[5] A firm is considered less constrained if it has fewer debt obligations relative to pledgeable collateral. Other indicators of financial constraints include lower liquidity (e.g. Greenaway et al. (2007)), a higher cash holdings ratio (e.g. Fee et al. (2009)), a smaller firm size (e.g. Hahn and Lee (2009)), and a lower firm age (e.g. Rauh (2006)). Composite measures, such as the Kaplan-Zingales, Whited-Wu, or Hadlock-Pierce indices, are linear combinations of firm characteristics.[6] These indices are typically computed by estimating a logit for some observed measure of whether a firm is financially constrained (e.g. qualitative information from financial filings), and regressing on observable firm characteristics thought to be related to financial constraints, such as cash flows, firm age, debt, and cash holdings. The third

[5]Berman and Hericourt (2010) use leverage as a proxy for financial constraints in studying the role of constraints on exporting behavior at the firm level.

[6]See Hadlock and Pierce (2010) for a detailed discussion of these three indices, as well as the estimation of the Hadlock-Pierce index.

Table 3.2: Summary Statistics for Financial Constraint Measures

	Glass		Concrete	
	Acquired	Never Acquired	Acquired	Never Acquired
Leverage Ratio	0.552	0.523	0.542	0.534
Liquidity Ratio	0.127	0.141	0.124	0.146
Cash Holdings Ratio	0.084	0.082	0.085	0.083
HP Index	-1.071	-1.290	-1.178	-1.492
Firm Age	17.11	20.96	16.92	21.44
Total Assets	14966	28799	8902	10513

Notes: Data cover the period 2004-2015. Sample was pre-screened to exclude firms with fewer than five years in the sample, firms with only consolidated data accounts, non-EU firms, firms with the first year in panel prior to 2000, firms acquired multiple times, firms with fewer than 10 employees, and firms with fewer than $100k assets.

approach, employed by EJW, follows Fazzari et al. (1988) and Almeida et al. (2004) in writing a model based on the assumption that under complete markets investment is unrelated to the financial structure of the firm. When firms' cash and investment policies seem to be a function of shocks to cash flow, this suggest that the firm is financially constrained.

I use the firm-level financial accounts contained in Orbis to construct several of these measures of financial constraints. I define leverage to be long-term debt plus current liabilities, divided by total assets. I define liquidity to be current assets minus current liabilities, divided by total assets. I define the cash holdings ratio to be cash & cash equivalent, divided by total assets. I compute the Hadlock-Pierce (HP) Index according to a the linear combination of assets and firm size found in Hadlock and Pierce (2010). I also use firm age and firm size (total assets). In table 3.2, I report summary statistics for these financial constraint measures for firms in the glass and concrete industries, based on whether firms were acquired. The averages of most measures show that firms which are acquired tend to look more constrained than firms which are never acquired. The sample of firms which are acquired in each industry are more leveraged, hold more cash, are less liquid, and have a higher HP index (which combines the fact that they have a lower firm age and smaller total asset size).

As noted by Farre-Mensa and Ljungqvist (2016), these indirect measures of whether firms are financially constrained have many problems. They use a natural experiment of firm responses to staggered increases in corporate tax rates, and show that firms classified as constrained by the literature's measures often do not have any trouble raising external financing. Even the cash flow sensitivity approach employed by EJW can be shown to exist in a model without financial constraints (Gomes (2001)). However, they remain the best method of identifying financially constrained firms using firm-level balance sheet data. To alleviate some of the concerns about these measures, the empirical exercises in section 3.4.2 follow the empirical corporate finance literature by separating the sample into terciles based on measures of financial constraints, and comparing the "least" constrained firms to the "most" constrained firms.[7]

3.3.3 Measures of Firm Performance

I assume a Cobb-Douglas functional form for the value-added production function in labor and capital, written in logs as:

$$y_{it} = \beta_l l_{it} + \beta_k k_{it} + \omega_{it} \tag{3.1}$$

For firm performance, I compute two reduced-form measures of productivity using firm-level data. First, I employ the cost-share approach, which estimates output elasticities using the cost share of each input as a fraction of total value-added. Under the assumptions of a Cobb-Douglas production function, perfect competition, homogenous goods, and no factor adjustment costs, the industry β_l should be equal to the median firm-level cost-share of labor. Second, I use a parametric estimation of an OLS value-added production function (3.1) in labor and capital, and take the residuals as estimates of productivity. Nominal values of production data are deflated by an industry-level price index. I stop short of estimating

[7]Rauh (2006), Hahn and Lee (2009), Fee et al. (2009), Almeida et al. (2004), and Chaney et al. (2012) all take this approach.

productivity using the semi-parametric method as was done in section 2.3.1 of the previous chapter. However, Syverson (2011) notes that first-pass metrics such as these are often closely correlated with estimation following the Olley and Pakes (1996) approach.

3.4 Empirics

3.4.1 Financial Constraints and the Acquisition Decision

One implication of a financing theory of mergers and acquisitions is that measures of financial constraints will be useful in explaining the probability of acquisition at any point in time. I consider the following logistic probability model of an acquisition of firm i from industry s in year t:

$$Acq_{it} = \alpha_0 + \alpha_1 \varphi_{it-1} + \alpha_2 FC_{it-1} + \lambda_t + d_s + c_i + \nu_{it} \tag{3.2}$$

where Acq_{it} is a dummy for whether firm i was acquired, λ_t are year dummies, d_s are industry dummies, c_i are country dummies, φ_{it-1} is lagged productivity, and FC_{it-1} is a lagged measure of whether the firm is financially constrained.[8] The purpose of estimating such an equation is to determine whether there is positive or negative selection on financial constraint variables FC_{it-1}. If we observe that acquirers tend to target firms which are more financially constrained, this lends credence to the theory that relieving financial constraints of the target is part of the acquisition decision process.

I estimate the logit on the entire sample of European manufacturing firms in Orbis. Results are reported in table 3.3 for several different measures of financial constraints from section 3.3.2. For total factor productivity I use the residual of a parametric OLS estimation of the production function; results remain significant if I instead rely on the cost-share approach. In each specification, I find that the sign on the constraint measures suggests that the more constrained firms are more likely to be acquired at any given time: more leveraged

[8] This exercise is similar to one of Guadalupe et al. (2012), which studies how foreign multinationals decide to acquire domestic firms. They run the same linear probability model similar to equation (3.2) in order to determine whether there is positive or negative selection on productivity.

firms, less liquid firms, firms holding more cash, and firms with a higher HP index. I also find that there tends to be positive selection on productivity in the acquisition decision.

3.4.2 Ex-Ante Financial Constraints and the Acquisition Effect on Firm Performance

Next, I test whether firms which are financially constrained prior to the acquisition experience a larger increase in productivity in the post-acquisition period. To do so, I first take a standard approach from the empirical corporate finance literature by splitting the sample into terciles based on ex-ante measures of financial constraints. I then estimate performance in the post-acquisition period separately for each group, in order to compare the most "unconstrained" firms to the most "constrained" firms. The appeal of this approach is to address concerns that the measures of financial constraints are poor proxies by reducing the granularity of the measures to a broad categorical classification. Conditional on accepting that firms with higher observed financial constraint measures tend to be more financially constrained, it should be true that the higher tercile contains more constrained firms on average.

To assess post-acquisition performance, I borrow the within-firm regression used by Braguinsky et al. (2015) and highlighted in the previous chapter:

$$\omega_{it} = \alpha_i + \lambda_t + \beta_{pre}\text{Acq}_{it+1} + \beta_{post}^{early}\text{Acq}_{it-1} + \beta_{post}^{late}\text{Acq}_{i\{t-2,t-3,..\}} + \epsilon_{it} \tag{3.3}$$

where ω_{it} is a measure of firm productivity from section 3.3.3, Acq_{it} are dummies for whether a firm is acquired at time t, α_i are firm fixed effects, and λ_t are year fixed effects. The coefficients on each of the acquisition dummies represent within-firm differences in productivity relative to an acquisition: β_{pre} captures the pre-acquisition effect on productivity, while β_{post}^{early} and β_{post}^{late} capture the early- and late-period post-acquisition effects on productivity.

Table 3.3: Acquisition Decision: Logistic Regression

Constraint Measure:	Leverage	HP Index	Liquidity	Cash Holdings
	(1)	(2)	(3)	(4)
Constraint Measure$_{t-1}$	0.164***	0.08***	-0.103***	0.052*
	(0.018)	(0.003)	(0.013)	(0.027)
TFP: OLS$_{t-1}$	0.031***	0.027***	0.026***	0.009
	(0.009)	(0.008)	(0.008)	(0.008)
Industry fixed effects	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes
Country fixed effects	Yes	Yes	Yes	Yes
N (firm-years)	1386157	1599711	1591000	1571063

Standard errors in parentheses

$^{*}: \ p < 0.01; \ ^{**}: \ p < 0.05; \ ^{***}: \ p < 0.1$

Notes: Data cover the period 2004-2015. Sample was pre-screened to exclude firms with fewer than five years in the sample, firms with only consolidated data accounts, non-EU firms, firms with the first year in panel prior to 2000, firms acquired multiple times, firms with fewer than 10 employees, and firms with fewer than $100k assets. This table reports results of a logistic regression of whether a firm is acquired on lagged productivity and financial constraint status, as in equation (3.2). Numbers reported in the table are the point estimates and robust standard errors (in parentheses, clustered by firm). The dependent variable in each regression (column) is a dummy which is equal to 1 if the firm experienced a change in direct controlling owner to a new firm in year t. The different specifications vary in which proxy for financial constraint is used: column (1) uses leverage (higher leverage implying financial constraints), column (2) uses the Hadlock-Pierce Index (higher values implying financial constraints), column (3) uses liquidity (lower liquidity implying financial constraints), and column (4) uses the cash holdings ratio (higher cash holdings implying financial constraints). I include fixed effects for the industry, year, and country of the acquired firm.

I report results for glass manufacturing firms in table 3.4, and for concrete manufacturing firms in 3.5. Each table presents the results of estimating equation (3.3) separately on the top and bottom tercile of firms by each constraint measure.

For glass manufacturing firms, the firms in the constrained tercile as determined by leverage, liquidity, and the HP index all experienced larger increases in late post-acquisition productivity. For example, the most leveraged glass manufacturing firms experience an average increase in productivity of 7.4% two years after acquisition and later, whereas the least leveraged firms have a 2.7% increase in productivity in the same time period. The results for cash holdings weakly moves in the opposite direction; glass manufacturing firms which have the highest ratio of cash holdings to total assets experience a smaller increase in post-acquisition productivity than firms which hold the least amount of cash. Among concrete manufacturing firms, the results are less conclusive. Concrete manufacturing firms tend to experience a larger increase in productivity in the year immediately following an acquisition than in the late post-acquisition period. When categorizing firms based on leverage, liquidity, and HP index as constraint measures, there isn't much difference in the early post-acquisition productivity between the constrained and unconstrained firms. When using cash holdings to sort firms, the unconstrained firms weakly outperform the constrained forms in the early post-acquisition period. In the late post-acquisition period, the more constrained firms as sorted by leverage, HP index, and cash holdings experience a larger increase in productivity than the unconstrained firms, although the coefficients are not significant.[9]

3.5 Conclusion

In this chapter, I have explored an extension of the financing theory of mergers suggested in Erel et al. (2015). If one purpose of an acquisition is to relieve the financial constraints of

[9]Fee et al. (2009) point out that the use of cash holdings as a measure of financial constraints is controversial. While many studies tend to agree with Almeida et al. (2004) that high cash holdings suggest financial constraints in line with the cash flow sensitivity of cash, a firm which is flush with cash may also be unconstrained.

Table 3.4: Ex-Ante Financial Constraints and Acquisition Performance: Glass

Dependent Variable:	TFP: OLS							
	(1)		(2)		(3)		(4)	
Constraint Measure:	Leverage		HP Index		Liquidity		Cash Holdings	
Constrained Tercile:	Cons.	Uncons.	Cons.	Uncons.	Cons.	Uncons.	Cons.	Uncons.
Pre-Acquisition	0.048	-0.003	-0.081*	0.007	-0.016	-0.064*	-0.057	0.005
Dummy $(s-1)$	(0.035)	(0.041)	(0.043)	(0.036)	(0.031)	(0.032)	(0.036)	(0.043)
Early Post-acquisition	0.013	0.044	-0.008	-0.002	0.043	-0.362	-0.032	0.048
Dummy $(s+1)$	(0.034)	(0.042)	(0.038)	(0.035)	(0.035)	(0.036)	(0.035)	(0.039)
Late Post-acquisition	0.074**	0.027	0.072**	0.005	0.085***	0.006	0.001	0.054*
Dummy $(s+2, s+3)$	(0.035)	(0.043)	(0.033)	(0.029)	(0.031)	(0.031)	(0.030)	(0.033)
Acquisition fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N (firm-years)	2958	2717	2602	3342	3110	2390	2577	3120

Standard errors in parentheses
$^{*}: \ p < 0.01; \ ^{**}: \ p < 0.05; \ ^{***}: \ p < 0.1$

Notes: Data cover the period 2004-2015, for European firms matching Nace Rev 2.0 code 23.1. Sample was pre-screened to exclude firms with fewer than five years in the sample, firms with only consolidated data accounts, non-EU firms, firms with the first year in panel prior to 2000, firms acquired multiple times, firms with fewer than 10 employees, and firms with fewer than $100k assets. This table reports results of a regression of firm performance on dummies for recent ownership change and a firm fixed effect, as in equation (3.3). The dependent variable in each regression (column) is firm TFP, based on a (biased) OLS regression of a Cobb-Douglass production function. Numbers reported in the table are the point estimates and robust standard errors (in parentheses, clustered by firm). The different specifications vary in which proxy for financial constraint is used: column (1) uses leverage, column (2) uses the Hadlock-Pierce Index, column (3) uses liquidity, and column (4) uses the cash holdings ratio.

Table 3.5: Ex-Ante Financial Constraints and Acquisition Performance: Concrete

Dependent Variable:	TFP: OLS							
	(1)		(2)		(3)		(4)	
Constraint Measure:	Leverage		HP Index		Liquidity		Cash Holdings	
Constrained Tercile:	Cons.	Uncons.	Cons.	Uncons.	Cons.	Uncons.	Cons.	Uncons.
Pre-Acquisition	-0.022	-0.014	0.023	-0.010	-0.025	-0.004	-0.086	-0.040
Dummy ($s-1$)	(0.032)	(0.032)	(0.032)	(0.031)	(0.032)	(0.036)	(0.032)	(0.032)
Early Post-acquisition	0.059*	0.055	0.068**	0.069**	0.035	0.062*	-0.008	0.051*
Dummy ($s+1$)	(0.031)	(0.031)	(0.031)	(0.029)	(0.031)	(0.034)	(0.030)	(0.030)
Late Post-acquisition	0.011	-0.017	0.057**	0.008	0.012	0.044	0.014	-0.023
Dummy ($s+2, s+3$)	(0.027)	(0.035)	(0.027)	(0.025)	(0.027)	(0.029)	(0.033)	(0.034)
Acquisition fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N (firm-years)	7408	7194	7037	7798	7786	5986	5441	6414

Standard errors in parentheses
* : $p < 0.01$; ** : $p < 0.05$; *** : $p < 0.1$

Notes: Data cover the period 2004-2015, for European firms matching Nace Rev 2.0 code 23.6. Sample was pre-screened to exclude firms with fewer than five years in the sample, firms with only consolidated data accounts, non-EU firms, firms with the first year in panel prior to 2000, firms acquired multiple times, firms with fewer than 10 employees, and firms with fewer than $100k assets. This table reports results of a regression of firm performance on dummies for recent ownership change and a firm fixed effect, as in equation (3.3). The dependent variable in each regression (column) is firm TFP, based on a (biased) OLS regression of a Cobb-Douglass production function. Numbers reported in the table are the point estimates and robust standard errors (in parentheses, clustered by firm). The different specifications vary in which proxy for financial constraint is used: column (1) uses leverage, column (2) uses the Hadlock-Pierce Index, column (3) uses liquidity, and column (4) uses the cash holdings ratio.

the target firm, one would expect that measures of the financial constraints faced by target firms could explain the acquisition of the firm, and that the post-acquisition increase in productivity may depend on whether the firm faced financial constraints ex-ante.

I test these two assertions using firm-level panel data on European glass and concrete manufacturers. I first introduce measures of financial constraints into a probability model for whether a firm is acquired, and show that firms that appear more constrained using each measure are more likely to be acquired. I next study the post-acquisition of performance of firms depending on their ex-ante financial constraints by separating firms into those which appear to be most and least financially constrained, and study the change in firm performance surrounding an acquisition for each group separately. To summarize, when considering leverage, liquidity, and the HP index, I find that glass manufacturing firms that appeared financially constrained prior to acquisition experienced larger post-acquisition productivity gains than firms which did not appear financially constrained. When considering acquisitions of concrete manufacturing firms, there is no significant difference between those which appeared financially constrained and those which appear unconstrained. For each industry, the ratio of cash holdings to total assets differed from the other measures of financial constraints in how it grouped firms; in each industry, the firms which held less cash prior to the acquisition tended to perform better post-acquisition.

The results in the previous section are presented with many caveats. For one, the reliance on the empirical corporate finance literature on measures of financial constraints is fairly imprecise, and far inferior to the use of direct evidence on financial constraints such as firm survey responses. While this chapter's treatment of financial constraints is up to the standard of the corporate finance literature, it is not clear at all that measures such as leverage, liquidity, or cash on hand are closely tied to whether firms are facing financial constraints. Secondly, my approach to the ownership data treats all "acquisitions" as equal, when in fact there is likely heterogeneity, for example in the types and industries of acquiring firms or the amount of voting rights acquired in the acquisition. The informal suggestion of

my model is that financially constrained firms stand to gain more from an acquisition, when it could be the case that I am comparing two different treatments entirely. Regardless, this is only a suggestive step toward a full model of a financing theory for mergers and acquisitions which incorporates both the acquisition decision of the firm, and the post-acquisition impact on performance.

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